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	International Journal of Cognitive Research in Science, Engineering and Education (IJCRSEE)
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EDITORIAL

International Journal of Cognitive Research in Science, Engineering and Education (IJCRSEE) is an open access international peer-reviewed, open-access journal, which provides a platform for highlighting and discussing various cognitive science issues dealing with the problems of cognition (and its evolution) within some specific subject field - philosophical, psychological, linguistic, mathematical, psychogenetic, pedagogical, ergonomic. Editorial Board strives to provide a possibility for the scientists of different fields to publish the results of their research, technical and theoretical studies. IJCRSEE is multidisciplinary in approach, and will publish a great range of papers: reports of qualitative case studies, quantitative experiments and surveys, mixed method studies, action researches, meta-analyses, discussions of conceptual and methodological issues, etc. IJCRSEE publisher is The Association for the Development of Science, Engineering and Education, Vranje, Serbia. Co-publishers are: University Business Academy, Faculty of Economics and Engineering Management in Novi Sad, Serbia and Don State Technical University, Rostov on Don, Russian Federation.

IJCRSEE particularly welcomes articles on the results of scientific research in various fields of cognitive science (psychology, artificial intelligence, linguistics, philosophy and neuroscience) catering for international and multidisciplinary audience. Readers include those in cognitive psychology, special education, education, adult education, educational psychology, school psychology, speech and language, and public policy. IJCRSEE has regular sections: Original Research, Review Articles, Studies and articles, Book Reviews, Case Studies, and is published three times a year. This journal provides an immediate open access to its contents, which makes research results available to the public based on the global exchange of knowledge. The journal also offers access to uncorrected and corrected proofs of articles before they are published.

The main aim of the Journal is to discuss global prospects and innovations concerning major issues of cognitive science, to publish new scientific results of cognitive science research, including the studies of cognitive processes, emotions, perception, memory, thinking, problem solving, planning, education and teaching, language and consciousness study, the results of studying man's cognitive development and the formation of basic cognitive skills in everyday life. The Journal seeks to stimulate the initiation of new research and ideas in cognitive science for the purpose of integration and interaction of international specialists in the development of cognitive science as interdisciplinary knowledge.

All articles are published in English and undergo a peer-review process.

The scope of IJCRSEE is focused on cognitive research both in topics covered as well as disciplinary perspective:

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- Text Processing and Cognitive Technologies

- Curriculum Development
- Development of Learning Environment
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- Learning Systems Platforms
- Media Education
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- Teaching and Learning Technologies
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IJCREE has an international editorial board of eminent experts in their field from Russia, USA, Republic of Macedonia, Germany, Hong Kong, Greece, Serbia, Australia, United Kingdom, USA, Turkey, Nigeria, Bulgaria, Romania, Spain, Italy, Republic of Srpska, Croatia, Kingdom of Saudi Arabia (KSA), India, China, Thailand, Israel, Malaysia, Morocco, Jordan,, Iran... We are confident that IJCREE will attract a great number of editors, eminent scientists in the field. The selection will be based on the activities of the editors and their desire to contribute to the development of the journal.

IJCREE provides a platform for academics and scientists professionals to refer and discuss recent progress in the fields of their interests. Authors are encouraged to contribute articles which are not published or not under review in any other journal.

Each submitted manuscript is evaluated on the following basis: the originality of its contribution to the field of scholarly publishing, the soundness of its theory and methodology, the coherence of its analysis, its availability to readers (grammar and style). Normal turn-around time for the evaluation of manuscripts is one to two months from the date of receipt.

Submission of an original manuscript to the journal will be taken to mean that it represents original work not previously published, that is not being considered elsewhere for publication; that the author is willing to assign the copyright to the journal as per a contract that will be sent to the author just prior to the publication and, if accepted, it will be published in print and online and it will not be published elsewhere in the same form, for commercial purposes, in any language, without the consent of the publisher.

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The requirement for the submission of a paper implies that it has not been published before; that it is not under consideration for publication anywhere else; that its publication has been approved by all co-authors.

When considering submitting an article, the Editors have provided the following criteria to assist authors with preparing their submissions:

Originality – The author should ensure that the manuscript has not been previously published nor is being considered by another journal.

Plagiarism - Content should be properly referenced. Be sure to check the paper for possible accidental plagiarism. Some plagiarism checker websites include: <http://www.ithenticate.com/>, www.antiplagiat.ru, www.grammarly.com, www.plagtracker.com or www.duplhecker.com

Writing – Please write in good English (American or British usage is accepted, but not a mixture of these). For non-native English speakers, and perhaps even for some native English speakers, grammar, spelling, usage, and punctuation of the texts are very important for an effective presentation. Hence, manuscripts are expected to be written in a clear, cogent, and readily understandable by an international readership.

Manuscripts must be submitted online. Electronic submission reduces the editorial processing and reviewing time. As part of the submission process, authors are required to check off their submission compliance with all of the following items, and submissions may be returned to authors who do not adhere to the following guidelines:

The submission has not been previously published or presented to another journal for consideration (or an explanation has been provided in Comments to the Editor).

The submission file is in OpenOffice, Microsoft Word, RTF, or WordPerfect document file format.

Where available, DOIs and URLs for the references have been provided.

The text is single-spaced; uses a 12-point font; employs italics, rather than underlining (except with URL addresses); and all illustrations, figures, and tables are placed within the text at the appropriate

points, rather than at the end.

The text adheres to the stylistic and bibliographic requirements outlined in the Author Guidelines.

If submitting to a peer-reviewed section of the journal, the instructions in Ensuring a Double Blind Review have been followed.

A manuscript goes through the peer review process. Authors submit manuscripts to Editorial office via the online system. The acknowledgement letter should be sent to the author to confirm the receipt of the manuscript. The Chief Editor first reviews manuscripts. Chief Editor is assisted by Section Editors (could also be Co- or Associated Editors). The Editor assigns a Section Editor to see the manuscript through the complete review process and return it with a recommendation or decision. The manuscript is checked to see if it meets the scope of the Journal and its formal requirements. If it is incorrect or unsuitable, the author should be informed and the manuscript filed (or returned if requested) – direct rejection. Manuscripts that are not suitable for publication in the Journal are rejected. A Rejection letter is sent to the author stating the reason for rejection. If the manuscript conforms to the aims and scope of the Journal, and formally abides by the Instructions to Authors it is sent out for review. Depending on the type of paper, it could be accepted immediately for publication (invited Editorial, Book review etc) by the Chief Editor.

Check that the manuscript has been written and styled in accordance with the Journal style; that it carries an abstract (if applicable), keywords, correct reference system etc. and check that the correct blinding system has been used. If anything is missing ask the author to complete it before the manuscript is sent out for review.

The manuscript is sent out for review. The reviewer reads and evaluates the manuscript and eventually sends a review report to the Chief Editor. The time for review can be set to 2-6 weeks depending on the discipline (more time is usually given to papers in the humanities and social sciences). Make sure to provide the reviewer with clear instructions for the work, e.g. outlined in the form of a Review report or a number of questions to be considered.

Based on the reviewers' comments the Chief Editor makes a decision to:

- Accept the manuscript without further revision
- Accept after revision
- Ask authors to resubmit
- Reject

An acceptance letter is sent to the author and the final manuscript is forwarded to production. Sometimes, the authors are requested to revise in accordance with reviewers' comments and submit the updated version or their manuscript to the Chief Editor. The time for review can be set to 2-6 weeks depending on the discipline and type of additional data, information or argument required. The authors are requested to make substantial revisions to their manuscripts and resubmit for a new evaluation. A rejection letter is sent to the author and the manuscript is archived. Reviewers might be informed about the decision.

After review a manuscript goes to the Copy Editor who will correct the manuscript concerning the correct referencing system, confirmation with the journal style and layout. When Copy Editor finishes his/her work they send manuscripts to the Layout editor.

Layout Editor is responsible for structuring the original manuscript, including figures and tables, into an article, activating necessary links and preparing the manuscript in the various formats, in our case PDF and HTML format. When Layout Editor finishes his/her job they send manuscripts to Proof Editor.

Proof Editor confirms that the manuscript has gone through all the stages and can be published.

This issue has 19 articles (15 Original researches and 4 Review articles). Our future plan is to increase the number of quality research papers from all fields of science, engineering and education. The editors seek to publish articles from a wide variety of academic disciplines and substantive fields; they are looking forward to substantial improvement of educational processes and outcomes.

Editor in Chief
Assoc. prof. Dr. Lazar Stošić, Research Associate

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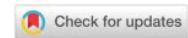
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Exploring Influential Factors and Conditions Shaping Statistical Literacy Among Undergraduate Students in Mathematics Education

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Abstract: Statistical literacy (hereafter SL) has been considered an important learning outcome in statistics learning in higher education, yet studies that focus on investigating the factors and conditions that influence students' SL, especially mathematics education students, are still limited. This study seeks to uncover the factors and conditions that significantly contribute to the SL of mathematics education students. This survey study involved 1,287 mathematics education students from 21 higher education institutions in Indonesia. Linear regression analysis involving four predictor variables (i.e., gender, status of higher education institution, laptop ownership, and research preference) was performed to determine the variables that contributed significantly in predicting SL achievement. The results revealed that gender, higher education institution's status, and laptop ownership contributed significantly, but research preference was not significant in predicting mathematics education students' SL. Furthermore, laptop ownership was found to have the highest contribution in predicting mathematics education students' SL. All findings and their implications are discussed.

Keywords: *gender, laptop ownership, mathematics education, research preference, statistical literacy, status of higher education institution.*

Introduction

Given that the world is developing so rapidly and complexly, students need to be facilitated to master fundamental skills to deal with daily life and various complex challenges and build character (intrapersonal and interpersonal) needed in dealing with dynamic environments. These fundamental skills are associated with the term 'literacy' whose meaning has expanded beyond simply referring to the skills of reading and writing effectively in a variety of contexts (Pilgrim and Martinez, 2013; Watson and Callingham, 2003). In addition to the expansion of meaning, literacy has also developed in terms of types based on the combination of literacy and a particular specialised discipline or field (Gal, 2002) to keep up with the challenges of an increasingly complex world. Among the types of literacy developed in the last two decades, such as mathematical literacy, ICT literacy, and cultural and civic literacy, we are more interested in exploring SL further. Although SL is considered as one of the new literacies needed along with the development of ICT which has led to the availability of large data and the rapid and wide distribution of data in the last decade, the term SL has in fact been introduced since 1979 by Haack. SL was introduced by Haack (1979a, 1979b) as a form of his concern for statistics which was positioned more as a research tool than as a language. As a result, statistics learning is only focused on facilitating students to remember formulas and the use of these formulas without understanding the meaning, so that students do not experience progress after participating in statistics learning, where they still cannot better understand the statistics they encounter in the media. Thus, this SL implicitly leads to positioning statistics as a language and is interpretive rather than calculative so that students who have adequate

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statistical literacy competence can apply the statistical principles they learn to the statistics they encounter in everyday life (Haack, 1979b).

SL then continues to evolve and receive increasing attention from researchers so that various meanings of SL have been offered – no consensus has been reached on the meaning of SL. Of the various narrow and broad meanings of SL, SL is seen as a key competency that refers to the ability to interpret, critically evaluate, and communicate statistical data, statistical information, or arguments contained in various forms of media in the context of everyday life (Gal, 2002; Kurnia et al., 2023; Schield, 2010; Sharma, 2017; Wallman, 1993). The prerequisite for a person to have behaviours that reflect statistical literacy is that the person masters the knowledge or understanding and fundamental competencies that include the symbols, concepts, terms, and language of statistics and mathematics (Gal, 2003; Rumsey, 2002) and is able to apply them (Gal, 2002). Given the significance of SL, it makes sense that existing studies (e.g., Carvalho and Solomon, 2012; Chick & Pierce, 2012, 2013; Gal, 2002; Kurnia et al., 2023; Sharma, 2017) have widely recognised that being statistically literate is not only essential for students, but also for everyone as individuals or as part of society, both in professional and social life. The importance of being statistically literate is again inseparable from the demands of the development of information technology that allows us to obtain, process and disseminate data and information for various purposes, such as making decisions and policies (Chick and Pierce, 2012, 2013; Gal, 2002; Sharma, 2017).

Given the importance of students and adults being statistically literate, a number of efforts to promote statistical literacy have been made by previous studies ranging from secondary school to higher education (Aksoy and Bostan, 2021; Forgasz et al., 2022; Yotongyos et al., 2015). Such efforts can certainly be based on aspects or components of SL, the results of studies that focus on investigating the achievements of SL so as to detect which aspects need more attention, and the results of studies that focus on investigating the factors that directly or indirectly influence SL. A number of studies focusing on the latter have successfully identified factors that potentially influence (Aizikovitsh-Udi and Kuntze, 2014; Aziz and Rosli, 2021; Carmichael et al., 2009; MacFeely et al., 2017) and that affect (Lukman and Wahyudin, 2020; Pamungkas and Khaerunnisa, 2020; Sproesser et al., 2014) SL. Based on literature reviews, systematic reviews, and interview studies that researchers have conducted, they suggest critical thinking (Aizikovitsh-Udi and Kuntze, 2014), student demographics, learning environment, student attitudes, basic knowledge and skills in statistics (Aziz and Rosli, 2021), interest or attitude towards statistics (Carmichael et al., 2009), and learning support including the application of specific learning models and the use of technology (Aziz and Rosli, 2021; MacFeely et al., 2017) as factors considered vital in influencing SL.

From the empirical studies we have identified, some of the factors that influence students' SL are socio-economic status, general cognitive abilities, and knowledge of specific content in mathematics especially those related to probability and functional reasoning (Sproesser et al., 2014). From their findings, Sproesser et al. (2014) recommended future studies to investigate the extent to which students' socio-economic status can explain the diversity of their SL. In another empirical study conducted by Lukman and Wahyudin (2020) which focused on investigating the factors influencing the SL of undergraduate students in terms of aspects or components of SL, fundamental knowledge in mathematics and statistics and adequate language skills acted as these factors. Prior knowledge and mathematical self-esteem have also been reported to be two factors that influence students' SL (Pamungkas and Khaerunnisa, 2020). Another study indicated that grade level affects the SL of high school students (Kurnia et al., 2023); although there were also studies (e.g., Yolcu, 2014) that reported the insufficient influence of grade level on students' SL.

When it comes to SL, we struggled to find sufficient studies that reveal the factors that influence and cause the differences in SL achievement. This is in contrast to when it comes to literacy achievement in mathematics – one of the focuses in the OECD's Programme for International Student Assessment (PISA) – and achievement in statistics. Extensive empirical studies have identified various factors that influence students' mathematical literacy achievement. The PISA 2018 results have suggested that immigrant background, gender, and the socio-economic status of students' families and schools have been factors that influence students' achievement in mathematical literacy across countries (OECD, 2019). Meanwhile, Wang et al. (2023) through a systematic literature review of 156 empirical studies have successfully identified 135 factors that contribute to influencing student achievement in mathematical literacy in PISA, where these factors are then categorised into five levels: individual student as level 1, household context as level 2, school community as level 3, education system as level 4, and macro society as level 5. One of

the results revealed from the systematic study of Wang et al. (2023) at level 1 is that although the influence of gender on students' mathematical literacy achievement has been extensively investigated, the results in this regard are still mixed in a number of countries. Mixed results were also found on the factor of students' experience in using ICT. At level 2, the study conducted by Wang et al. (2023) indicates that the factor of ICT availability at home has received relatively little attention by previous studies compared to other factors at level 2. Previous studies show mixed results regarding the effect of ICT availability at home on students' mathematical literacy – some show a positive effect, while others show a negative or insignificant effect. Furthermore, among the three factors most investigated by previous studies at level 3, the effect of school type (i.e., private or public) on students' mathematical literacy is the most diverse than socio-economic status (SES) composition and school location (Wang et al., 2023).

It has been mentioned earlier the importance of mastering two things, namely fundamental knowledge in statistics and statistical reasoning, in order to be statistically literate. Both of these can be reflected by students' achievements in statistics, where one of the factors that affect students' achievements in statistics is their perception or attitude towards statistics (Emmioğlu and Capa-Aydin, 2012; Ncube and Moroke, 2015; Ramirez et al., 2012). In addition, perceptions or attitudes towards statistics can also influence undergraduate students in determining the preference of the research method or approach they will choose, whether it is more quantitative or qualitative (Dani and Al Quraan, 2023). When students have negative perceptions or attitudes towards statistics due to various factors including the view that statistics overemphasises numerical and technical activities in their experience in dealing with mathematics and statistics during high school, they tend to avoid quantitative research (Dani and Al Quraan, 2023) and prefer qualitative research. Their aversion to quantitative research may also reflect their reluctance to engage in learning related to statistics, so it could possibly hinder their opportunity to develop their SL. However, how much students' preference for research methods or approaches contributes to their SL is still under-investigated. Therefore, in this study, we endeavour to shed light on the extent to which research method or approach preferences contribute to students' SL, including how the potential of gender, higher education institution's status, and laptop ownership to explain students' SL. In detail, this study focused on answering the following two research questions (RQs).

RQ1: How is the SL profile of undergraduate students in mathematics education programme in terms of gender, higher education institution's status, laptop ownership, and research preference?

RQ2: What factors and conditions significantly predict the SL of undergraduate students in mathematics education programme?

Statistical Literacy and Statistical Literacy of Undergraduate Students

It cannot be denied that SL is considered important to have in the midst of the massive distribution of data and information containing statistics which brings its own opportunities and challenges. Various meanings of SL have been offered by the literature, where the diversity concerns what competencies build SL and what content needs to be the focus in SL. By Wallman (1993), SL is interpreted as a competency built by cognitive abilities in the form of understanding and critically evaluating statistical results in people's daily lives and the ability to appreciate the role of statistical thinking to solve problems and make decisions in various contexts of daily life. It is implied that to be statistically literate which is demonstrated through the ability to critically evaluate, one must first have an adequate understanding of the underlying concepts or ideas associated with these statistical results. The basic idea of grouping the skills that build SL into cognitive and affective elements is also offered by Gal (2002), where according to him, SL is a competence composed of skills that support each other which can be grouped into knowledge and dispositional elements. The skills in the knowledge element include general literacy skills – the ability to read and interpret data, information, or readings in various forms and contexts and communicate what has been read and interpreted clearly, basic knowledge of statistics and mathematics, basic knowledge related to various contexts in everyday life, and critical thinking skills (Gal, 2002). Meanwhile, the dispositional elements of SL include attitudes and beliefs to engage in statistical thinking for various purposes and having the willingness to think critically about information that contains statistics despite having no formal learning experience in statistics or mathematics (Gal, 2002).

The idea that Wallman puts forward that places an important role on understanding basic statistical concepts as the foundation of SL is in line with some of what Watson (1997), Sharma (2017), and Gonda et

al. (2022) stated in presenting the meaning of SL. According to them, SL in addition to being built by higher order cognitive skills (i.e., interpreting, making predictions, thinking critically) is also built by basic skills or lower order cognitive skills consisting of understanding basic concepts, symbols, and terminology in numeracy, mathematics, probability, and statistics and general literacy skills (i.e., reading, understanding what is read, and communicating what is understood from reading). The meaning of SL in more detail is conveyed by [Watson \(2006\)](#), where the meaning of SL does not only emphasise on the components of the skills that build SL but also on the components of the topic, context, motivation, and task form that encourage someone to demonstrate their SL. Based on the components of SL that [Watson \(2006\)](#) provides and the interaction between these components, SL refers to the mathematical or statistical skills and literacies that a person demonstrates when faced with a task whose context relates to variation, data collection including sampling, presentation of data in various representations, averaging, chance, and inference. The task requires the person to choose the best among a number of options or provide a range of alternative possible solutions. The meaning of SL that [Watson \(2006\)](#) put forward aligns with that of [Gonda et al. \(2022\)](#) mentioned that some of the skills that make up SL, especially the basic skills, are working with data which includes organising data, presenting data into various representations, and using these various data representations for specific purposes.

Based on the meanings of SL that we have found in the literature, we agree with those mentioned by [Kurnia et al. \(2023\)](#) that SL includes the skills involved when one provides data or information for others to use or receives data from others to use for a specific purpose. The skills involved in producing data include the skills to ask questions (e.g., what to investigate, what problems to answer, and what is needed), collect data, analyse data, and interpret the results of the data analysis. Meanwhile, the skills involved when one uses or receives data may include describing the data, organising the data so that one can determine what is important, analysing the data, interpreting or evaluating the data, and critiquing the data received. These skills are ultimately inseparable from the skill of communicating what has been gained from working with data. Furthermore, all the skills we have mentioned are again based on an understanding of context, representation, and basic knowledge of statistics and mathematics ([Gal, 2002](#); [Gonda et al., 2022](#); [Watson, 1997, 2006](#)). An understanding of the basic knowledge of statistics required to be statistically literate includes the rationale and techniques or methods of data collection, descriptive statistics, data presentation and interpretation, basic notions of probability, and statistical inference. Thus, based on the meaning of SL that we described based on the literature, we conclude that SL is the skill of applying an understanding of basic ideas about statistics (and probability) supported by an understanding of basic ideas in mathematics, interpreting statistical data and information, communicating statistical data and information in various forms effectively, and critically evaluating the results of data analysis or inference in various contexts and basic topics in statistics (and probability).

Previous studies have attempted to investigate the extent of students' SL at the secondary school level ([Aksoy and Bostan, 2021](#); [Kurnia et al., 2023](#); [Utomo, 2021](#)) to higher education ([Forgasz et al., 2022](#); [Hassan et al., 2020](#); [Lukman & Wahyudin, 2020](#); [Setiawan and Sukoco, 2021](#); [Yotongyos et al., 2015](#)). When it comes to undergraduate students, we found limited studies exploring the extent of their SL attainment. One of the studies that focused on undergraduate students was a study conducted by [Setiawan and Sukoco \(2021\)](#) with the aim of uncovering the SL of 39 first-year undergraduate students in a statistics study programme at a public higher education institution in terms of their skills in describing and visualising data. This study reported that the SL level of students in general could already be categorised as high in terms of skills in describing data, while in terms of skills in visualising data, the SL level of students was still in the medium category.

In another study (i.e., [Hassan et al., 2020](#)) involving 360 undergraduate students in their eighth semester from programmes in applied science and social science disciplines, it was revealed that their SL in terms of statistical symbols, central tendency, descriptive and inferential statistics, and elements of data analysis in SPSS programme were overall at a low level. Although the study descriptively showed that students from applied science programmes had better SL than those from social science programmes, there was no statistically sufficient evidence that the achievements of students from the two disciplines were different or that one was superior to the other. In addition, involving 114 undergraduate students from mathematics and mathematics education programmes and using the SL framework proposed by [Gal \(2002\)](#), [Lukman and Wahyudin \(2020\)](#) found that students' SL was already at a satisfactory level and found that the SL achievement of students who had taken elementary statistics was significantly better

than those who had not. By also using the SL concept that Gal (2002) proposed which divides SL into knowledge and dispositional components, Yotonyos et al. (2015) reported that the overall SL of 103 undergraduate students in the faculty of education at a public higher education institution was moderate.

Potential Factors and Condition Contributing to Statistical Literacy

Many previous studies have attempted to investigate the factors that might influence student learning outcomes in primary to higher education and that might lead to differences in outcomes between one group and another. In science and mathematics, including statistics, gender – the biological difference of being male or female (El Refae et al., 2021) – has been recognised as one such factor (Meinck and Brese, 2019; Wang et al., 2023). Student learning outcomes in terms of gender show mixed results (Yolcu, 2014), both in small-scale and large-scale assessments. Some studies demonstrate that male students significantly outperform female students, but others show the opposite (Meinck and Brese, 2019; OECD, 2019; Wang et al., 2023). However, there are also studies that do not show sufficient evidence that the achievement of one group is superior to the other in terms of gender (Arroyo-Barrigüete et al., 2023). Studies focusing on literacy in mathematics – part of SL – of students aged around 15 years report that male students perform better than female students (OECD, 2019), although this is not uniform across countries in the world as reported in the study by Wang et al. (2023). Nevertheless, some studies that directly focus on SL leading to students' skills in understanding, interpreting and communicating data show that female students outperform male students (Risqi and Ekawati, 2020; Yolcu, 2014). Another study conducted by Kurnia et al. (2023) showed that there was no significant difference in students' SL achievement in terms of gender. Based on the results of these studies, it can be said that the influence of gender on students' SL achievement and differences in students' SL achievement in terms of gender still need to be explored further considering that there is still an opportunity to obtain different results depending on various contexts, including research subjects.

It is believed that the status of a school or higher education institution, public or private, also has an influence on student achievement. The main distinction between public and private higher education institutions is in terms of funding sources. This distinction is considered to contribute to differences in the provision of learning opportunities and facilities to students, which in turn may lead to differences in student achievement. Previous studies, however, have reported inconsistent results on the consequences of differences in the status of higher education institutions on student outcomes as reported by Wang et al. (2023) who focused on literacy in mathematics. A number of studies reported a significant difference in students' literacy achievement in terms of school status, where students from private schools outperforming those from public schools (Cheema, 2015, 2016). However, it is still unclear how the SL achievement of students from public higher education institutions differs from those from private.

The use of technology in learning has been widely shown by previous studies (e.g., Kristanto, 2018; Liestari and Muhandis, 2021; Rusilowati et al., 2022) to support students' learning process, which in turn can promote learning achievement. The availability of access to technology such as laptops or computers allows students to be able to gain the potential offered by the technology when it is used optimally, which can develop problem-solving skills, communication, and conduct research through searching for important information relevant to the research being carried out (Kposowa and Valdez, 2013). When students have widespread access to technological devices such as laptops, they are likely to have a better chance than those without laptops of using their time flexibly to optimise their learning, such as doing homework, conducting research, and reading study materials (Reisdorf et al., 2020). The presence of technological advances that occur today has the consequence that the use of technology in learning is inevitable, especially in higher education, where the use of laptops is considered an integral part of the learning culture in the classroom. On the one hand, this phenomenon is certainly an opportunity that should be utilised, but on the other hand, by Reisdorf et al. (2020) it is considered to bring its own challenges for those who do not have a laptop. It is clear that the ownership of technological devices such as laptops will have an influence on students' learning and their learning achievement, especially when the role of laptops has become an integral part of learning.

In mathematics and statistics learning, ownership of a laptop can also lead to differences to a varied degree in learning opportunities that students receive and in students' learning achievement. A number of studies (e.g., Kposowa and Valdez, 2013; Papadakis et al., 2016) have suggested that when

technological devices such as laptops are used appropriately, including with teacher guidance, to conduct mathematical or statistical exploration activities through applications available on laptops and access any relevant information that students learn using the internet, it will provide greater opportunities for students to be able to more easily understand concepts that are abstract in nature than when they do not use laptops. Other studies (e.g., [Wittwer and Senkbeil, 2008](#)) have also implicitly demonstrated the effect of home computer use on students' mathematics achievement. In contrast to most studies that show a large effect of home computer use on students' academic performance at school such as mathematics achievement, [Wittwer and Senkbeil's study \(2008\)](#) shows the frequency of computer use and how it is used by students has little impact on their mathematics achievement. Such mixed results are influenced by a variety of factors such as the context of the country in which the study was conducted and the educational level of the students involved in the study ([Wang et al., 2023](#)). [Wittwer and Senkbeil's study \(2008\)](#) suggests that the computers students own can have a greater impact on their mathematics achievement depending on the students' skills in using the computers and the problem-solving and higher-order thinking activities that teachers facilitate in the classroom using the computers or laptops. To date it remains unknown whether laptop ownership can lead to differences in undergraduate students' SL achievement and to what extent laptop ownership supports undergraduate students' SL.

Lastly, one's research preferences (i.e., qualitative and quantitative) clearly influence one's development as a researcher, such as motivation to conduct specific research method and attitude towards research ([Gonulal, 2018](#); [Nenty, 2009](#)). Researchers who embrace a more quantitative research orientation may wish to develop themselves in areas related to statistical methods, and engage in more quantitatively orientated research ([Gonulal, 2018](#)). Quantitatively-orientated students are likely to take more statistics courses and do more self-training in statistics ([Gonulal, 2018](#)). On the other hand, those who have tended to avoid their orientation towards quantitative research, or tended to be orientated towards qualitative research methods, it is possible that they have difficulties in learning quantitative or empirical research methods ([Nenty, 2009](#)). In this regard, because learning quantitative or empirical research methods can be associated with learning statistics, there are indications that those who are more orientated towards qualitative research or have a negative view of quantitative research tend to struggle more in learning statistics. This implicitly leads to the hypothesis that there will be differences in students' SL achievement, where those who favour quantitative research are likely to perform better in statistics than those who favour qualitative research.

Materials and Methods

Design of the Study

This survey study ([Check and Schutt, 2012](#)) focused on uncovering the factors and conditions that are thought to influence mathematics education students' SL attainment. A total of four predictor variables have been selected to test their contribution in predicting the SL of mathematics education students. The four predictor variables are gender, higher education institution's status, laptop ownership, and research preference. In order to capture information related to students' SL achievement and the predictor variables that influence it, we administered a survey to mathematics education students who were taking or had taken Elementary Statistics course or its equivalent course. Although the survey could be accessed online, the administration of the survey was still carried out in the classroom or computer laboratory directly supervised by the survey supervisor. This is to ensure that the responses obtained are accurate and truly represent the actual condition of the participants.

Participants

A total of 1,287 undergraduate students in their first to tenth semesters from mathematics education programmes participated in completing the SL survey in this study. They were taking or had taken Elementary Statistics, Introduction to Statistics, Educational Statistics, or equivalent course. Participants were spread across 21 higher education institutions (university, college, or institute) selected through convenience sampling technique ([Edgar and Manz, 2017](#)). This technique was chosen because it is relatively cheap, less time-consuming, and simple ([Stratton, 2021](#)). In addition, this sampling technique

was also used with the consideration that the results of this study could contribute to developing potential hypotheses or references for further studies that are more rigorous (Stratton, 2021).

Table 1. *Description of participants (n = 1,287)*

Variable	n (%)
Gender:	
Male	227 (17.6)
Female	1060 (82.4)
Higher education institution's status:	
Public	1053 (81.8)
Private	234 (18.2)
Laptop ownership:	
Yes	1011 (78.6)
No	276 (21.4)
Research preference:	
Quantitative	867 (67.4)
Qualitative	420 (32.6)

The institutions were divided into two status categories, namely public ($n = 15$) and private ($n = 6$). In addition, the institutions were also divided into three area categories based on time zones in Indonesia, namely western area ($n = 11$), central area ($n = 7$), and eastern area ($n = 3$). The higher education institutions involved in this study were mostly in the western area because most higher education institutions in Indonesia are located in the western area. The participants in this study were mostly female students and came from public higher education institutions. Table 1 presents description in detail of the participants involved in this study.

Instrument and Data Collection

We developed an online survey to capture information related to SL of mathematics education students and the factors and conditions that influence it. The online survey consisted of two parts. The first part captured information related to students' higher education institution where the student studies, gender, laptop ownership, and research preference. The second part was a test used to measure the SL of mathematics education students. In this study, the test to measure SL was developed based on the aspects and their respective descriptions that were derived based on the results of the literature review (e.g., Gal, 2002; Gonda et al., 2022; Sharma, 2017; Watson, 2006) (see Table 2). Besides considering the aspects and indicators in Table 2, the SL test also focused on the core content of elementary statistics. We used four basic statistical contents in the SL test, namely sampling techniques and probability, data presentation (i.e., tables, diagrams, and graphs), descriptive statistics (i.e., measures of central tendency and dispersion), and inferential statistics (i.e., t -test, correlation, regression, and analysis of variance). Thus, a total of 20 multiple-choice items with four options were used to measure the SL achievement of mathematics education students. Before being used for data collection, the SL test was first sent to three reviewers for collecting feedback. They were experts in statistics education, statistics, and educational measurement. They were asked to provide suggestions and assessments of the correctness of the substance and quality of the SL test items. All feedback from reviewers was accommodated to improve the quality of SL test. The test reliability estimate obtained Cronbach's $\alpha = .612$. Although the reliability coefficient is not very high, the test is reliable enough (Reynolds et al., 2010; Rudner and Schafer, 2002; Taber, 2018) or it can be regarded as having moderate reliability (Taber, 2018) to measure the SL of mathematics education students.

Table 2. Indicators of SL and their descriptions

Aspect	Description	Item
Application of statistics concepts (Application)	Able to apply basic concepts of statistics in various contexts	1, 6, 11, 16
	Understand the use of various simple statistical symbols	
Interpretation of statistical data and information (Interpretation)	Able to read and interpret tables, graphs and charts accurately	2, 3, 7, 8, 12, 13, 17, 18
	Identify trends, patterns, and outliers in data	
	Draw accurate conclusions from data and hypothesis testing results	
Communication skills (Communication)	Able to effectively communicate important statistical findings to an audience	4, 9, 14, 19
	Able to present information using visual aids to enhance understanding	
Critical evaluation (Evaluation)	Able to assess the credibility and reliability of statistical claims	5, 10, 15, 20
	Able to make effective decisions based on data	
	Recognise data limitations and potential biases	

We used Zoho Survey (<https://www.zoho.com/id/survey/>) to distribute the online survey to mathematics education students. Data collection through the online survey was conducted during October 2023. We recruited mathematics education lecturers at the higher education institutions selected for the sample to administer and supervise the survey at their institutions. To ensure that data collection was conducted in an honest manner, we invited all recruited lecturers to attend a technical briefing on the rules for conducting the survey. The recruited lecturers were given the responsibility to conduct data collection in their respective institutions honestly. Students completed the survey by accessing the survey link and password shared by our recruited lecturers. Students could access the survey via their laptops or smartphones. In order for the survey to run smoothly, we required that the survey be completed in the classroom and guided and supervised directly by the lecturers we have recruited. Completing the survey could also be done in the computer labs owned by each higher education institutions that we have selected as a sample. Students were expected to take about 5 minutes to complete their personal data on the survey. Meanwhile, the time provided to answer the SL test is a maximum of 45 minutes. To anticipate students answering the SL test carelessly, we set a minimum time to complete the SL test. Students could not submit their answers if they have not passed 25 minutes. In taking the SL test, students were not allowed to collaborate with other students and use a web browser other than to access the survey and take the SL test. In addition, students were not provided with a piece of paper to do calculations because in the SL test students did not need to do any calculations.

Data Analysis

After the data collection process, we conducted data verification to remove duplicate responses and incomplete responses. Data on gender, the higher education institution where the student studies, laptop ownership, and research preference were binary coded. For gender, code 1 for male and code 0 for female. For the higher education institution where the student studies, code 1 was given if the student was from a public higher education institution and code 0 for a student from a private higher education institution. For laptop ownership, code 1 was given for students who own a laptop and code 0 for students who do not own a laptop. Meanwhile, for the research preference, code 1 was assigned for students who chose quantitative and code 0 was assigned for students who chose qualitative. These binary codes were used to describe the SL achievement of mathematics education students in terms of each code.

We assigned a score of 1 for the correct answer on each SL test item. Thus, respondents will obtain a maximum score of 20 if they can answer all SL test items correctly. A score of 0 is given for each item answered incorrectly and there is no penalty (point deduction) for each incorrect answer. The total score of each respondent was then used to describe the SL profile of mathematics education students in general and based on the four aspects of SL (i.e., application, interpretation, communication, and critical evaluation). The SL scores were then cross-tabulated with the variables of gender (male vs. female), status of higher education institution (public vs. private), laptop ownership (yes vs. no), and research preference (quantitative vs. qualitative). This cross tabulation was conducted to compare students' SL score achievement in terms of the category of each variable. An independent sample *t*-test procedure was conducted to test the significance of differences in mean SL scores in terms of gender, higher education institution's status, laptop ownership, and research preference. The *t*-test was conducted by first providing

evidence that the statistical literacy score data was normally distributed (skewness = 0.012, $SE_{\text{skewness}} = 0.068$, kurtosis = -0.258, $SE_{\text{kurtosis}} = 0.136$) and evidence that there was no significant difference in the variance of statistical literacy scores between the two groups by gender ($F = 0.959$, $p = .328$), higher education institution's status ($F = 0.683$, $p = .409$), laptop ownership ($F = 0.219$, $p = .64$), and research preference ($F = 0.699$, $p = .403$). Lastly, we used linear regression analysis to investigate the variables that contributed significantly in predicting the SL level of mathematics education students. We conducted this linear regression analysis on the basis that the assumption of collinearity has been confirmed in regard to gender (VIF = 1.01, Tolerance = 0.995), status of institution (VIF = 1.03, Tolerance = 0.974), laptop ownership (VIF = 1.03, Tolerance = 0.971), and research preference (VIF = 1.00, Tolerance = 0.996) and autocorrelation was not a concern (autocorrelation = 0.123, Durbin-Watson = 1.75). All statistical tests used a significance level of 5%.

Results

A total of 1,287 mathematics education students participated in this study. First, we report the SL profile of mathematics education students in general and by gender, higher education institution's status, laptop ownership, and research preference. Afterwards, we report the results of regression analysis to reveal the variables that significantly contribute to predicting the SL of mathematics education students.

SL Profile of Mathematics Education Students

Table 3 presents descriptive statistics of SL of mathematics education students in general and based on SL aspects. In general, the mean score of SL of mathematics education students is not satisfactory. Based on four aspects of SL, the mean score of the interpretation is the highest, while the mean score of the critical evaluation is the lowest. Furthermore, when it comes to the variance of students' SL scores based on the aspects of SL, students' scores on the interpretation aspect were the most varied compared to the other three aspects.

Table 3. Descriptive statistics of SL of mathematics education students ($n = 1,287$)

Aspect of SL	M (SD)	Min.	Max.
Application	1.70 (0.96)	0	4
Interpretation	3.96 (1.48)	0	8
Communication	1.63 (0.87)	0	4
Evaluation	1.47 (1.02)	0	4
Score of SL	8.76 (2.70)	0	17

SL Profile of Mathematics Education Students Based on Gender

The SL profile of mathematics education students in terms of gender (male vs. female) is summarised in Table 4. The results presented in Table 4 demonstrate that both male and female students performed the best in the interpretation aspect compared to the other three aspects. In addition, male students outperformed female students in every aspect of SL and the overall SL. Furthermore, through inferential analysis, the current study revealed that the mean score of SL of male and female students differed significantly ($t(1285) = -3.913$, $p < .01$), where SL scores of male students were higher than female students. On the application aspect, the mean score of male and female students was not significantly different ($t(1285) = -0.512$, $p = .608$). In the interpretation aspect, the mean score of male students is significantly higher than female students ($t(1285) = -2.361$, $p = .018$). On the communication aspect, there was no difference in mean score of SL between male and female students ($t(1285) = -1.746$, $p = .081$). On the critical evaluation aspect, this study found that the mean score of male students was higher than female students ($t(1285) = -4.944$, $p < .01$).

Table 4. Descriptive statistics of SL of mathematics education students based on gender

Aspect of SL	Male (n = 227)			Female (n = 1060)		
	M (SD)	Min.	Max.	M (SD)	Min.	Max.
Application	1.73 (0.93)	0	4	1.70 (0.97)	0	4
Interpretation	4.17 (1.54)	0	8	3.92 (1.46)	0	8
Communication	1.72 (0.86)	0	4	1.61 (0.87)	0	4
Evaluation	1.78 (1.06)	0	4	1.41 (1.00)	0	4
Score of SL	9.40 (2.84)	0	17	8.63 (2.65)	0	16

Statistical Literacy Profile Based on Status of Higher Education Institution

The SL profile of mathematics education students based on the higher education institution's status (public vs. private) is summarised in Table 5 indicating that students from both public and private higher education institutions performed best in interpretation and performed poorest in evaluation. Students from public higher education institutions in general out-performed those from private higher education institutions. The performance of students from private higher education institutions was slightly better than those from public higher education institutions, although in the other three aspects of SL those from public institutions were superior.

Table 5. Descriptive statistics of SL of mathematics education students based on higher education institution's status

Aspect of SL	Public (n = 1053)			Private (n = 234)		
	M (SD)	Min.	Max.	M (SD)	Min.	Max.
Application	1.70 (0.97)	0	4	1.69 (0.94)	0	4
Interpretation	4.02 (1.46)	0	8	3.67 (1.52)	0	7
Communication	1.62 (0.86)	0	4	1.64 (0.88)	0	4
Evaluation	1.52 (1.03)	0	4	1.28 (0.94)	0	4
Score of SL	8.87 (2.71)	2	17	8.27 (2.59)	0	15

This study revealed that the mean SL scores of students from public and private higher education institutions were significantly different ($t(1285) = 3.091, p < .01$), where the SL scores of students from public higher education institutions were higher than private higher education institutions. In the application aspect, the mean score of students from public and private higher education institutions is not significantly different ($t(1285) = 0.239, p = .811$). In the interpretation aspect, the mean score of students from public higher education institutions is significantly higher than private higher education institutions ($t(1285) = 3.391, p < .01$). On the communication aspect, there was no difference in mean score between students from public and private higher education institutions ($t(1285) = -0.190, p = .850$). In the critical evaluation aspect, this study found that the mean score of students from public higher education institutions was significantly higher than private institutions ($t(1285) = 3.190, p < .01$).

Statistical Literacy Profile Based on Laptop Ownership

The SL profile of mathematics education students based on laptop ownership (yes vs. no) is summarised in Table 6. Table 6 indicates that ownership of a laptop offers more opportunities to perform better in SL, including in every aspect of SL, than those who do not own a laptop.

Table 6. Descriptive statistics of SL of mathematics education students based on laptop ownership

Aspect of SL	Has a laptop (n = 1011)			Has no laptop (n = 276)		
	M (SD)	Min.	Max.	M (SD)	Min.	Max.
Application	1.74 (0.95)	0	4	1.56 (0.10)	0	4
Interpretation	4.10 (1.46)	0	8	3.46 (1.45)	0	7
Communication	1.64 (0.85)	0	4	1.58 (0.91)	0	4
Evaluation	1.56 (1.02)	0	4	1.14 (0.95)	0	3
Score of SL	9.04 (2.64)	2	17	7.75 (2.65)	0	14

This study also found that the mean score of SL of students who own a laptop is significantly different from students who do not own a laptop ($t(1285) = 7.219, p < .01$). In terms of application, the mean score of students who have laptops is significantly higher than students who do not have laptops ($t(1285) = 2.812, p < .01$). In terms of interpretation, the mean score of students who have laptops is also significantly higher than students who do not have laptops ($t(1285) = 6.413, p < .01$). However, in terms of communication, the mean score of students who own and do not own a laptop was found not significantly different ($t(1285) = 1.024, p = .306$). While in terms of communication aspect, the mean score of students who own a laptop is significantly higher than students who do not own a laptop ($t(1285) = 6.125, p < .01$).

Statistical Literacy Profile Based on Research Preference

The SL profile of mathematics education students based on research preference (quantitative vs. qualitative) is summarised in Table 7. Table 7 reports that those who favour quantitative research tend to have better SL performance, both overall and by aspects of SL, than those who favour qualitative research.

Table 7. Descriptive statistics of SL mathematics education students based on research preference

Aspect of SL	Quantitative (n = 1011)			Qualitative (n = 276)		
	M (SD)	Min.	Max.	M (SD)	Min.	Max.
Application	1.71 (0.95)	0	4	1.68 (0.98)	0	4
Interpretation	4.02 (1.48)	0	8	3.85 (1.47)	0	7
Communication	1.63 (0.84)	0	4	1.61 (0.91)	0	4
Evaluation	1.48 (1.02)	0	4	1.45 (1.02)	0	3
Score of SL	8.85 (2.68)	2	17	8.60 (2.73)	0	14

In this study, the mean score of SL of students who favour quantitative research was found to be not significantly different from that of students who favour qualitative research ($t(1285) = 1.547, p = .122$). The study also revealed that there was no significant difference in mean score between students who preferred quantitative and qualitative research in terms of application ($t(1285) = 0.476, p = .634$), interpretation ($t(1285) = 1.933, p = .054$), communication ($t(1285) = 0.436, p = .663$), and critical evaluation ($t(1285) = 0.470, p = .639$).

Factors and Conditions Affecting Statistical Literacy

In this study, we used four predictors to determine the factors and conditions that influence the SL of mathematics education students. We binary coded each predictor to perform linear regression analysis. The first stage of regression analysis involved all predictors. Simultaneously, all four predictors significantly contributed to the SL achievement of mathematics education students ($F(4, 1282) = 20.042, p < .001$), but these four predictors only had a coefficient of determination $R^2 = 0.059$. This indicates that the four predictors used can only explain about 5.9% of the variation in the statistical literacy scores of mathematics education students. Table 8 presents the coefficients of the regression equation and the contribution of each predictor. Gender, higher education institution's status, and laptop ownership each contributed significantly in predicting the SL achievement of mathematics education students, but research preference was found not to contribute significantly.

Table 8. Regression coefficient involving all predictors

Predictors (Reference)	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	SE	β		
(Constant)	7.104	0.237		29.926	.000
Gender (Male)	0.878	0.192	0.124	4.573	.000
Institution's status (Public)	0.440	0.192	0.063	2.292	.022
Laptop ownership (Yes)	1.276	0.181	0.194	7.067	.000
Research preference (Quantitative)	0.213	0.156	0.037	1.365	.173

We then eliminated the insignificant predictor (i.e., research preference) from the regression model and re-analysed, and obtained the results as presented in Table 9. The three predictors simultaneously still contributed significantly in predicting the SL achievement of mathematics education students ($F(3, 1283) = 20.084, p < .001$). However, the coefficient of determination of these three predictors is $R^2 = 0.057$, meaning that they only explain about 5.7% of the variation in the SL scores of mathematics education students, while the rest (i.e., more than 90%) may be explained by other predictors. In addition, the three predictors, namely gender, higher education institution's status, and laptop ownership, each still made a significant contribution in predicting the SL achievement of mathematics education students. Although the contribution of these three predictors simultaneously only explains about 5.7% of SL achievement, laptop ownership has the highest contribution in predicting the SL achievement.

Table 9. Regression coefficient after removing insignificant predictors

Predictors	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	<i>p</i>
	<i>B</i>	<i>SE</i>	β		
(Constant)	7.247	0.213		33.997	.000
Gender (Male)	0.877	0.192	0.124	4.563	.000
Institution's status (Public)	0.428	0.192	0.061	2.233	.026
Laptop ownership (Yes)	1.289	0.180	0.196	7.148	.000

Discussions

This survey study sought to uncover how gender, higher education institution status, laptop ownership, and research preferences affect the SL attainment of mathematics education students. Firstly, our study found that there is a significant difference in the SL attainment of mathematics education students in terms of gender. This finding is consistent with the findings of previous studies (Cheema, 2015, 2016), but different from the findings of other studies (Kurnia et al., 2023; McLauchlan and Schonlau, 2016). This gender predictor was found to contribute significantly in predicting the SL achievement of mathematics education students. Based on our findings, males were predicted to have higher SL than females. This indicates that the current statistics learning curriculum tends to favour male students. This has an impact on the SL gap between men and women. Cheema (2015, 2016) explains that the existence of a literacy gap in terms of gender indicates that the education process has not been able to serve male and female students fairly. Referring to this argument, we believe that this also occurs in the learning process of statistics in mathematics education study programmes. Thus, this finding also encourages higher education institutions, especially mathematics education study programmes, to adjust the statistics learning curriculum in order to fairly develop the SL potential of both male and female students.

In terms of higher education institution's status, this study revealed that the SL achievement of students from public and private higher education institutions differed significantly. This finding is consistent with the findings of previous studies (Cheema, 2015, 2016). This indicates that there is a gap in students' SL in terms of higher education institution's status. Thus, this reveals the fact that there is still a gap in the statistics lecture process between public and private universities. In addition, the predictor higher education institution's status was found to have a significant contribution in predicting the SL achievement of mathematics education students. Our study reveals that students from public higher education institutions are predicted to have better SL than students from private higher education institutions. This finding encourages private higher education institutions to pay more attention to the quality of statistics learning in their institutions. Cheema (2016) asserts that learning in private educational institutions is more varied than public, where those with high economic status can obtain higher quality learning. Thus, it can be understood that students in private higher education institutions have not been thoroughly provided with equal services in learning statistics. This is strongly suspected to contribute to the differences in SL of mathematics education students. In addition, Cheema (2015) revealed that there may be three things that cause differences in student literacy between public and private institutions, namely

the ability to recruit qualified educators, differences in curriculum, and the availability of facilities, and infrastructure to support learning. We believe that these three factors are plausible causes of differences in SL of students from public and private higher education institutions.

In this study, we use the variable of laptop ownership to describe the economic status of students. Students who own a laptop represent middle to upper economic status, whereas students who do not own a laptop represent middle to lower economic status. Our findings revealed that the SL attainment of mathematics education students was also found to be significantly different between students who owned and did not own laptops. Unsurprisingly, this finding is consistent with several previous studies (Cheema, 2015, 2016) which revealed that there is a literacy gap in terms of students' economic status. The predictor of laptop ownership was also found to contribute significantly in predicting the SL achievement of mathematics education students. We found that students who own a laptop are predicted to have higher SL achievement than students who do not own a laptop. As stated by Cheema (2016), learners with socioeconomic status advantage can access higher quality education services. We believe that the different opportunities to gain access to better education between students with high and low economic status contribute to the development of SL of mathematics education students.

Unlike the other predictors, research preference (quantitative vs. qualitative) was found not to contribute significantly in predicting the statistical literacy achievement of mathematics education students. This finding is different from previous findings (Gonulal, 2018; Loewen et al., 2014). Although Gonulal (2018) stated that one's research orientation (i.e., qualitative or quantitative) will influence one's development as a researcher, or vice versa, this study did not find any differences in students' SL in terms of their chosen research orientation. Gonulal (2018) explained that researchers who adopt a quantitative research orientation tend to take more statistics courses, but our study did not find evidence that this had an impact on the SL achievement of mathematics education students. It should be noted that the studies of Loewen et al. (2014) and Gonulal (2018) were conducted in the context of Second Language Acquisition (SLA) so the sample characteristics in these two studies are clearly different from our study. Mathematics education students, although preferring qualitative research, are still required to take statistics courses, both at the basic and advanced levels, as offered by the study programme curriculum. Whereas students of non-statistics and non-mathematics study programmes, there is no such obligation. This is what we believe to be the cause of the absence of differences in SL achievement of mathematics education students in terms of their research choices.

Overall, this study managed to reveal three predictors that significantly influenced the statistical literacy achievement of mathematics education students, namely gender, higher education institution's status, and laptop ownership. However, these three predictors only explained about 5.7% of SL achievement. The contribution of these three predictors in predicting the SL achievement of mathematics education students is relatively small. This means that these three predictors are not the main predictors in predicting SL of mathematics education students. Although the contribution of these three predictors is small, these three predictors are still useful for predicting the SL achievement of mathematics education students. Compared to the other two predictors, laptop ownership has the largest contribution in predicting SL achievement. Without ignoring the contribution of the other two predictors, it seems that the issue of socio-economic status gap needs to get more serious attention to overcome the gap in SL achievement of mathematics education students. We present some recommendations in this regard in the implications section.

Implications for Practices and Policies

The gap in SL achievement in terms of gender, higher education institution's status, and laptop ownership indicates that the statistics learning curriculum in the mathematics education study programme has not been able to serve the SL development needs of all students. Reorganising the statistics learning curriculum is needed to overcome, at least reduce the gap. The existence of a statistics learning curriculum that is fair, equal, and able to facilitate students from all economic groups is believed to be able to provide new hope for the SL development of mathematics education students. The facility gap as one of the triggers of the SL gap is the responsibility of the authorities to provide equitable distribution of learning support facilities (for example, computer laboratories, statistics applications or software, and other statistics learning resources) for public and private institutions. For statistics educators, they are

expected to be able to design statistics learning and assessment that is fair for males and females and able to facilitate the learning needs of students from economically disadvantaged groups. Although the use of technology is inseparable in learning statistics (Austerschmidt et al., 2022; Koparan, 2019; Lloyd and Robertson, 2012; Sosa et al., 2011), it needs to be considered so that the use of technology does not become a problem for students from low economic backgrounds.

Limitations and Future Directions

The main limitation of this study lies in the non-random sampling technique. Although the number of respondents involved in this study is quite large and we have strived to consider the distribution of higher education institutions based on the coverage of regions in Indonesia, the generalisation of the research findings cannot fully reach all members of the population. Thus, in the future we encourage other researchers to conduct studies on this topic by applying random techniques in selecting research samples. In addition, we believe that the characteristics of mathematics education students between countries may differ. Therefore, we encourage studies in this area to also involve samples from various countries. The existence of new studies in this area involving a wider population is expected to be used as a consideration in making policies related to improving the SL achievement of mathematics education students. In addition, considering that the three predictor variables in this study can only explain a small part of the SL of mathematics education students, future studies are advised to explore other factors that have the potential to further explain students' SL. Given the study conducted by Kurnia et al. (2023) and the recent study by Wang et al. (2023) which showed that grade level has an impact on high school students' attainment, while the study by Yolcu (2014) suggested no significant impact of grade level on students' SL, what year a student is in university or college could be considered by future studies as one of these other factors.

Conclusions

This study offers results that contribute to efforts to promote SL in prospective mathematics teachers through the disclosure of factors that potentially affect SL achievement which include gender, higher education institution's status, and laptop ownership. Differences in gender, higher education institution's status, and laptop ownership cause a gap in SL achievement. Although the contribution of these three factors in predicting SL is small, these three factors are important to consider in designing curriculum and policies to improve the SL of mathematics education students. This study encourages the need to reorganise the statistics education curriculum so that it can facilitate all student characteristics in developing their SL. Based on the findings of this study, we also encourage other researchers to investigate other factors that are thought to contribute significantly in predicting the SL achievement of mathematics education students.

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Conflict of interests

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Author Contributions

Conceptualization, H.R. and K.H.; methodology, H.R. and E.A.; software, E.A., I.R. and M.N.R.; validation, H.R. and K.H.; formal analysis, E.A. and I.R.; investigation, E.A., I.R. and M.N.R.; resources,

H.R. and K.H.; data curation, E.A., I.R. and M.N.R.; writing—original draft preparation, E.A. and I.R.; writing—review and editing, H.R. and K.H.; visualization, I.R.; supervision, H.R.; project administration, M.N.R.; funding acquisition, H.R. and K.H. All authors have read and agreed to the published version of the manuscript.

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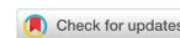
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The Effect of Primary School Teachers Using Online Education on Their Professional Creativity

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Abstract: This study aims to examine the effect of online education on the professional creativity of primary school teachers. The research was carried out in a mixed method. The study group of the research consisted of 319 primary school teachers who work in various primary schools in Zhetysu Region, Kazakhstan, and have online education experience. The data collection tools of the research were the teacher creativity scale, whose Kazakh language validity was provided by the researchers, and the semi-structured interview form. The analysis of the quantitative data of the research was carried out with SPSS 25 statistical program. Content analysis was performed for the analysis of the qualitative data of the studies. As a result of the research, it was determined that the creativity levels of primary school teachers were high. According to the seniority variable among primary school teachers, it was determined that the creativity levels of those with medium seniority were higher than the others. The vast majority of teachers stated that online education has a positive effect on professional creativity. The study recommends increasing the creativity level of primary school teachers, by establishing in-service training programs for all teachers, especially those who are in the first and last years of their professions.

Keywords: online education, primary school, professional creativity, teachers.

Introduction

Raising useful individuals for society is possible with a modern education perspective that starts in the early period (Harangus, 2021). One of the most important duties of teachers in the process of adopting this understanding is to make an effort to gain various skills and qualifications primarily for themselves and their students, and then to the society and environment they live in (Domingo and Gargante, 2016). In contemporary societies, teachers are not only mechanical officials responsible for education and training, but also role models who shed light on the society they live in (Dandashly et al., 2019). One of the most important learning goals is to encourage children to be creative. Effective participation of teachers is very important for the realization of this goal. Creativity is the first factor in the development of a society (Henriksen et al., 2017). Instructors must be attentively focused on creativity and have a thorough understanding of its definition and development to do this.

Theoretical and conceptual framework

Creativity is the ability to purposefully imagine an original product, to do something in different ways than anyone else, and to develop new ideas (Bereczki and Karpai, 2018). Creativity is also defined as a quality that emerges with unconventional thinking, original behavior, and products (Rubenstein et al., 2018). When creativity is perceived as a product of thought, it refers to the process of reconstructing

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ideas that have not been linked to meaning before. Considered an original behavior output, it is the reinterpretation of old experiences according to original behavior patterns (Perry and Karpova, 2017). Creativity is a process that includes features such as flexibility, multidimensional thinking, sensitivity, alertness to the environment and people, fluency, comfort, quick and independent thinking, originality, and reaching different and different results. Using data wisely, arranging it, solving problems with flexible approaches, and putting forth an original product, fluency in expressions are the characteristics inherent in creativity. The fact that all of these features can be developed through education increases the importance of creativity in education (Perry and Karpova, 2017; Tran et al., 2017). Creative thinking includes both intellectual, affective, and behavioral products. In the information age, it is of great importance to raise individuals who think critically and produce and question information (Craft et al., 2014). Thus, expectations from education have begun to differ. The aim of education is not only to acquire knowledge but also to raise individuals who think differently, flexible, original, and creative (Mola and Dagnew, 2020). In this context, education programs and teachers have been involved in efforts to improve creativity in children (Mullet et al., 2016).

Teacher creativity is defined as teaching by trying originality in the teaching process and using imagination and problem-solving abilities (Lapeniene and Bruneckiene, 2010). A creative teacher is considered to be innovative, multi-faceted, open to change, not afraid to express his views, and open-minded (Cheung, 2012). In creative teaching, teachers use creative approaches to make the lesson more interesting, enjoyable, and effective. Teachers can be highly creative in developing materials and methods to encourage students (Ozcinar et al., 2020; Newton, 2013). Creative teaching emerges when the teacher transforms the existing knowledge into a new form for the student to understand. Raising individuals who can think, apply knowledge, produce, and solve problems depends on the teacher's application of different teaching approaches rather than direct teaching in the classroom (Songkram, 2015). It can be more effective for teachers to use creative thinking as a teaching tool in the teaching process. Methods and techniques used in each lesson, tools and materials, resources, and activities, among other things, make it easier to use creativity as a whole and usual teaching tool (Laisema and Wannapiroon, 2014).

Distance education, with its most general and simple definition, is the formal education process where students and teachers are not physically in the same place (Uaidullakzy, 2021). In the distance education process, students and teachers physically connect by making use of teaching resources and interactive communication technologies in different environments (Bhuyan, 2021; Selvaraj et al., 2021). Distance education has conceptual aims such as creating new educational opportunities, combining work and education, creating equal opportunities in education, providing lifelong learning, incorporating educational technologies into the process, providing individual and mass education opportunities, and making education effective, efficient, and cost-effective (Izmagambetova et al., 2022). The effect of online education applications, which are known to have many advantages and disadvantages on teacher creativity is an important research topic.

Related research

Edinger (2008), in his study on teacher behaviors nurturing creativity in secondary school classes, evaluated teacher behaviors that are effective in the development of creative thinking. The results revealed that the teachers participating in the research exhibit behaviors that foster creativity at a moderate level. Pelfrey (2011) evaluated the classroom behaviors of primary school teachers defined as creativity enhancers. The researcher concluded that teachers should encourage their students to explore by creating creative products. Davies et al., (2014) conducted a study on teachers' roles and development needs to support creativity. As a result of the research, it was emphasized that teachers play a key role in the development of creative thinking skills and that they should provide versatile support.

Aish (2014) studied teachers' beliefs about creativity in primary education. As a result of the research, it was determined that teachers emphasized originality in creativity, that creativity is related to art and that, it forms the basis for academic learning. Colley (2015) evaluated the teaching practices for creativity in primary schools in developing creativity and revealed that teachers aim to enrich the learning process activities. Guiller et al., (2008) investigated the effects of online and classroom discussions on students' critical thinking skills.

Important research on creativity and online education can be listed as follows. Carter (2008)

compared the creative thinking dispositions of the students before and after the online course and revealed that the applied online courses did not cause any increase in the students' creative thinking dispositions. [Maor et al. \(2023\)](#) examined whether teachers integrate metacognition and creativity in their online lessons more than in classroom instruction. [Gu et al \(2023\)](#) developed and examined an online creativity training program, which employed a comprehensive training approach and consisted of twenty self-instructional exercises delivered throughout five weeks. In her study, [Wu \(2022\)](#) conducted one of the first studies that used an online interactive creativity task platform to explore a person's creativity performance in paired player mode.

It is very important for teachers to constantly improve their professional creativity. As it is known, it has become of great importance for teachers to have online education skills during and after the COVID 2019 period. It can be argued that teachers' ability to use their creativity in online teaching skills and provide effective and efficient teaching makes it easier for students to learn. When we look at the studies carried out in this direction in recent years, we see that the focus is on online learning and creativity. However, when we look at the literature carefully, it is seen that there are research gaps regarding the extent to which the professional creativity of primary school teachers is effective in the online education they provide.

Purpose of the research

The purpose of this research was to examine the effect of online education on the professional creativity of primary school teachers. The research seeks answers to the following research questions.

1. What are the teachers' creativity scale mean scores?
2. Do teachers' creativity levels differ according to the variable of professional seniority?
3. How do teachers evaluate the impact of online education on their professional creativity?
4. How do teachers evaluate the advantages of online education that enable the development of professional creativity?
5. How do teachers evaluate the disadvantages of online education that prevent the development of professional creativity?

Materials and Methods

In this section, information on the method of the research, the study group, the data collection tools, the stages of data collection and processing, and the ethical principles of the research are presented.

Research method

This research was carried out in a mixed method. In the field of health, social, and behavioral sciences, where the researcher collects both quantitative data (closed-ended) and qualitative data (open-ended) to understand research problems, integrates two datasets, and then draws conclusions using the advantages of integrating these two datasets. The basic assumption of this approach is that combining statistical trends (quantitative data) with stories and personal experiences (qualitative data) will be more advantageous than using either of these methods alone to better understand the research problem ([Doyle et al., 2009](#)). Accordingly, in this study, while the creativity levels of teachers were obtained by the quantitative method, the effect of online education on their professional creativity was evaluated by the qualitative method.

Participants

The quantitative study group of the research consists of 319 primary school teachers working in various primary schools in the city of Zhetysu Region, Kazakhstan, in the 2022-2023 academic years and having online education experience. The qualitative part of the research was carried out by selecting 25 teachers by random sampling method among 319 teachers participating in the research. The demographic characteristics of the teachers participating in the research are given in Table 1.

Table 1. Demographic characteristics of primary school teachers

Gender	F	%
Woman	319	100
Professional Seniority		
1–5 years	88	27.6
6–10 years	95	29.8
11–15 years	76	23.8
16 years and above	60	18.8

Demographic characteristics of primary school teachers participating in the research are given in Table 1. All (100%) of the primary school teachers participating in the research are women. 88.2 of the primary school teachers participating in the research have professional seniority between 1 and 5 years (27.6%), 95 of them have professional seniority between 6 and 10 years (29.8%), 76 of them have professional seniority between 11 and 15 years (% 23.8), and 60 of them have 16 years or more professional seniority (18.8%).

Data collection tools

Teacher Creativity Scale

“Teacher Creativity Scale,” one of the data collection tools of the research, was developed by Uçar (2015). The following steps were followed while establishing the language validity of the scale.

- Translation: At this stage, the “Teacher Creativity Scale” (Uçar, 2015) was translated into Kazakh using a 5-stage technique. This process consists of the steps of first translation, first translation evaluation, back translation, back translation evaluation, and expert opinion. The first translation of the Teacher Creativity Scale was carried out by 2 experts who were familiar with the cultural, psychological, and grammatical differences in both languages. Afterward, the translation was evaluated and the scale was translated back into its original language. After the back translation was carried out, the final translation was evaluated and it was decided that the scale was ready for pilot application.
- Establishment of the Pilot Practice Sample Group: At this stage, 307 primary school teachers experienced in the field of online education formed the pilot implementation sample group to pilot the scale. Primary school teachers included in the pilot study sample group were excluded from the main sample group of the study.
- Exploratory Factor Analysis: The SPSS 25.0 statistical program was used in exploratory factor analysis. In the exploratory factor analysis, the suitability of the data set for the analysis was evaluated. Kaiser-Meyer - Olkin (KMO) and Barlett Sphericity tests were used. In Kaiser-Meyer tests, the Olkin (KMO) coefficient should be between 0.80-0.90 for the sample size, and in Barlett tests, the Sphericity test should be significant at the .05 level (Hadi et al., 2016). In the Kaiser Meyer analysis, since the Olkin (KMO) coefficient was 0.84 and the Barlett sphericity test was $p < 0.05$, the null hypothesis was rejected and it was accepted that the correlation matrix was not a unit matrix. Finding statistically significant data shows that it is suitable for factor analysis. As a result of the exploratory factor analysis, it was determined that the scale items were grouped under 3 factors with an eigenvalue greater than 1. The factor loadings of the first factor of the scale, which includes 10 items and is called “Expertise,” ranged from 0.65 to 0.77. The factor loads of the second factor of the scale, which includes 10 items and is called “Creative Thinking Skill,” vary between 0.59 and 0.79. It was determined that the third factor, which consists of 8 items and is called “Motivation,” had factor loads ranging from 0.73 to 0.86.
- Confirmatory Factor Analysis: SPSS Amos in Confirmatory Factor Analysis 25.0 statistics program was used. To accept the confirmatory factor analysis results as valid, the goodness of fit indices of the model must be sufficient. The goodness of Fit Index (GFI), Normed Fit Index (NFI), Relative Fit Index (RFI), Comparative Fit Index (CFI), and Incremental Fit Index (IFI) values greater than 0.90 indicate that there is sufficient fit, and the values decrease to 0. Approximate bad, approaching 1 perfectly fit root mean square Residuals (SRMR) and Root mean square. If the Error of Approximation (RMSEA) is less than 0.05, it is stated that it has a good fit, if it is below 0.10, it is an acceptable goodness of fit, and the ratio of the Chi-square value to the degree of freedom is less than 5 (Schermelleh-Engel et

al., 2003). As a result of the confirmatory factor analysis, it was determined that the ratio of the Chi-square value to the degrees of freedom had a sufficient level below 5. The fit index values were found to be RMSEA=0.04, SRMR= 0.03, GFI=0.97, NFI=0.93, RFI=0.91, CFI=0.93, and IFI=0.98. When the goodness of fit indices obtained as a result of confirmatory factor analysis was examined, the model was determined to be compatible.

- Reliability Study: The consistency of the scale was checked with the Cronbach alpha internal consistency coefficient. The Cronbach's alpha internal consistency coefficient of the "Expertise" factor was 0.82, the Cronbach's alpha internal consistency coefficient of the "Creative Thinking Skill" factor was 0.85, and the Cronbach's alpha internal consistency coefficient of the "Motivation" factor was 0.88. The Cronbach alpha internal consistency coefficient for the Teacher Creativity Scale was found to be 0.84 in general. When calculating the score of the 5-point Likert-type scale, "strongly agree" was determined as 5, "strongly agree" 4, "moderately agree" 3, "little agree" 2, and "strongly disagree" 1 point. Item score ranges were accepted as equal, between 1.00-1.79 "I strongly disagree," 1.80–2.59 "I agree little," 2.60–3.39 "moderately agree," 3.40–4.19 "strongly agree," and 4.20- Between 5.00 and 5.00 was formed as "totally agree".

The Effect of Online Education on Teacher Creativity Semi-Structured Interview Form

"The Effect of Online Education on Teacher Creativity Semi-Structured Interview Form" was developed by the researchers to collect the qualitative data for the study. Opinions of 3 experts were taken to determine the content validity of the three semi-structured interview questions created during the development of the semi-structured interview form. Interview questions organized in line with expert opinions were applied to 4 primary school teachers and the clarity of the questions was evaluated. The semi-structured interview form was given its final form with the opinions of the teachers. The semi-structured interview form prepared to be used in the research is given in Table 2.

Table 2. *The effect of online education on teacher creativity semi-structured interview form*

1. How do you evaluate the impact of online education on teachers' professional creativity? Give your opinion by choosing one of the options below.			
Very effective in a positive way ()		Positively effective ()	
Ineffective ()	Negatively effective ()		Very effective in the negative direction ()
Teacher's opinion:			
2. How do you evaluate the advantages of online education that enable the development of professional creativity?			
Teacher's opinion			
3. How do you evaluate the disadvantages of online education that prevent the development of professional creativity?			
Teacher's opinion:			

The Effect of Online Education on Teacher Creativity in semi-structured interview form is given in Table 2. The form includes 1 closed and open-ended question and 2 open-ended questions.

Data collection process

Research data were collected in two stages. The first of these is the pilot implementation phase of the Teacher Creativity Scale, which was adapted into language for use in the research. In the second stage, primary school teachers who constituted the sample group of the research were studied. Data collection tools were delivered to the teachers through Google Forms. It took approximately 3 months for all data to be collected and delivered to the researchers.

Compliance with Ethics

At every stage of the research, an understanding of research by ethical principles was displayed. Necessary permissions were obtained for the language adaptation study of the Teacher Creativity Scale, whose language validity was established to collect the research data. A consent form was obtained from all primary school teachers who participated in the study, stating that they voluntarily participated in the study. In addition, a statement was made to the participants that the research data and personal information would be kept confidential and not used for any other purpose or anywhere.

Data analysis

The analysis of the quantitative data of the research was carried out with the SPSS 25.0 statistical program. In addition to percentage, frequency and mean calculations, one-way analysis of variance (ANOVA) were applied. Content analysis was performed for the analysis of the qualitative data of the studies. The process of content analysis is to bring together similar data within the framework of certain concepts and themes and to present them in a way that the reader can comprehend (Stemler, 2000). In this direction, the effect of online education on teacher creativity was presented by transforming the data obtained from the semi-structured interview form into frequency and percentage tables with content analysis.

Results

In this section, the findings obtained with the Teacher Creativity Scale and the Effect of Online Education on Teacher Creativity Semi-Structured Interview Form are given.

Findings Regarding the Teacher Creativity Scale

In Table 3, the weighted average and standard deviations of the primary school teachers participating in the research regarding the overall teacher proficiency scale and its sub-dimensions are given.

Table 3. *Weighted mean and standard deviations of the teacher creativity scale*

	M	SS
Expertise	3.68	0.773
Creative Thinking Skill	3.77	0.791
Motivation	3.59	0.834
Teacher creativity scale	3.69	0.698

In Table 3, the sub-dimension of expertise ($M=3.68$, $SS=0.773$), the sub-dimension of creative thinking skills ($M=3.77$, $SS=0.791$), the sub-dimension of motivation ($M=3.59$, $SS=0.834$) and the overall scale of teacher creativity ($M=3.69$, $SS=0.698$) weighted average and standard deviations are given. From this point of view, it has been determined that primary school teachers have a high degree of creativity in the teacher creativity scale sub-dimensions and overall.

According to the professional seniority variable of primary school teachers participating in the research in Table 4, a one-way analysis of variance, ANOVA results is given.

Table 4. *One-way analysis of variance ANOVA results*

Class	N	M	SS	F	P
1–5 years	88	3.29	0.839	16.552	0.000
6–10 years	95	4.08	0.677		
11–15 years	76	4.01	0.682		
16 years and above	60	3.26	0.848		

In Table 4, the creativity of primary school teachers participating in the research was evaluated according to the variable of professional seniority. As a result of one-way analysis of variance ANOVA, it was determined that the creativity of primary school teachers showed a significant difference according to the variable of professional seniority ($F=16.552$, $P<0.5$). It was determined that the significant difference was in favor of primary school teachers with 6–10 years and 11–15 years of professional seniority.

The Effect of Online Education on Teacher Creativity Findings Regarding the Semi-Structured Interview Form

In Table 5, the evaluations of the primary school teachers participating in the research regarding the effect of online education on professional creativity are given.

Table 5. *Evaluations of primary school teachers on the effect of online education on professional creativity*

Category	F	%
Very effective in a positive way	4	16
Positively effective	14	56
Ineffective	5	20
Negatively effective	2	8
Negatively very effective	-	-
Total	25	100

In Table 5, the views of primary school teachers participating in the research on the effect of online education on professional creativity are categorized. 16% of primary school teachers answered very effectively in a positive way, 56% in a positive way, 20% ineffective and 8% in a negative way. Among the teachers participating in the research, no teacher stated that online education hurts professional creativity.

In Table 6, the evaluations of the primary school teachers participating in the research regarding the advantages of online education that enable the development of professional creativity are given.

Table 6. *Primary school teachers' evaluations of the advantages of online education that enable the development of professional creativity.*

Category	F	%
Offers the opportunity to combine technology with professional knowledge	19	76
Allows the use of abilities	13	52
Encourages the development of different methods	10	40
Allows multidimensional thinking	7	28
Provides a review of habits	6	24
Improves the ability to find solutions	4	16
Improves the ability to think flexibly	2	8

In Table 6, the evaluations of the primary school teachers participating in the research regarding the advantages of online education that enable the development of professional creativity are categorized. About 76% of the teachers answered that it offers the opportunity to combine technology with professional knowledge, 52% allows the use of talents, 40% encourages the development of different methods, and 28% provides multidimensional thinking. About 24% of the teachers provided the review of habits, 16% answered that it develops the ability to produce solutions, and 8% answered that it develops the ability to think flexibly.

In Table 7, primary school teachers' evaluations of the disadvantages of online education that prevent the development of professional creativity are given.

Table 7. *Evaluations of primary school teachers about the disadvantages of online education that prevent the development of professional creativity.*

Category	F	%
Blocks interaction	16	64
Restricts the learning environment	15	60
Makes classroom management difficult	11th	44
Makes material development difficult	9	36
Deprives the opportunities and opportunities of the classroom environment	8	32
limits the imagination	5	20
Limits the student assessment process	2	8
Does not create an environment of cooperation and trust	1	4

In Table 7, the evaluations of the primary school teachers participating in the research regarding the disadvantages of online education that prevent the development of professional creativity are categorized. About 64% of the teachers answered that it prevents interaction, 60% limits the learning environment, 44% makes classroom management difficult, 36% makes it difficult to develop materials, and 32% deprives the classroom environment of opportunities and opportunities. About 20% of the teachers answered that they limit their imagination, 8% limit the evaluation process of the student, and 4% do not create an environment of cooperation and trust.

Discussions

The primary school teachers participating in the research showed a high degree of creativity in the teacher creativity scale sub-dimensions and in general. This finding corroborates the results of previous studies. [Kaufman \(2006\)](#) and [Aljughaiman \(2002\)](#) aimed to reveal teachers' creativity perceptions in their research. As a result of the researches, it was revealed that teachers have positive perceptions and tendencies about creativity. As a result of the research conducted by [Mullet et al., \(2016\)](#), it was revealed that teachers attach importance to creative thinking and consider it valuable, but they do not know theories and research related to creative thinking.

The findings obtained from the research reveal that, there is a significant difference in favor of primary school teachers who have professional seniority of 6–10 years and 11–15 years according to the variable of professional seniority. [Polat \(2017\)](#), in his study with classroom teachers, found that the creativity levels of classroom teachers differ according to their professional seniority. As a result of the research, the creativity score averages of teachers with 11–15 years and 16–20 years of seniority were found to be higher than teachers with 1–5 years of seniority.

The majority of primary school teachers stated that online education had a positive effect on professional creativity. Providing the opportunity to combine technology with professional knowledge, enabling the use of talents, encouraging the development of different methods, providing multidimensional thinking, reviewing habits, developing the ability to produce solutions, and thinking flexibly are the answers given by primary school teachers to the advantages of online education that enable the development of professional creativity. In similar studies conducted in the field, it is shown as an important advantage that online education allows teachers to develop by contributing to their technology knowledge ([Zuhairi et al., 2006](#); [De Paepe et al., 2018](#)).

The primary school teachers participating in the research, on the disadvantages of online education that prevent the development of professional creativity expressed it as preventing interaction, restricting the learning environment, making classroom management difficult, making it difficult to develop materials, depriving the opportunities and opportunities of the classroom environment, limiting the imagination, limiting the evaluation process of the student, and not creating an environment of cooperation and trust. In his study, [Attr \(2012\)](#) revealed that the communication between the student and the teacher and the need to increase the in-class interaction in distance education activities, this situation negatively affects the use of the teacher's potential. In their research, [De Alencar and Oliveira \(2016\)](#) also stated that teacher candidates and teachers realized the importance of creativity skills, but they encountered some problems in developing this skill in the learning-teaching process.

Conclusion

In this study, the effect of online education on primary school teachers' professional creativity was examined. In the quantitative dimension of the research, the creativity levels of primary school teachers were examined according to the professional seniority, while the effect of online education on creativity was evaluated in the qualitative dimension. As a result of the research, it was determined that the creativity levels of primary school teachers were high. According to the seniority variable among primary school teachers, it was determined that the creativity levels of those with medium seniority were higher than the others. The vast majority of teachers stated that online education has a positive effect on professional creativity.

Providing the opportunity to combine technology with professional knowledge, enabling the use

of talents, and encouraging the development of different methods are stated by the majority of teachers as the advantages of online education that enable the development of professional creativity. Preventing interaction, restricting the learning environment, making classroom management difficult, making material development difficult, and depriving the classroom environment of opportunities and opportunities are the answers given by the majority of primary school teachers to the disadvantages of online education that prevent the development of professional creativity.

Higher education programs that train teachers should be developed according to the requirements of the age so that primary school teachers, who are the most important step in shaping the society and raising qualified manpower, have high-level thinking skills such as creativity following the requirements of the information age. To increase the creativity level of primary school teachers, in-service training programs should be established for all teachers, especially those who are in the first and last years of their profession. In addition, the educational content to be created to eliminate the negative effects of online education on the professional creativity of primary school teachers should be included in in-service training programs.

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Conflict of interests

The authors declare no conflict of interest.

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Author Contributions

Conceptualization, A.K and G.Z; methodology, H.U.; software, H.U. and U.A.; formal analysis, H.U. and U.A.; writing—original draft preparation, A.K. and G.Z.; writing—review and editing, H.U. and U.A. All authors have read and agreed to the published version of the manuscript.

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Effectiveness of Virtual Co-Teaching: A New Perspective on Teaching

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Abstract: The teaching method of virtual co-teaching helps the mutual sharing of new experiences and methods of pedagogues in teaching in formal education, through digital technologies. It also facilitates the involvement of practitioners in teaching, which can be a key mechanism for ensuring quality education. This article focused on comparing the effectiveness of co-teaching in two environments, face-to-face and virtual. In terms of methodology, an experiment was used, which was implemented in three independently selected schools, from which eight groups of thirty students were formed. The phenomenon measured was the level of understanding of the material taught during these lessons of history, mathematics and a foreign language. The test results of the individual groups were subsequently analyzed. From the results, we can confirm the null hypothesis based on the independent samples t-test and the Mann-Whitney U test, which indicates that there is no statistically significant difference between the test results of the two groups. However, it is essential to emphasize the added value in virtual co-teaching, which is primarily in the economic aspect and flexibility. Specifically, it is a reduction in the cost of commuting, reduced time and easy availability of experts. These results form the basis for follow-up research that can focus on improving the quality of teaching using this method.

Keywords: co-teaching, digital technology, teaching effectiveness, virtual co-teaching, experiment.

Introduction and theoretical framework

In many countries, co-teaching is seen as a useful educational method that benefits students with and without individual learning needs. It is thus widely used in primary, secondary and higher education (Friend et al., 2003; Fluijt et al., 2016). Defining joint teaching is not clear-cut in pedagogical practice. In professional literature, we often come across terms such as co-teaching (Fluijt et al., 2016), collaborative (Beninghof, 2012) or team teaching (Wobaka and Schnelzera, 2015). Currently, in the world context, the term co-teaching is often associated with the concept of inclusion, i.e. with the assumption that the traditional classroom environment is the most suitable environment for the majority of students, and therefore it is necessary to provide the greatest possible support here (Wilson and Blednick, 2011). The very definition of co-teaching is then usually understood as the cooperation of a general pedagogue with a special pedagogue within the framework of inclusive practice, which contributes to meeting the needs of different groups of pupils (Rytivaara et al., 2021; Fluijt, 2016). Another perspective on co-teaching is provided by Bacharach et al. (2010), who defines it as the joint planning and teaching of two or more teachers. A specific form of co-teaching can then be a model where the lesson is basically managed by one teacher or uses the opportunity given by the double occupation of the lesson to divide students into groups that teach either in the same class or even in separate rooms (for details see Beninghof, 2012; Murawski, 2017; Dove et al., 2018; Veteška et al., 2022; Kursch, 2022). Friend et al., (2010) and Murawski (2009) divide co-teaching into a total of six types:

1. Traditional interactive pair teaching - both teachers participate equally in teaching, design teaching and teach together in a synchronous environment.
2. Complementary pair teaching – one teacher explains the material while the other provides

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supplementary instruction.

3. Station teaching – pupils are divided into smaller groups between which the teachers alternate.
4. Parallel co-teaching – pupils are divided into two equal-sized groups and each teacher teaches one group.
5. Alternative pair teaching – pupils are divided into groups according to their learning needs.
6. Pair teaching in the style of one teaching and one assisting (Friend et al., 2010).

From the above definitions and an overview of the types of co-teaching, it is possible to deduce that the practice of co-teaching does not have to be limited only to the cooperation of general and special pedagogues and that co-teaching can be included in various forms and types of education (Wilson and Blednick, 2011). In the context of the wide use of co-teaching in various educational systems and its connection with inclusive educational practice, our study brings a new perspective on the virtual form of co-teaching. Although concepts such as co-teaching, collaborative and team-based learning are well established in pedagogical theory and practice, our work focuses on the innovative application of these principles in an online environment. It thus expands the discussion on the possibilities and challenges associated with the adaptation of traditional methods of joint teaching to the conditions of the virtual classroom, which represents a significant contribution to the current discourse on the effectiveness of educational methods. Virtual co-teaching is based on standard methods of joint teaching and expands it with a virtual component. It is therefore a collaboration between two pedagogues, where one of them is always virtually connected (Svobodová, 2021; Svobodová et al., 2022).

The development and expansion of virtual co-teaching into formal education is currently important and topical with regard to global social changes (e.g. wars in the world, natural disasters, growing political tension, increased migration and refugee crisis, economic inequalities, etc.), but above all also due to the technical progress associated with the concept of Industry 4.0 and, more recently, Industry 5.0, which indicates a new global industrial transformation (Leng et al., 2022). This is primarily the advent of robotics, automation of artificial intelligence and new technologies that significantly interfere with educational processes and influence their direction (Veteška and Kursch, 2019; Malik et al., 2018; Leng et al., 2022).

Last but not least, the Covid-19 pandemic fundamentally changed the perspective of traditional education, as education systems across the world faced an unprecedented situation of mass school closures. In response to this challenge, educators have been forced to turn to new, innovative approaches and didactic methods in order to maintain an uninterrupted educational process through digital tools and platforms (Pokhrel and Chhetri, 2021). This period also caused the need to carry out research studies that would prove what real impacts this non-standard period had on the education of pupils. A negative influence on student learning has been proven (e.g. Spiteri et al., 2022), but also the need to introduce completely new methods of education and fundamentally innovate teachers' approaches to the pedagogical process in changed social and educational conditions. Emphasis on greater use of digital technologies is one of the keys to effective (Berry, 2020; livari et al., 2020; Pokhrel et al., 2021). The pandemic brought with it the necessity to focus teaching on the development of didactic competences, human relationships and values (Sakalli et al., 2021). The possibilities of using co-teaching mentioned in this text can of course also be used in other situations, outside of the framework of the ordered isolation of pedagogues, whether due to epidemics or other individually justified absence of a pedagogue from teaching (e.g. in the context of further professional education, foreign internships, etc.). In addition, the use of virtual co-teaching can also bring benefits in the professional development of teachers, when cooperation can stimulate the mutual sharing of experiences and new methods. All these aspects highlight the potential and flexibility of virtual co-teaching, which reduces the cost of commuting, lost time, the easy availability of teachers and the involvement of practitioners (for example, the involvement of a native speaker in foreign language teaching). In this context, virtual co-teaching becomes a key mechanism for ensuring quality education (Kursch et al., 2022).

Effectiveness of co-teaching and virtual co-teaching – literature review

Our research tries to bring a new perspective to the question of the effectiveness of co-teaching. The very definition and forms of this method are defined in different ways, but they are all united by the question of the effectiveness of joint teaching, which can be characterized as a central and cross-cutting

topic that includes the teacher's view of effectiveness (Wilson and VanBerschoot, 2014, Jurkowski and Müller, 2018, Neifeald and Nissim, 2019, Rabin, 2020) and students (Puttonen, 2014, Strogilos and King-Sears, 2019). Current research focused on the use of co-teaching mainly focuses on the effectiveness of joint teaching in inclusive classes.

Iacono et al. (2021) conducted a review of research that used a quantitative approach, six qualitative and one with a mixed design. The results of this analysis revealed that there is little rigorous research to inform how two teachers with complementary skills can best work together to meet the diverse learning needs of students. According to the authors of Iacono et al. (2021), therefore, more research is needed on how co-teaching can be used to optimize outcomes for students based on the nature and extent of their problems. For example, some interventions, according to the analysis, may improve academic outcomes, while others may benefit social or behavioral goals.

An interesting starting point for our research was the comprehensive meta-analysis by Vembye et al. (2023) who examined the effectiveness of co-teaching models and related collaborative teaching on student achievement. These authors included a total of 76 studies from 1984 to 2020 in their meta-analysis. The results of this systematic review and meta-analysis provide evidence of the effectiveness of cooperative learning models in improving student academic achievement. This is independent of the specific model of cooperation in the classroom between teachers, the taught subject and the year of study. Additionally, in this meta-study, research on co-teaching often had a small sample size and was based on non-randomized research designs. Following the recommendations of Vembye et al. (2023) for future research, we use randomized controlled designs in our study. This approach allows us to better assess the real effect of co-teaching and brings an important added value to the discussion about the effectiveness of the researched learning model.

In terms of monitoring the effectiveness of virtual co-teaching, Svobodová et al. (2022) from the results of a qualitative study point to co-teaching as a method of expanding the pedagogical space into an environment where schools cannot normally reach. However, it is also a method that places high demands both on other teachers and on their cooperation and preparedness. Ensuring the necessary time for the preparation of teachers is essential in terms of the effectiveness of co-teaching, which is also confirmed by the results of several studies in which the lack of time for planning was identified as a barrier to the actual implementation of co-teaching (Mofield, 2020). In addition to sufficient time for teaching preparation, technical equipment is a significant determinant of the success of virtual co-teaching (Veteška and Kursch, 2019).

At the same time, the results of the study by Svobodová et al. (2022) mention that, through virtual co-teaching, it is also possible to target the attractiveness of the entire taught subject through the involvement of experts who would otherwise be unavailable to students and physically unable to get to school. Virtual co-teaching thus opens new doors to make teaching and various subjects (e.g. technical subjects, chemistry, physics, foreign languages, etc.) more attractive. From the point of view of measuring the effectiveness of virtual co-teaching through quantitative research, a study by Kursch et al. (2022), where the maximum effort was made to eliminate variables and all possible disturbing factors (e.g. selection of students with the same average results in the last two years of study, the same educational program, homogeneous course of the entire experiment, etc.). The results show that virtual co-teaching is as effective as classic co-teaching. This finding was interpreted with statistical significance. As the value of "p" does not approach the limit where errors of the first or second type can be considered, we can say with certainty that the differences between classical and virtual co-teaching do not show either a significantly positive or a significantly negative effect.

From the point of view of the effectiveness of virtual co-teaching, the area of technical equipment and readiness is essential, which stands on the borderline between effectiveness and a barrier in the preparation and implementation of teaching using this method. In addition to the mentioned technical readiness, the human readiness (cooperation) of pedagogues is also important for students in the virtual form of joint teaching, enabling students to get a good orientation in teaching.

For the effectiveness of joint teaching (including virtual joint teaching), it is important to deal with its entire process (planning, implementation, reflection, including the choice of the type of joint teaching and its specific variant of virtual joint teaching). Other contextual conditions that influence the effectiveness of (virtual) joint teaching and are elaborated in sub-topics in this study include technical readiness, the time factor for considering the specific educational needs of pupils (Kursch et al., 2022; Svobodová et al.,

2023; Veteška et al., 2022).

Our study builds upon the existing literature by empirically investigating the effectiveness of virtual co-teaching. In our exploration, we emphasized the importance of technical equipment, readiness, and collaboration among educators, which enables effective navigation of the teaching process in a virtual environment.

Materials and Methods

The purpose of our study was to compare the effectiveness of learning in classic co-teaching versus virtual co-teaching. A simple research question asks whether virtual co-teaching is more effective in absorbing learning than traditional co-teaching. Due to the purpose of our research, we chose an experiment as a research method. Our research therefore took the form of a simple experiment. For the purposes of the experiment, we selected 3 independent schools in Czech Republic, from which 8 groups of 30 students each. The teaching subjects were history, mathematics, and English. The phenomenon measured was the learning of the subject matter in these lessons. Then the result of the test of individual groups is a sign. The groups were selected as homogeneous independent, randomized selection. Both control and experimental groups were selected by random selection. For all groups, we checked the students' previous performance in the tested subjects in order to verify the normal distribution of the students' performance. Therefore, we did not change the groups, as they all had the same average score of the previous year's achievement assessment. The research sample is therefore a total of 240 pupils from 3 faculty schools in the Czech Republic. The benefit of all pupils is subject to a normal distribution. The benefit was determined based on the students' report cards from the previous year of study. The age of the pupils was in the range of 12-14 years. The experimental and control groups were randomly selected, and their descriptive statistics are shown in Table 2. It can be seen from the table that the groups do not differ and are homogeneous in the parameters of the descriptive statistics of the studied counterparts. The sample is a representative sample of elementary school students in the Czech Republic.

The control groups had an hour of classic co-teaching with two teachers, the experimental groups were subjected to virtual co-teaching, i.e., one teacher physically present and the other who was present only virtually with the help of a 150 cm television screen. For the experiment to be valid, we had to separate out any confounding influences and ensure that other variables were the same for all groups. Table 1 lists the influences we eliminated. The test took place within two hours after the lesson, in order to eliminate the possible self-teaching of pupils or the individual influence of forgetting.

Table 1. *Disturbing variables in the experiment and their elimination*

Undesirable phenomenon	Applied elimination
Equipment outage	Secure WiFi access to a dedicated router, connect UPS to TV and PC, turn off automatic hardware shutdown.
High-quality sound	Installation of special microphones with the requirement for the quality of speech acquisition and noise reduction using CVC technology.
Quality visuals	We used full HD resolution for a 150 cm TV.
Sensing the space of the whole class	The virtual teacher had an HD image of the entire class on his laptop to ensure a holistic perception similar to that of a person in the classroom.
Same spatial layout	In both cases of teaching, the teachers stood in the same places so that we did not introduce an element of movement that could be a difference factor. In classical co-teaching, the teacher stood in the same place as the television was placed in the virtual co-teaching.
Same teaching content	In preparation, both teachers prepared the same curriculum content.
Same behaviour of teachers	For both cases, an script was created, according to which the teachers taught and thus evoked virtually identical situations throughout the lesson. Including questions and timings of individual teaching sections.
Same teachers	Both teachers were identical in both lessons.
Teaching time	The lessons were always in the morning at the same hour, so as not to affect the changes by fatigue of pupils in the afternoon.
Testing within 2 hours after lessons	To eliminate the effects of forgetting, which differs individually more with increasing time, both groupswere tested within two hours of teaching.

The only variable that changes in the experiment remains the virtuality of one of the teachers. The experiments took place from September 2022 to November 2023 (extended research of our previous researches in this area) and were supervised by us to check that all criteria for a valid experiment were met by ensuring the removal of all confounding influences that could bias the results. The description of experiment is showed on Figure 1. For the purposes of the experiment, we established the alternative hypothesis H_a :

H_a : The test results of students who completed a virtual co-teaching class will be better than the test results of students who had a classic co-teaching class.

The verification statistical methods were the T-test and, as a supplement, the Mann-Whitney U test.

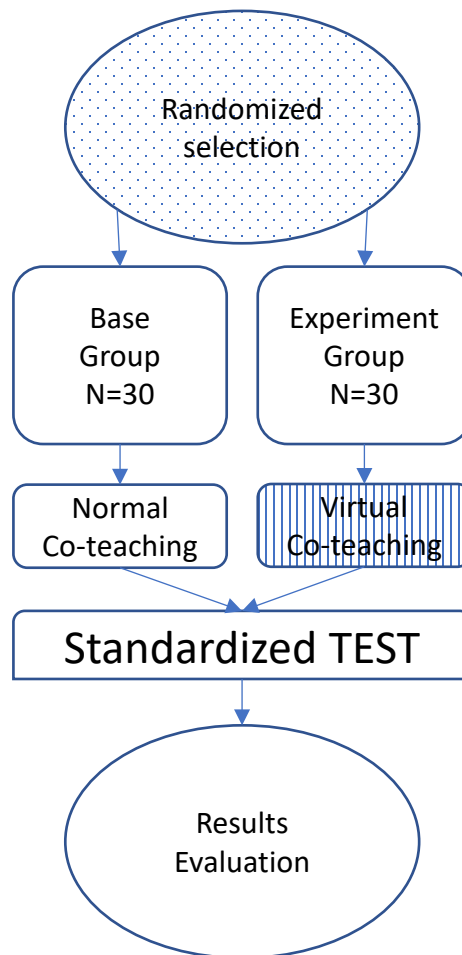


Figure 1. Description of experiment.

Results

After the experiment, we evaluated the results using appropriate statistical methods. Descriptive statistics are shown in Table 2. All groups are based on the normal distribution of the performance of the basic set of pupils. We used the t-test for independent groups as a test statistic. As our sample was very small, we also performed a non-parametric Mann-Whitney U test. Table 3 shows the results of the t-test, which was processed using the Statistica program.

Table 2. Descriptive statistics of research samples

Group	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Standard
G1B	30.0	14.8	15.0	9.0	19.0	7.0	2.6	0.5
G1E	30.0	14.8	15.0	8.0	19.0	5.4	2.3	0.4
G2B	30.0	13.2	12.0	3.0	25.0	32.1	5.7	1.0
G2E	30.0	13.6	12.0	5.0	25.0	22.9	4.8	0.9
G3B	30.0	20.3	20.0	11.0	28.0	19.0	4.4	0.8
G3E	30.0	20.9	21.0	13.0	28.0	11.6	3.4	0.6
G4B	30.0	17.1	18.0	3.0	25.0	20.4	4.5	0.8
G4E	30.0	17.2	18.5	2.0	23.0	24.9	5.0	0.9

Table 3. T-test for Independent Samples

G1 vs G2	Mean	Mean	t-value	df	p	N	N	Std.Dev.	Std.Dev.	F-ratio	p
G1B vs. G1E	14.77	14.80	-0.05	58.00	0.96	30	30	2.65	2.33	1.30	0.49
G2B vs. G2E	13.17	13.63	-0.34	58.00	0.73	30	30	5.66	4.78	1.40	0.37
G3B vs. G3E	20.30	20.92	-0.61	58.00	0.54	30	30	4.36	3.41	1.64	0.19
G4B vs. G4E	17.10	17.23	-0.11	58.00	0.91	30	30	4.52	4.99	1.22	0.60

From the results in the table, it can be seen that we reject the alternative hypothesis and confirm the null hypothesis, i.e., that the test results of both groups do not differ statistically significantly at the level of significance $\alpha = 0.05$, $p > 0.05$. So, we conclude that the results are almost the same. Figure 2 shows the differences in both groups.

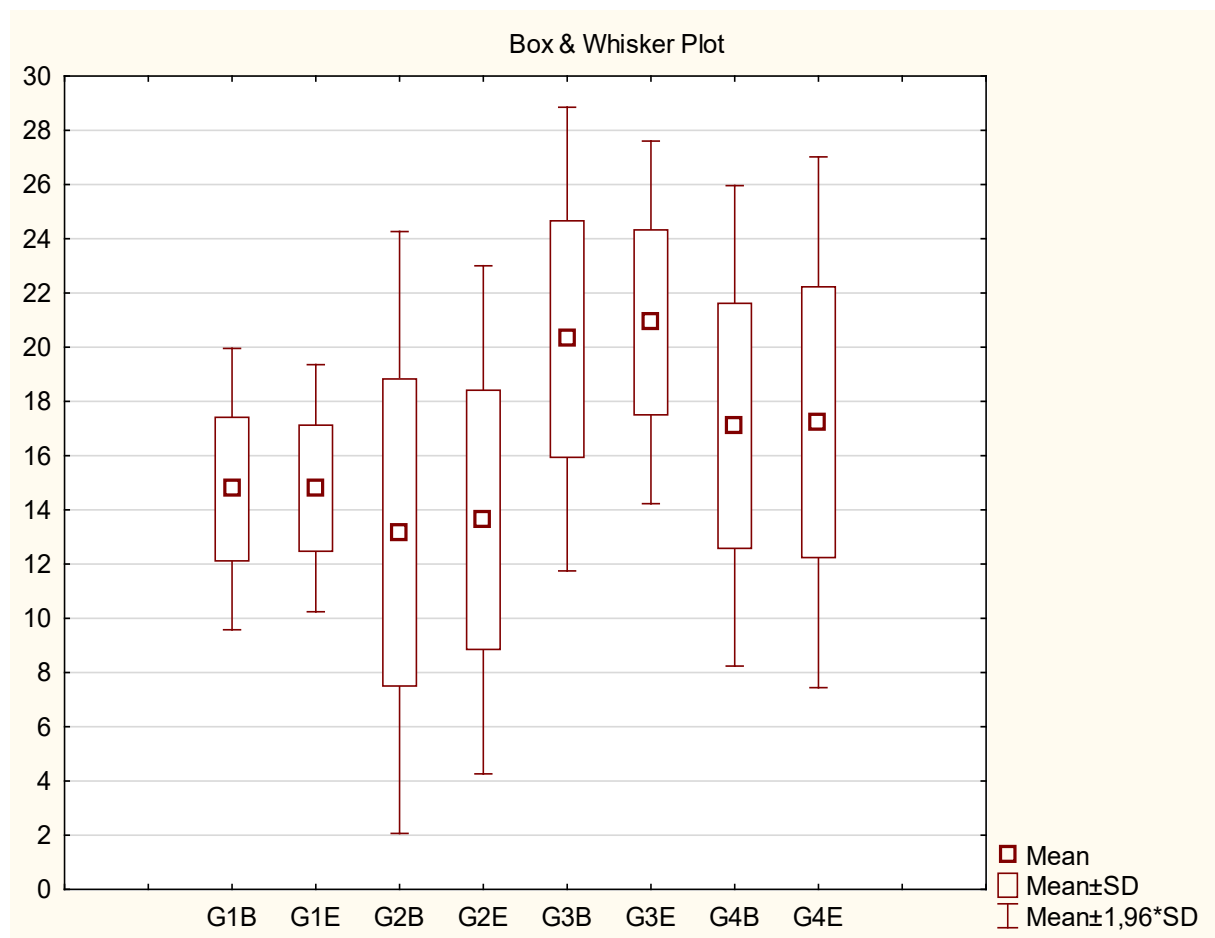


Figure 2. Summary statistics – comparison of all groups test results.

We also performed an additional non-parametric Mann-Whitney test, the results of which are in Table 4. We came to confirm our results using this test as well.

Table 4. Mann-Whitney U Test (w/ continuity correction)

Rank Sum	Rank Sum	U	Z	p-value	Z	p-value	N	N	2*1sided
910.50	919.50	445.50	-0.06	0.95	-0.06	0.95	30	30	0.95
879.00	951.00	414.00	-0.52	0.60	-0.53	0.59	30	30	0.60
845.50	984.50	380.50	-1.02	0.31	-1.03	0.30	30	30	0.31
886.50	943.50	421.50	-0.41	0.68	-0.42	0.68	30	30	0.68

Our findings show that co-teaching could be a full-fledged alternative to classic co-teaching in terms of the impact on learning represented by ex post test results. However, from the point of view of effectiveness, if we define it as the achievement of results in the test including all the costs of co-teaching, virtual co-teaching appears to be more effective than classic co-teaching. This conclusion can easily be reached when calculating the costs of commuting, time lost, the ease of availability of teachers (for example, a native speaker, a production expert, a foreign expert, etc.), provided that the costs of the equipment are also used for other purposes and are therefore not only purchased for the purpose of co-teaching.

Discussions

In our study, we tried to separate the variables in order to avoid side effects. That is why we have selected groups of pupils with the same average results in the last two years of study. These pupils were selected randomly, from a reference group provided to us by the principals of the schools where the research was carried out. These were pupils of the same educational program, the same and previous academic results. As far as other independent variables are concerned (apart from the homogeneity of the control and experimental groups), we paid attention to the homogeneous course of the entire experiment. We focused on ensuring the sameness of virtual vs traditional teaching. As an example, we can mention the same location in the space of the teacher implementing frontal teaching and co-teaching. Furthermore, we tried to establish the same situations throughout the entire lesson in terms of content and form. We have eliminated all risks related to the failure of the technical background for virtual teaching. We have always prepared the infrastructure for this teaching in advance.

Limitations of our study include primarily the limited sample size, which may affect the generalizability of the findings. Minor individual differences between participants, which could not be fully compensated for, represent another limitation, as well as the impossibility of achieving complete uniformity throughout the teaching units. Although we found virtual co-teaching to be comparably effective to the traditional form, these findings should be interpreted with these limitations in mind and with caution given the potential influence of these factors on outcomes. Since the “p” value does not indicate a statistically significant difference, we can state that the effectiveness between the classic and virtual form of co-teaching is not statistically distinguishable, which indicates that neither method is significantly more effective than the other. This finding underscores the need for further research in this area, taking into account the aforementioned limitations of our study. Our study was methodologically elaborated so that it can be accurately replicated by other research teams. Complementary to our study was further qualitative research, which brought the observations of teachers and pupils, secondary externalities of both a positive and negative nature, and suitably complements our quantitative research. A qualitative study is presented by [Svobodová et al. \(2023\)](#).

From the point of view of the use of virtual co-teaching, which was examined in the presented study (i.e. one teacher in person and the other online), we will not meet in the research. In current empirical studies, teaching is mainly investigated only in an online environment, not in a combined form (face-to-face and online). At the same time, this model has been investigated in more detail during the COVID-19 pandemic, which has initiated a number of studies focusing on online platforms, student motivation, teaching effectiveness and social interaction, with most current studies limited to fully online learning environments. ([Kim and Pratt, 2023](#); [Chizhik and Brandon, 2020](#); [Barron et al., 2022](#); [Coy and Miller,](#)

2023). Our work thus contributes to expanding knowledge about the potential and challenges associated with this hybrid model of teaching.

Both approaches are of significant importance for the development of virtual education and the involvement of digital technologies to optimize them in teaching at primary and secondary schools. The virtual co-teaching we explored opens the door for innovation in the educational space. This hybrid model may be particularly relevant in situations where flexibility, adaptability, and the involvement of practitioners in teaching are needed. These technologies give students and teachers access to information, communication, and collaboration on new levels. This creates modern and interactive educational environments that can be adapted to the individual needs of different groups of students (e.g. talented students, students with special educational needs, etc.).

The results of this study confirm that virtual learning and modern technology have a key role in the education of the 21st century. Their importance and potential will continue to grow, requiring constant research and innovation. Some other lines of research that could be based on this study could focus on evaluating the long-term effects of virtual co-teaching on the development of students' communication skills, cooperation, and critical thinking. The results of this study represent an important step towards a better understanding and use of the potential of virtual co-teaching in primary and secondary schools.

Conclusions

The aim of this study was to conduct an experiment aimed at comparing the effectiveness of co-teaching in two environments – face-to-face (classical) and virtual. The main phenomenon measured was the effectiveness of virtual co-teaching on learning the subject matter in three different subjects: history, mathematics, and English. Based on the independent samples t-test and the Mann-Whitney U test, we were able to confirm the null hypothesis, indicating that there is no statistically significant difference between the t-test results of the two groups. However, it is necessary to emphasize the added value of virtual joint teaching, which is mainly in the economic aspect and flexibility. Specifically, it is about reducing commuting costs, reducing time and easy availability of experts.

Based on our findings, we suggest that further studies focus on in-depth exploration of student-teacher interactions in virtual co-teaching and examine how these interactions affect learning outcomes. Particular attention should be paid to how pedagogical methods and the use of technology can improve student engagement and motivation. It is also recommended to conduct longitudinal studies that would assess the effect of virtual co-teaching on the academic development of students over time.

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Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, M.K. and J.K.; Resources, J.V. and J.K.; Methodology, M.K.; Investigation, J.K. and J.V.; Data curation, M.K.; Formal Analysis, J.V.; Writing – original draft, M.K. and J.K.; Writing – review & editing, J.V. All authors have read and agreed to the published version of the manuscript.

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Metacognitive Strategies for Mathematical Modeling with Engineering Groups of Students: Adaptation and Validation of a Questionnaire

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Abstract: A sequential exploratory mixed-methods study is implemented to develop an instrument that allows for the evaluation of the metacognitive strategies used by engineering groups of students when solving mathematical modeling problems. The findings of the qualitative study guided by observations and interviews reveal the use of metacognitive strategies of 'planning', 'monitoring and, if necessary, regulation', and 'evaluation'. In this article, we present the final categories of the qualitative analysis and discuss how these data were shaped into a theoretical construct and items of an instrument to measure metacognitive strategies. The psychometric properties of the instrument are analyzed, and it is argued that it has a similar interpretation among males and females, as there are no significant differences in these results. The development of the present study demonstrates how the qualitative method can support the adaptation of an instrument to measure metacognitive strategies, thus contributing to validity and applicability.

Keywords: modeling, metacognitive strategies, engineering education, questionnaire, gender invariance.

Introduction

Several authors suggest that the future of work is uncertain, but this uncertainty does not refer to the lack of employment, but rather to the skills that new jobs will demand (Dirksen, 2019; Weller et al., 2019; World Economic Forum, 2020). The case of engineering is particular, as professionals in this field are expected to be able to handle large volumes of data, work in teams with machines, possess communication skills, solve complex and open-ended problems, among other skills (Richert et al., 2016; Humberto and Rojas, 2017). The skills to solve complex and open-ended problems underlies much of the standards for 21st-century engineering education (Kent and Noss, 2003; International Engineering Alliance, 2014; ABET, 2017; Alpers, 2021). However, the literature has suggested that the deployment of metacognitive skills is required to successfully solve this type of task (Blum, 2011; Borromeo, 2006; Maaß, 2006; Stillman, 2011; Vorhölder et al., 2019). Therefore, metacognition influences the way complex and open problems are approached and modeled in engineering (Wengrowicz et al., 2018; Hidayat, Zulnadi, et al., 2018; Wedelin et al., 2015; Yildirim, 2010).

Modeling tasks concentrate essential features of common engineering professional environments' problems since they are complex, open-ended, and have few structure (Jonassen et al., 2006; Gainsburg, 2013; Lyon and Magana, 2020). When students in engineering training solve this type of tasks, they understand the connection between engineering contexts and mathematics (Aravena et al., 2022; Soon et al., 2011). Therefore, mathematical modeling in engineering is relevant due to its role in the connection between mathematics and industry problems (Li, 2013; Palmer et al., 2013). However, addressing modeling tasks is challenging because they are complex, open-ended, and it is not evident where to commence and where one is expected to arrive (Kaiser and Schwarz, 2010). Usually, students face obstacles in successfully solving modeling problems due to their own beliefs, limited self-regulation, inappropriate attitudes, and expectations (Wedelin et al., 2015). Incorporating this type of tasks in the classroom requires careful consideration of metacognition due to its significant impact.

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Metacognition plays an essential role in solving complex engineering problems as it promotes the understanding of mathematical concepts, encourages organizational behavior, and enhances teamwork. Metacognition enables the evaluation of local and global effects in engineering problem-solving, the organization of resolution strategies, and the effective monitoring of the calculation process (Hegedus, 2001). Furthermore, it has been found that metacognition positively influences the development of mathematical modeling skills among engineering students, fostering deliberate behaviors and a deeper understanding of the theoretical implications of application (Tzohar-Rozen and Kramarski, 2014; Wedelin et al., 2015; Hidayat et al., 2018). Collaboration in the resolution of modeling tasks also stimulates the use of metacognitive strategies in small groups, allowing efficient monitoring of progress, assessment of viability, and critical analysis of innovative ideas and results (Newell et al., 2004; Cardella, 2008; Gainsburg, 2013). Together, these findings highlight the importance of metacognition in the context of mathematical modeling in engineering.

However, at this educational level, there are few instruments for measuring metacognitive strategies in mathematical modeling problems (Yildirim, 2010; Czocher, 2018; Hidayat et al., 2018; Hidayat, Zulnaidi, et al., 2018), especially for measuring metacognitive strategies with engineering groups of students. The study contributes to the research field by addressing the need to construct instruments as didactic tools to measure the metacognitive strategies used by engineering students in mathematical modeling processes. In this article, we present the development of the metacognitive strategies instrument guided by a mixed methods study, which was conducted over an academic semester through observations, interviews, and the application of a questionnaire.

To address the study, two research questions are sequentially answered. The first question was: How do the metacognitive strategies of 'planning,' 'monitoring and, if necessary, regulation,' and 'evaluation' in the domain of mathematical modeling documented in the literature relate to the observed metacognitive strategies in engineering groups of students in a multiple case study? Based on the results of the qualitative research and theoretical aspects, an instrument was adapted and validated to measure metacognitive strategies in mathematical modeling among engineering groups of students. Based on the development of the instrument, the second research question was: What are the psychometric properties of the instrument, such as content validity, reliability, and measurement invariance? To answer this question, a quantitative correlational research design is utilized. The gender variable is used to investigate measurement invariance.

The stereotypes that exist regarding gender differences (Correl, 2004; Cheryan and Plaut, 2010; Cheryan, 2012) could play a significant role in shaping how engineering students employ their metacognitive strategies to solve mathematical modeling problems. Beliefs based on gender stereotypes have shaped the interest and performance in engineering, science, technology, or mathematics careers (Charles and Bradley, 2009; Noel-Levitz, 2014). This has led to, on the one hand, women and other minorities being underrepresented in engineering careers (Wang and Degol, 2017; National Center for Science and Engineering Statistics, 2023), that is to say, there is low entry into such careers. On the other hand, some women who enter engineering do not persist in their trajectory in response to negative feedback associated with performance in introductory mathematics or science courses, cultural stereotypes, limited peer networks, or discrimination (Riegle-Crumb, 2006; Cech et al., 2011; Mann and DiPetre, 2013; Sanabria and Penner, 2017). This situation generates a global-scale problem, as industries and the economic sector of countries require the presence of men, women, and diverse individuals to develop innovative and creative solutions to complex problems, drive the economy, and achieve sustainable development (Woetzel et al., 2015; Smith-Doerr et al., 2017).

Inquiry into gender disparities regarding metacognitive skills in complex problem-solving has been the subject of study for a long period, revealing diverse results concerning the gender effect on self-efficacy, self-regulation, and metacognitive skills (Ciascai and Lavinia, 2011; Hong et al., 2021). It has been demonstrated that women tend to use self-regulation strategies more effectively, adjusting their efforts according to learning tasks and showing superior performance compared to men when solving complex problems (Bidjerano, 2005). However, there are studies suggesting the absence of gender differences in this field (Fitzpatrick, 1994; Bembenuitty, 2007; Aravena-Díaz et al., in press), highlighting the lack of clarity in the relationship between gender and the control of one's own learning processes, that is, metacognition.

Metacognitive strategies in mathematical modeling

A first approach to the analysis of metacognitive strategies in contextualized problems in real-world environments is carried out by [Stillman and Galbraith \(1998\)](#), who take into account the cognitive-metacognitive framework of [Garofalo and Lester \(1985\)](#), to categorize the knowledge of the metacognitive strategy for understanding the problem, organizing information, developing and executing plans, monitoring progress, and verifying the final result. Later, [Stillman \(2011\)](#) highlights the importance of metacognitive activity in the development of mathematical modeling processes, considering the presence of metacognition in each transition between the stages of the modeling cycle. Furthermore, the work of [Schukajlow and Krug \(2013\)](#) reveals the positive influence of metacognitive planning and monitoring strategies on modeling problems that require assuming missing data. Continuing the line of research, [Vorhölter \(2018, 2019\)](#) implemented a project aimed at stimulating ninth and tenth-grade students in this domain, from which he developed an analytical framework for analyzing metacognition in the context of mathematical modeling.

According to [Vorhölter et al. \(2019\)](#), declarative metacognition involves understanding the characteristics of individuals, strategies, and tasks related to modeling. In contrast, procedural metacognitive strategies focus on 'planning', 'monitoring' and, if necessary, 'regulation', as well as the 'evaluation' of actions and performance in the process of solving mathematical modeling problems. Metacognitive strategies play an essential role in the successful development of modeling tasks. The metacognitive strategies for 'planning' allow for an understanding of the task's objectives, the prediction of outcomes, and the exploration of various resolution approaches. Decision-making regarding which approach to employ for resolution is also considered part of metacognition. "Monitoring" involves the constant review of one's own cognitive processes during the task, posing questions to verify the accuracy of the steps being followed. 'Regulation' is activated when students encounter obstacles and seek support. 'Evaluation' analyzes the processes undertaken and the team's performance, considering the strengths, weaknesses, and team dynamics. These classifications in dimensions of metacognitive strategies are applicable to both individual and group metacognition ([Vorhölter, 2019](#); [Vorhölter and Krüger, 2021](#)).

Materials and Methods

The design of this research is of a mixed, sequential exploratory type ([Creswell and Plano, 2018](#)), in which the findings from four months of observation and interviews were integrated into an instrument to measure metacognitive strategies ([Tashakkori and Teddlie, 2003](#)). This research method allowed for a profound understanding of student's metacognitive strategies and assisted in formulating items for the instrument. This design is developed in two phases: the first phase identifies and classifies the metacognitive strategies of the engineering groups of students. In the second phase, the instrument is adapted and validated based on the categories established in the first phase and a review of the existing literature. The development of the instrument allowed for the application of the study to a larger and more diverse sample, thus extending the scope of the results. For both phases, the analytical framework of specific metacognitive strategies in the mathematical modeling process ([Vorhölter et al., 2019](#)) was employed, along with studies that reveal metacognitive aspects of engineering students.

Qualitative component

In the qualitative phase, research techniques guided by multiple case studies were used, including non-participant observations and interviews ([Yin, 2014](#)). The observations were carried out while the students were participating in a mathematical modeling program in a one-variable calculus course for engineering. In this initial research phase, a qualitative approach was adopted with the purpose of exploring the processes of mathematical modeling in engineering students to deeply understand the metacognitive strategies that may contribute to the development of this type of problems ([Creswell, 2009](#)).

Participants

In the phase that adopts a qualitative design, four engineering student cases with experience in mathematical modeling problem solving are selected to observe the metacognitive behavior of students

encompassing greater diversity (Simons, 2013). The cases consist of four groups, each composed of three students who had participated in a mathematical modeling program within the context of an engineering calculus course, collaborating on modeling problems. For a detailed description, see Cárcamo Mansilla et al., (in press). To distinguish the groups in description of Table 1, we will use the letter G1, G2, G3 and G4 and the students with the letters s1, s2, s3 respectively.

Data collection

Non-participant observations were made of four groups of students as they worked on a sequence of mathematical modeling problems in the classroom. The sessions were recorded using twelve video recordings, and interviews were conducted with the groups after solving the modeling tasks to record retrospective knowledge of the metacognitive strategies they had used in their own process of mathematical modeling. The interviews were organized around metacognitive strategies for 'planning,' 'monitoring and, if necessary, regulation,' and 'evaluation,' based on the work of Vorhölter et al. (2019). The interview script was validated by experts according to the criteria of Escobar-Pérez and Cuervo-Martínez (2008).

Data analysis

A deductive-inductive content analysis (Mayring, 2014; Gläser-Zikuda et al., 2020) is used to categorize metacognitive strategies. For this purpose, a categorization was carried out considering codes based on the literature, taking into account the metacognitive strategies of 'planning,' 'monitoring and if necessary regulation,' and 'evaluation' (ME1 to ME3) based on the theoretical framework of Vorhölter et al. (2019). Besides the literature-based codes, the research team allowed for the emergence of additional phenomena (Kuckartz, 2019; Kohlbacher, 2006) related to the metacognitive strategies of engineering students, such as the necessity to make assumptions, as it prompted engineering students to comprehensively address the context of the problem. Additionally, the organization of groups, the definition of roles, and the allocation of time fostered autonomy. Such skills are crucial for future engineers because they will face new challenges ahead (Newell et al., 2004; Penagos, 2011).

Qualitative results

A set of topics organized into categories and subcategories emerged from the observations that were contrasted with the interviews conducted, and are summarized in Table 1. These topics were used to form the final constructs of the instrument to measure metacognitive strategies, which are discussed later.

Table 1. Qualitative categories and subcategories

Category/ subcategories	Description
Planning metacognitive strategies (ME1) • They discuss the information among all [p1] • Establish demands and objectives among everyone [p2] • Discuss solution strategies [p3] • Realize the need to establish assumptions [p4] • Consider the resources available to solve the task [p5]	It reflects the active participation of students in the discussion and the joint establishment of demands, objectives, and solution strategies, as well as the awareness of the importance of making assumptions and considering the available resources to effectively address the tasks.
Monitoring and regulation metacognitive strategies (ME2) • Monitor the progress of the modeling process [m1] • Validates the modeling process [m2] • Question the evolving mathematical model [m3] • Discuss successes and difficulties in the process [r1] • Establish a course of action at the local level [r2] • Discuss action plans at a global level [r3] • Select a new solution plan [r4]	It refers to the constant awareness and reflection on progress and difficulties in the modeling process, where students demonstrate their ability to monitor, question, and adjust evolving mathematical models.
Evaluation metacognitive strategies (ME3) • Evaluate the effectiveness of resources [e1] • Evaluate the effectiveness of the process [e2] • Evaluate the effectiveness of the strategies [e3]	They demonstrate their skills to analyze the effectiveness of available resources, as well as to critically assess the modeling process itself, considering approaches, methods, successes, and challenges. Furthermore, the evaluation of the strategies employed highlights their skill in identifying those that prove effective and applicable in future contexts.

Several of these categories of metacognitive strategies have been previously studied, specifically in the contexts of high school students (Schukajlow and Krug, 2013; Vorhölter, 2017, 2018; Vorhölter, 2019), but have not been explored with engineering groups of students.

Development of the instrument to measure metacognitive strategies

The qualitative data analysis phase reported categories and subcategories of metacognitive strategies, serving as constructs for the instrument to measure metacognitive strategies in mathematical modeling among groups of engineering students. These constructs were operationalized using the dimensions from the analytical framework of Vorhölter et al. (2019) and the transcriptions of video episodes and retrospective interviews to create items that formed part of the assessment tool. For instance, if a phrase appeared in multiple video episodes and interviews, it was used to create an item addressing this theme in the assessment instrument and added to the corresponding dimension. Table 2 presents examples of qualitative data transformed into assessment instrument items.

Table 2. Item creation from qualitative data

Qualitative Data	Category/ subcategories	Survey Item
Video episodes transcription: “What I want is for the four of us to do it to see if we are doing it equally and well” (G4_S1) “Let’s all four do the data for the cylinder and if they give us the same it’s because the cylinder is good” (G2_S2) Interview transcription: “We try to see everything together and then compare and follow the same path” (G4_S2)	<i>Planning metacognitive strategies (ME1)</i> • <i>Discuss solution strategies [p3]</i>	i14: ... We agreed on the same approach to solving the problem individually, to then compare and review results or calculations together
Video episodes transcription: “Wait, let’s check again” (G3_S1) “With these numbers, what we are getting is the capacity that we are going to have inside, do you understand me?” (G1_S3) Interview transcription: “I thank my colleagues because sometimes I miss a sign...” (G4_S1)	<i>Monitoring and, if necessary, regulation metacognitive strategies (ME2)</i> • <i>Monitor the progress of the modeling process [m1]</i>	i10: ... The groups ensures that everyone understand individually in order to proceed with the resolution of the issue
Video episodes transcription: “Yes, if you look at the photo I sent, ehm, it actually has an interval of thirteen points, it has an interval of thirteen point sixty-five” (G4_S3) “Why do you give us 10 bottles at the base, it seems that it is bad?” (G3_S1) “Did you see the measurements? It’s bad, we have to check it” (G1_S2) Interview transcription: “Then we saw that it should not be easy but it is important to try to apply mathematics to something that one recognizes” (G4_S1) “At one point, when we calculated the number of bottles it didn’t fit us and we realized it was wrong and we had to calculate everything again” (G3_S3)	<i>Monitoring and, if necessary, regulation metacognitive strategies (ME2)</i> • <i>Select a new solution plan [r3]</i>	i2: ... In some occasions, we notice that it is necessary to change the work plan (due to confusion or errors)

Additionally, theoretical items were incorporated into each dimension of the instrument. The theoretical references in specialized literature served as a guide. The scale developed by Rakoczy et al. (2005) was used and translated to adapt the instrument, with reported reliability exceeding a Cronbach's alpha of .70 in each of its dimensions. The Schukajlow and Krug (2013) scale is also employed, who reported reliability levels of .74 and .84 for the planning and monitoring dimensions, respectively. Finally, the items are supplemented with the findings of those who have measured metacognitive strategies in the specific domain of mathematical modeling (Vorhölter, 2017, 2018, 2019).

Before administering the instrument, an expert validity test was conducted. Specialists in mathematics education and cognitive psychology evaluated the instrument by reviewing the used scale and items obtaining a score of .9 and guaranteeing content validity (Tristán-López, 2008). Then, a pilot study is conducted to carry out a preliminary analysis of the instrument with a sample of 30 engineering students (Johanson and Brooks, 2010) who had experience in modeling processes. The overall reliability of the scale is analyzed through the Cronbach's alpha coefficient, which reaches a value of 0.83, surpassing the minimum acceptable internal consistency criterion (Allen et al., 2008).

Then, an instrument with 23 items and three subconstructs is obtained (Appendix A): metacognitive strategies for 'planning' (8 items), 'monitoring and, if necessary, regulating' (12 items) and 'evaluating' (3 items). To measure the metacognitive strategies with the instrument, a 5-point Likert scale is used (1 = totally disagree, 5 = totally agree).

Quantitative component

After the creation of the instrument, the quantitative phase of the cross-sectional study is conducted. This phase should be treated as a follow-up to the initial qualitative phase, as suggested by the sequential exploratory research design (Creswell and Plano, 2018). This phase has been designed to analyze the psychometric properties of the metacognitive strategies assessment instrument and its invariance across male and female.

Participants

According to the guidelines outlined by Creswell and Plano (2018) for mixed methods, this phase involved different participants from the same student population. Engineering students with experiences in mathematical modeling problem solving were selected. To recognize such expertise, it is considered that they have participated in a modeling program or courses such as calculus, linear algebra, structural analysis, differential equations, among others, where students confront problems in the field of engineering, applying knowledge of mathematics and engineering, with critical thinking and analytical capacity. A total of 104 students (random selection) participated, who had experience in mathematical modeling problem solving acquired through various courses, including 71 men and 33 women. The age ranged from 18 to 47 years (SD = 11.89). They belonged to various engineering fields. The statistical power of the sample was calculated to be .80, considering a confidence level of .05; a root mean square error of approximation (RMSEA) index approximation of 0.080, and 227 degrees of freedom (Preacher and Coffman, 2006).

Data collection

The instrument was administered in 2022, after obtaining approval from the authorities of the institutions involved in the study and informed consent from the participants. The students took approximately 20 minutes to complete the instrument. Once the data were collected through the application of the instrument, they were transcribed in Excel format, and a spreadsheet was prepared for further analysis in the statistical programs M-Plus (Muthén and Muthén, 2007) and R Studio, respectively.

Data analysis

A descriptive analysis of the items was carried out, considering the mean, standard deviation, and skewness in order to assess the performance of each questionnaire item, ensuring that none of them exhibit an extreme mean or an excessively low standard deviation. Confirmatory factor analysis (CFA) procedures were used to assess the construct validity of the instrument (Ferrando & Anguiano-Carrasco, 2010). The internal consistency values were measured using ordinal data alpha (Oliden and Zumbo,

2008) to estimate the reliability of the scale's dimensions. To identify reliability by factor, the criterion of Ferrando and Anguiano-Carrasco (2010) is followed, that is, if there is a factor loading less than 0.3 in magnitude, the item's inclusion is evaluated.

The measurement invariance between male and female students was also evaluated. Due to the lack of normality assumption in the variables, confirmed by the Kolmogorov-Smirnov test ($p < 0.05$), the non-parametric method of the Mann-Whitney U test was used to compare two independent groups (Flores-Ruiz, 2017).

Results

Quantitative results

The mean scores, variance, and skewness were obtained for each of the items. As shown in Table 3, participants exhibit a relatively high level of metacognitive strategies in the specific domain of modeling, with an average of 4.22 on a scale of 1 to 5. The items showed a slight negative skewness within acceptable ranges (Ferrando and Anguiano-Carrasco (2010)) for the development of a CFA (Confirmatory Factor Analysis). The skewness indicates that the responses for each item are clustered around the mean, consistent with the high level of reported metacognitive strategies. The standard deviations demonstrate that all items were able to discriminate among subjects.

The information presented in Table 3 does not justify the elimination of any item due to low discrimination capacity, a high grouping of responses in very low or very high scores, or asymmetries outside acceptable ranges. This is confirmed by the high significant correlations among the items and the corrected total score, which ranged from 0.30 to 0.70, which has been acceptable in studies in the educational field (Assis Gomes et al., 2017). With the factors composed of 23 items, organized according to the defined theoretical perspective, a confirmatory factor analysis for categorical variables was conducted. Upon evaluating the validity of the proposed construct, the following statistics are observed. RMSEA, CFI, TLI: The factorial model exhibited a good fit to the data (χ^2 (N=108, df=227) = 289.426, $p=.003$; CFI=.947; TLI=.940; RMSEA=.051 (CI90%=.031, .068).

Table 3. Descriptive statistics of items from the metacognitive strategies questionnaire and factorial loads resulting from the confirmatory factor analysis.

N	Items	Mean	SD	Skewness	Factor loading
Metacognitive strategies for planning					
i1	... We ensure to have clarity on what the problem is about	4.61	0.58	-1.16	0.38
i19	... We realize that we can establish assumptions (hypotheses) to solve the problem	4.16	0.95	-1.15	0.80
i15	... First, we plan how to deal with the problem	4.09	0.98	-1.15	0.70
i13	... We make sure to focus on the objective requested in the problem	4.63	0.58	-1.30	0.46
i18	... We realize that it is necessary to organize time, roles, and responsibilities to respond to what the professor has requested	4.29	0.97	-1.36	0.72
i7	... We discussed the steps that we must take to solve the task (strategies)	4.35	0.81	-1.25	0.66
i5	... We discussed different ways to solve the problem with the aim to choose then the best one	4.36	0.91	-1.45	0.58
i14	... We agreed on the same approach to solving the problem individually, to then compare and review results or calculations together	3.79	1.25	-0.72	0.50
Metacognitive strategies for monitoring and, if necessary, regulation					
i12	... Throughout the problem solving process, we continuously check whether we are on the right track	4.44	0.72	-1.19	0.55
i10	... The groups ensures that everyone understand individually in order to proceed with the resolution of the issue	3.94	1.13	-0.89	0.70
i4	... Every now and then we monitor the time we have left to finish solving the problem	4.37	0.90	-1.57	0.30
i9	... We questioning the evolving mathematical model	4.32	0.85	-1.22	0.75
i6	... We questioning whether mathematical procedures (equation solving, variable manipulation, matrix resolution, application of theorems) are well-developed	4.36	0.93	-1.55	0.63
i3	... We endeavor to try to clarify if the solution is reasonable according to the real problem	4.54	0.64	-1.04	0.61
i8	... When difficulties arose, we discussed them together as a groups	4.38	0.84	-1.19	0.62
i11	... We realized the need to ask the teacher for support when we encountered difficulties	4.49	0.79	-1.82	0.56
i20	... In some occasions during the resolution process, we realized that we needed to change the resolution strategy	4.33	0.70	-1.40	0.67
i2	... In some occasions, we notice that it is necessary to change the work plan (due to confusion or errors)	4.21	0.88	-0.85	0.46
i23	... When we notice that we are facing difficulties in reaching a solution to the problem, we undertake a new plan	4.32	0.84	-1.64	0.73
i17	... When there are incorrect solutions, we review the resolution process, and if deemed necessary, we propose a new work plan	4.41	0.80	-1.34	0.63
Metacognitive strategies for evaluation		3.47	1.30	-0.43	0.78
i16	... At the final of process, we collectively reflect on the quality of our performance, the fulfillment of roles we undertook, time management, and agreements				
i21	... At the final of process, we reflect on the entire problem-solving process to enhance our performance in future opportunities, considering successes, errors, strategies, achievements, and obstacles.	3.96	1.00	-1.03	0.81
i22	... At the final of process, we discuss whether there was alternative approach that could have led to the solution.	3.63	1.30	-0.70	0.72
TOTAL		4.23	0.89	-1.19	NA

The Mann-Whitney U test results indicated that there are no statistically significant differences associated with gender in the metacognitive strategies of (1) 'planning,' (2) 'monitoring and, if necessary, regulation,' and (3) 'evaluation' ($p > 0.05$).

Figures 1a and 1b of metacognitive strategies for planning related to (i13) task objective and (i1)

clarity of the problem, did not reveal students in disagreement. However, 7% of male students expressed indifference compared to females who predominantly chose agreement or complete agreement. Nevertheless, these differences are not statistically significant (i13: $U = 1320$, $p = 0.20$; i1: $U = 1072.5$, $p = 0.41$). Only the strategy related to (i14) agreeing on the same way to solve the problem and then comparing together showed higher disagreements, which were not statistically significant, and a lower frequency of usage ($U = 1171.5$, $p = 1$).

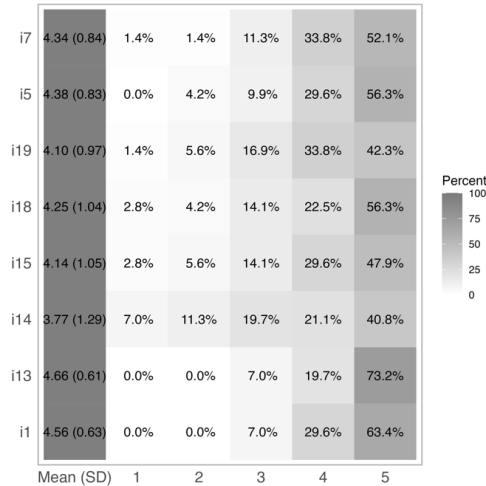


Figure 1a. The percentage for likert scale 'planning', mean and standard deviation of the student male

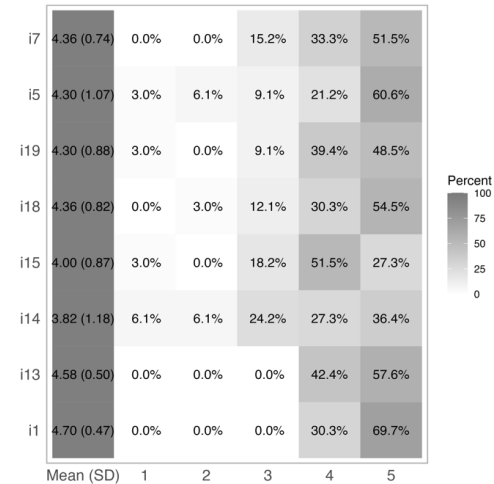


Figure 1b. The percentage for likert scale 'planning', mean and standard deviation of the student female

While female students use metacognitive strategies at a slightly higher level, there were no significant differences between the groups regarding (i7) discussing steps ($U = 1178.5$, $p = 0.96$), (i19) realizing the need to establish assumptions ($U = 1036.5$, $p = 0.31$), and (i18) discussing time organization, roles, or other available resources to solve the task ($U = 1151.5$, $p = 0.88$). Likewise, no significant differences were found in the use of metacognitive strategies for (i5) discussing different ways to solve a problem to choose the best one ($U = 1157$, $p = 0.91$) and for (i15) planning first ($U = 1339.5$, $p = 0.21$); even though men have slightly higher scores than women.

Figures 2a and 2b of metacognitive monitoring and, if necessary, regulation strategies show that they are, on average, higher than the total scale. Students predominantly tend to agree or strongly agree with the statements.

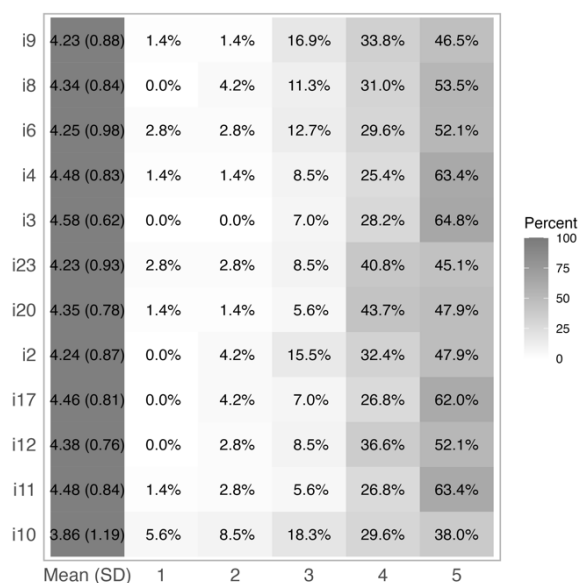


Figure 2a. The percentage for likert scale 'monitoring and if necessary regulation', mean and standard deviation of the student male.

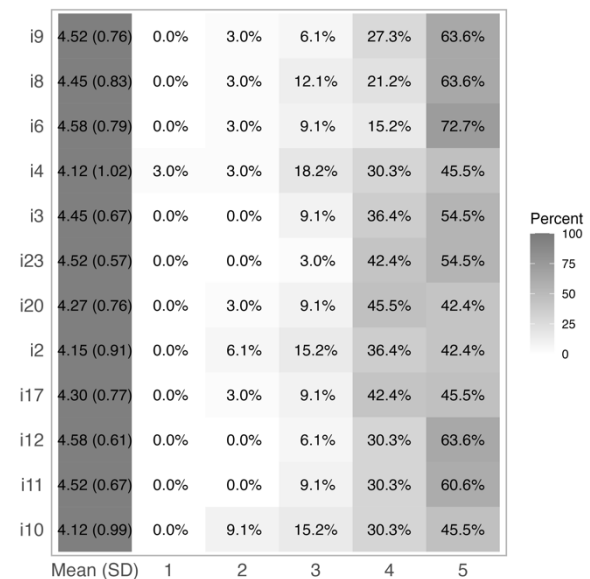


Figure 2b. The percentage for likert scale 'monitoring and if necessary regulation', mean and standard deviation of the student female.

The strategy related to ensuring that (i10) everyone understands individually before continuing with the problem resolution shows a slightly higher frequency of use in women ($M = 4.12$) compared to men ($M = 3.86$). However, there were no statistically significant differences ($U = 1042$, $p = 0.34$). The strategy (i3) of trying to clarify if the solution is reasonable according to the real problem concentrates more than 90% of preferences on agreement or strong agreement, with a slight advantage towards men ($M = 4.58$) compared to women ($M = 4.45$), which is not statistically significant ($U = 1291.5$, $p = 0.33$). Similarly, metacognitive strategies associated with (i9) questioning the evolving mathematical model ($U = 947$, $p = 0.08$), (i23) undertaking a new plan in the face of difficulties ($U = 1003$, $p = 0.19$), (i12) checking if one is on the right track ($U = 1020.5$, $p = 0.24$), and (i11) ask the teacher for support when we encountered difficulties ($U = 1193$, $p = 0.86$) concentrate 90% of responses in the agreement or strong agreement preference, with a slight advantage towards women that is not significant.

Figures 3a and 3b indicate a moderately lower average compared to the overall scale average, suggesting that students use metacognitive evaluation strategies less frequently.

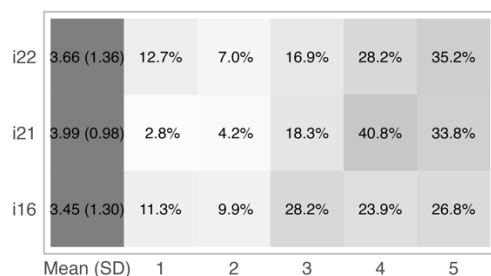


Figure 3a. The percentage for likert scale 'evaluation', mean and standard deviation of the student male.

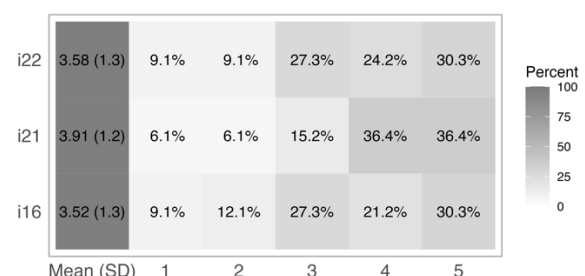


Figure 3b. The percentage for likert scale 'evaluation', mean and standard deviation of the student female.

While the (i16) team reflection on performance, roles, time, and agreements strategy is slightly higher in women ($M = 3.52$) compared to men ($M = 3.45$), there are no statistically significant differences ($U = 1140.5$, $p = 0.83$). Even though male students more frequently use metacognitive evaluation strategies for (i21) improving performance in a future opportunity ($M = 3.99$) compared to women ($M = 3.91$) and (i22) analyzing other solution approach ($M = 3.66$) compared to women ($M = 3.58$), there are no statistically significant differences (i21: $U = 1178.5$, $p = 0.96$; i22: $U = 1242$, $p = 0.61$).

Discussions

The qualitative results reveal the presence of specific metacognitive strategies in engineering students, divided into planning categories (ME1) involving active discussion and joint decision-making on objectives, strategies, and available resources; monitoring and if necessary regulation categories (ME2) involving constant reflection and adjustment of the modeling process based on progress and encountered difficulties; and evaluation categories (ME3) highlighting students' ability to critically analyze the modeling process, resources used, and the effectiveness of employed strategies. Regarding the first research question, it can be concluded that the observed metacognitive strategies in engineering students align with existing literature based on the analytical framework of metacognitive strategies in the domain of mathematical modeling (Vorhölter et al., 2019).

Furthermore, the quantitative results support these qualitative findings. There is evidence of a generally high level of use of all metacognitive strategies. Previous research has highlighted the crucial role of metacognition in solving complex mathematical modeling problems among engineering students (Li, 2013; Palmer et al., 2013; Hidayat et al., 2018). Team collaboration has also been identified as a key factor that stimulates the effective use of metacognitive strategies, reinforcing the importance of social interactions in the development of metacognitive competence (Gainsburg, 2006; Newell et al., 2004; Cardella, 2008).

Regarding the second research question, it can be concluded that the instrument exhibits adequate psychometric properties. The analytical framework aligns appropriately with the observed data, as indicated by the results of the construct validity test. Additionally, it can be concluded that there were no statistically significant differences associated with gender male or female in terms of the metacognitive

strategies used in mathematical modeling processes. Therefore, the instrument is invariant across gender groups. The existing literature has shown various results in terms of gender disparities in the metacognitive dimension, especially in the context of engineering careers and the use of metacognitive strategies to address complex problems (Ciascai and Lavinia, 2011; Hong et al., 2021; Aravena-Díaz et al., in press). However, our findings coincide with the results obtained by Aravena-Díaz et al. (in press), indicating that no significant gender differences are observed when students face mathematical modeling tasks, especially in relation to the metacognitive strategies they use.

Because addressing modeling challenges is generally not the task of students alone, but is done in small groups, it is crucial not only to consider individual metacognitive strategies, but also to pay special attention to group metacognitive strategies (Vorhölter and Krüger, 2021). For this reason, an instrument has been developed to measure metacognitive strategies at the group level in this study.

Conclusions

Based on the qualitative and quantitative results obtained in this study on metacognitive strategies in the context of mathematical modeling among engineering students, clear patterns of behavior have been identified. Qualitative findings revealed the presence of three main categories of metacognitive strategies, namely planning strategies (ME1), monitoring and if necessary regulation strategies (ME2), and evaluation strategies (ME3). These categories reflect students' active involvement in the modeling process, highlighting their ability to collaborate, critically reflect, and effectively evaluate their own performance and team progress.

It is worth noting that this study provides additional evidence on the issue of gender disparities in the use of metacognitive strategies in the context of mathematical modeling, demonstrating that there were no statistically significant differences based on the gender variable. These findings contradict some previous research suggesting possible gender differences in the application of metacognitive strategies. The refutation is grounded in the strengths of mathematical modeling as an educational innovation in engineering training since, at the metacognitive level, it does not reproduce gender differences.

In conclusion, this study provides a deeper understanding of the dynamics of metacognitive strategies among groups of engineering students in the context of mathematical modeling and offers an instrument to measure metacognitive strategies that can be useful for future research exploring in-depth interactions between metacognitive strategies, mathematical performance, and other relevant factors in the field of mathematics and engineering education.

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The study has been approved by the Scientific Ethics Committee of the Catholic University of Maule in Act N°41/2021. All study participants expressed their willingness to participate freely, consensually and voluntarily.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, N.C.M., M.A.D.; Investigation, N.C.M., M.A.D.; Methodology, N.C.M., M.A.D.; Software, N.C.M.; Formal analysis, N.C.M., M.A.D.; Visualization, N.C.M.; Writing—original draft preparation, N.C.M.; Writing—review and editing, M.A.D.. All authors have read and agreed to the published version of the manuscript.

Appendix A

Items included in the Metacognitive Strategies Questionnaire for Mathematical Modeling

When I solve problems that come from the real world...

- i1 ... We ensure to have clarity on what the problem is about
- i2 ... In some occasions, we notice that it is necessary to change the work plan (due to confusion or errors)
- i3 ... We endeavor to try to clarify if the solution is reasonable according to the real problem
- i4 ... Every now and then we monitor the time we have left to finish solving the problem
- i5 ... We discussed different ways to solve the problem with the aim to choose then the best one
- i6 ... We questioning whether mathematical procedures (equation solving, variable manipulation, matrix resolution, application of theorems) are well-developed
- i7 ... We discussed the steps that we must take to solve the task (strategies)
- i8 ... When difficulties arose, we discussed them together as a groups
- i9 ... We questioning the evolving mathematical model
- i10 ... The groups ensures that everyone understand individually in order to proceed with the resolution of the issue
- i11 ... We realized the need to ask the teacher for support when we encountered difficulties
- i12 ... Throughout the problem solving process, we continuously check whether we are on the right track
- i13 ... We make sure to focus on the objective requested in the problem
- i14 ... We agreed on the same approach to solving the problem individually, to then compare and review results or calculations together
- i15 ... First, we plan how to deal with the problem
- i16 ... At the final of process, we collectively reflect on the quality of our performance, the fulfillment of roles we undertook, time management, and agreements
- i17 ... When there are incorrect solutions, we review the resolution process, and if deemed necessary, we propose a new work plan
- i18 ... We realize that it is necessary to organize time, roles, and responsibilities to respond to what the professor has requested
- i19 ... We realize that we can establish assumptions (hypotheses) to solve the problem
- i20 ... In some occasions during the resolution process, we realized that we needed to change the resolution strategy
- i21 ... At the final of process, we reflect on the entire problem-solving process to enhance our performance in future opportunities, considering successes, errors, strategies, achievements, and obstacles.
- i22 ... At the final of process, we discuss whether there was alternative approach that could have led to the solution.
- i23 ... When we notice that we are facing difficulties in reaching a solution to the problem, we undertake a new plan

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Constructivist Feedback-Based Assessment Method as Key for Effective Teaching and Learning: The Development and Impact on Mechanical Engineering Students' Adaptive Capacity, Decision Making, Problem Solving and Creativity Skills

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Abstract: Educators must conduct assessments in their learning; it determines students' weaknesses in the teaching material they follow during learning. Unfortunately, the implementation of assessment by educators was not optimal, and the weakness was that the existing assessment method was only fixated on assessing students without providing feedback on the assessment. At the same time, this feedback was essential for students in learning, which can help learners assess performances that cannot be seen and felt by themselves, as well as a tool to motivate students, notification or information, and reinforcement. Therefore, this research aimed to develop a Constructivist Feedback-Based Assessment Method for learning assessment. The method used in this research was Research and Development (R&D). After development, the Constructivist Feedback-Based Assessment Method for learning assessment will be implemented to see its effect on students' adaptive capacity, decision-making, problem-solving, and creativity skills. Independent sample t-test and linear regression analysis were used as data analysis techniques describing the impact of the assessment on those skills. The results showed that the Constructivist Feedback-Based Assessment Method has five stages: preparing the assessment material, diagnostic assessment, assessment for learning, assessment of learning, and reflection. It effectively affects students' skills, such as adaptive capacity, decision-making, problem-solving, and creativity. It can be concluded that the Constructivist Feedback-Based Assessment Method can improve students' adaptive capacity, decision-making, problem-solving, and creativity. Novelty in this research was the existence of constructivism integrated into feedback-based assessment, which the existing assessment has not highlighted the constructivist side of assessment.

Keywords: *assessment, feedback, constructivist, teaching and learning, vocational education.*

Introduction

Implementing assessment in learning significantly contributes to educators' professional development and learners' learning (Bragg et al., 2021; Hennessy et al., 2022). Assessment serves to provide feedback to learners. Based on this, educators can analyze the information, comment on it, and use it to check and regulate learning. Assessment, if implemented correctly, can improve the quality of learning. The function of assessment is not to give a rating but to see where the learners' mastery is and what they have not mastered (Wetzel et al., 2020). Based on the survey results, using assessment as an evaluation has not been maximally implemented in learning. Too many lecturers/educators still do not utilize this evaluation function to improve the process and quality of teaching and learning. It is not even an exaggeration to say that lecturers/educators very rarely develop evaluations to obtain information about what has been planned for an interaction. It can be seen that assessment is not carried out optimally,

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where tests are usually given only at the time of Mid Test or Final Test (Jalinus et al., 2023). If assessment is not really implemented properly, then educators cannot know the extent of students' understanding, so that learning that occurs is not effective.

Therefore, the solution to this problem is to develop an assessment method. Although the assessment method has existed before and is applied in schools, the weakness of the existing assessment method is that the assessment method is fixated on assessing students only, without providing feedback on the assessment. At the same time, this feedback is essential for students in learning, which can help learners assess performances that cannot be seen and felt by themselves (Hattie, 2008), as well as a tool to motivate learners, notification or information, reinforcement, and motivation (Sims et al., 2023). The advantage of this feedback-based assessment method is that it will obtain information about the pattern of achieving learning objectives. To meet the learning objectives set, diagnostic information for each learner can more effectively help learners know which parts of the topic they still have not mastered so that these learners can quickly learn the lesson topics that have not been mastered (Waskito et al., 2022). The assessment results from using this feedback-based assessment method provide diagnostic information from each score obtained by each learner, called individual diagnostic information, and information on groups of learners or group diagnostic information (Duan et al., 2020).

According to (Fuchs and Fuchs, 1986), many meta-analysis studies on learning quality improvement factors. Based on the results, assessment methods that include feedback are the most influential factor in improving learning quality. Based on previous research, the assessment that includes feedback positively impacts many learner behaviors, especially those related to students' skills. In the literature, assessment methods rank at the top of the list of studies, compared to teaching strategies and techniques to improve learners' academic achievement. Relevant meta-analysis studies also show that assessments that include feedback significantly impact learner success (Karaman, 2021; Phelps, 2019; Wisniewski et al., 2020; Yan et al., 2023). At the same time, constructivism emphasizes students' active role in constructing their knowledge through interaction with learning materials and social experiences. This approach also positively impacts assessment methods (Mohammed et al., 2020).

However, there seems to be an empirical gap in previous research. There is a lack of rigorous research in the previous literature. Constructivist integrated feedback on assessment in enhancing students' ability, which has not been explored, seems essential and worthy of investigation. Empirical investigation of these issues is necessary because assessment is one of the learning elements that can provide better learning quality if combined with feedback and constructivism. In addition, previous research has focused on combining assessment with feedback only, as well as focusing only on improving learning outcomes (Prasetya, Fajri, et al., 2023; Prasetya, Syahri, et al., 2023; Waskito et al., 2023). Therefore, this research aims to develop a constructivist feedback-based assessment method as a key to effective learning in improving the quality of learning in vocational schools and to see the impact of a constructivist feedback-based assessment method on students' adaptive capacity, decision-making, problem-solving, and creativity.

Materials and Methods

Research Design

The method used in this research was Research and Development (R&D). The development model in this study refers to the Research and Development model based on Borg and Gall (Aka, 2019) (Figure 1).

The steps of this research are as follows: 1) identifying problems and analyzing the needs for the development of constructivist feedback-based assessment methods; this problem identification activity is carried out using a survey method and analysis questionnaire; 2) designing and developing constructivist feedback-based assessment methods and its procedures, this development stage was carried out using the explanatory sequential design method in designing constructivist feedback-based assessment method, and; 3) expended trials the constructivist feedback-based assessment method to students using the quasi-experiment method, to see the impact on adaptive capacity, decision making, problem-solving and student creativity. In the expended trials stage, the group of students who were given the constructivist

feedback-based assessment method treatment was called the experimental group, where the treatment was given for 12 weeks. The first week was given a pre-test, weeks 2 to 11 were given treatment, and the last week was given a post-test.

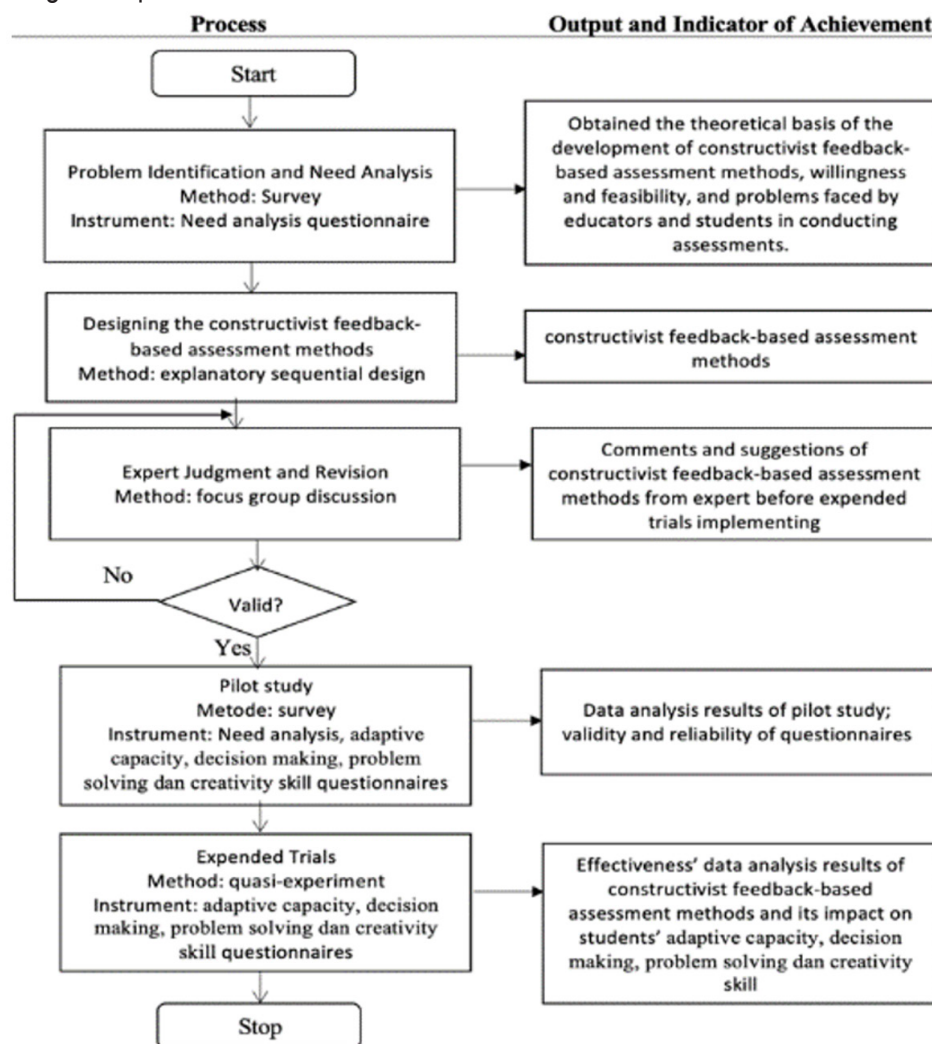


Figure 1. Research Design

Research Participants

Research respondents in the needs analysis activities amounted to 20 Vocational High School, and respondents in this trial activity were 121 mechanical engineering students of Vocational High School who were divided into two groups, namely 61 in the experimental group and 60 in the control group.

Research Instruments

This questionnaire was adapted from the rubric for assessing work-relevant skills developed by (Sánchez-Ramírez et al., 2022), consisting of a series of closed questions with answers to be rated on a scale of 1 to 5 to investigate their skills. The pilot study aims to determine the validity and reliability of the research questionnaire before it is retrieved in an expanded trial, and this pilot study was conducted on 60 vocational high school students. Validity data analysis was carried out using the Intraclass Correlation Coefficient (ICC); if the rater consistency is 0.500, it is classified as valid (Su et al., 2023). It can be concluded that the agreement between raters is very strong, and each rater has a pretty good consistency. The reliability of the questionnaire was tested using Cronbach's alpha to analyze the suitability of the research questions (Surucu and Maslakci, 2020). Cronbach's alpha has been widely used in studies in the field of science education to see if the questionnaire is reliable (Baidal-Bustamante et al., 2023).

Table 1. Research Instrument Indicators and Pilot Study Analysis Results

Variables and Indicators		Answer	Intraclass Correlation Coefficient (ICC)	Cronbach's alpha Coefficient
Adaptive capacity has three evaluation indicators: adapting and accepting change, contributing to change, and encouraging and handling change.	Rubric assessment	Likert scale - strongly agree (5), to strongly disagree (1)	0.890	0.578
Decision Making has two indicators of evaluation objectives: decision-making with criteria when alternatives are proposed and choosing the most appropriate option to anticipate the consequences.	Rubric assessment	Likert scale - very often (5), to never (1)	0.696	0.616
Problem Solving has three indicators of evaluation objectives: identifying problems, analyzing and solving problems, preventing problems, and overcoming complex problems.	Rubric assessment	Likert scale - strongly agree (5), to strongly disagree (1)	0.821	0.801
Creativity has two evaluation indicators, namely, generating ideas and creating original ideas for specific purposes	Rubric assessment	Likert scale - strongly agree (5), to strongly disagree (1)	0.601	0.615

Table 2. Hypothesis Development

Variable		Hypothesis		Data Analysis Technique
Independent	Dependent	Null Hypothesis (H0)	Hypothesis Alternatives (Ha)	
Constructivist Feedback-Based Assessment Method	Adaptive Capacity	There is no difference in the Adaptive Capacity ability of experimental and control group students after applying the Constructivist Feedback-Based Assessment Method.	There is a difference in the Adaptive Capacity ability of experimental and control group students after applying the Constructivist Feedback-Based Assessment Method.	Independent sample t-test
	Decision Making	There is no difference in the decision-making ability of experimental and control group students after applying the Constructivist Feedback-Based Assessment Method.	There is a difference in the decision-making ability of experimental and control group students after applying the Constructivist Feedback-Based Assessment Method.	
	Problem-Solving	There is no difference in the problem-solving ability of experimental and control group students after applying the Constructivist Feedback-Based Assessment Method.	There is a difference in the problem-solving ability of experimental and control group students after applying the Constructivist Feedback-Based Assessment Method.	
	Creativity	There is no difference in the creativity ability of experimental and control group students after applying the Constructivist Feedback-Based Assessment Method.	There is a difference in the creativity ability of experimental and control group students after applying the Constructivist Feedback-Based Assessment Method.	
	Adaptive Capacity, Decision Making, Problem Solving and Creativity	The constructivist feedback-based assessment method does not impact students' adaptive capacity, decision-making, problem-solving, and creativity in the experimental group.	The constructivist feedback-based assessment method impacts students' adaptive capacity, decision-making, problem-solving, and creativity in the experimental group.	

Data Analysis Technique and Hypothesis Development

This research was analyzed quantitatively using the methods of percentage, average, standard deviation, and parametric statistics. Hypotheses and data analysis techniques regarding the impact of the Constructivist Feedback-Based Assessment Method on students' adaptive capacity, decision-making, problem-solving, and creativity skills are presented in Table 2.

Results and Discussions

Needs Analysis and Development of Constructivist Feedback-Based Assessment Method

Need analysis is an analysis conducted to examine a phenomenon of the needs of a program (Mubai et al., 2020). Respondents used in filling out this needs analysis questionnaire are teachers of Vocational High Schools majoring in mechanical engineering in Padang City. The needs analysis is carried out to identify the learning evaluation that has been carried out at this time. This analysis is carried out as a consideration for developing constructivist feedback-based assessment methods in Vocational Schools. The results of observations made at several vocational schools in Padang City stated that teachers had implemented evaluation or assessment in every lesson. However, the assessment teachers implement is still unstructured; sometimes, teachers give formative tests, and sometimes, they do not. Thus, teachers have not found the right way to implement assessment in learning. Teachers expect a structured assessment method that teachers can guide. The assessment plays an essential role in learning. A well-implemented assessment will improve the quality of education.

The needs analysis data shows a gap between the current assessment and the mean expectation of assessment implementation. It means that teachers expect an assessment method they can guide in a structured and easy-to-understand manner. It does not mean that teachers at school have not implemented the assessment system, but that the assessment has not been implemented optimally due to confusion in implementing the assessment method. Therefore, teachers expect an innovative assessment method to improve their education and learning levels. Teachers in vocational high schools are very open-minded to change, innovation, and the times, which is why they are also open-minded to this new assessment method that will be developed. Literate teachers always try to adapt to the environment and changing times. Assessment that is guided and maximally implemented can give students a perfect understanding of the material because teachers can design learning based on the assessment given, and the feedback given in this method can result in students being active in learning because there is more discussion about what has been understood, what will be done to improve understanding.

The implementation of assessment can analyze the extent of learners' mastery and what they have not mastered. Even in the literature, this assessment is ranked at the top in improving the quality of learning (Phelps, 2019). It means that by improving the quality of learning, students' learning outcomes will also increase (Hartmann, 2019). So, this research is expected to contribute to the science and related literature on constructivist feedback-based assessment methods, and the correct implementation of assessment will be implemented in learning. The assessment method has existed before and is implemented in schools. However, the weakness of the existing assessment method is that the assessment method is fixated on assessing students only without providing feedback on the assessment. This feedback is essential for students in learning, which can help learners assess performances that cannot be seen and felt by themselves (Jalinus et al., 2023), as well as a tool to motivate learners, notification or information, reinforcement, and motivation (Hattie, 2008).

This constructivist feedback assessment method was developed by (Middleton et al., 2023), which uses tutor input and the '5 Keys' indicators of academic value, namely: (i) internal locus of control; (ii) understanding the class; (iii) forward-thinking; (iv) improvement-focused, and (v) action-oriented. However, the weakness of the (Middleton et al., 2023) assessment method is that they do not emphasize dialogic interaction. Thus, the novelty of this research is to develop a constructivist feedback-based assessment method, which aims to achieve positive outcomes by providing a person with comments or suggestions that are useful for their learning or future and constructing students' knowledge. This constructive feedback focuses on the work rather than being a personally damaging attack on the individual. So, the results can

be faster processes, improved behavior, identifying weaknesses, or providing new perspectives. The following constructive feedback-based assessment methods have been developed.

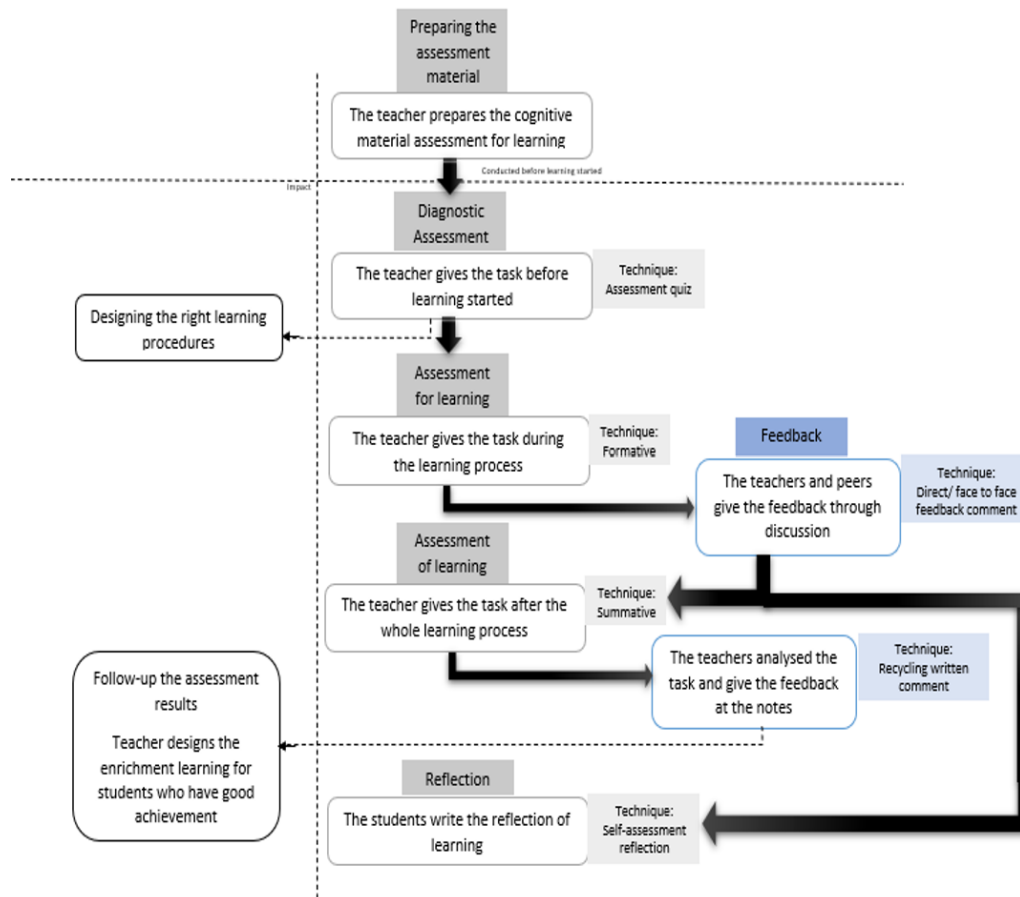


Figure 2. Constructivist Feedback-Based Assessment Method

In this constructivist feedback-based assessment method, there are five steps that the teacher must take: Preparing the assessment material; at this stage, the teacher prepares the assessment material before the learning begins. Educators often forget to prepare assessment materials because they are busy preparing them in the form of syllabuses, lesson plans, and teaching materials before learning begins, so the preparation of assessment materials is often neglected. When teachers implement this assessment method, this first stage will remind teachers to prepare assessment materials that will be implemented in learning. This activity is carried out before learning begins. Diagnostic Assessment: this second stage is conducted before the learning begins; at this stage, teachers can provide a series of written questions (multiple choice or short answer) to assess students' current knowledge base or current views on the topic/issue to be studied in the subject. Teachers can use this diagnostic assessment to analyze students' initial abilities. Thus, the teacher can design the proper learning procedure according to the student's initial abilities visible through the diagnostic assessment.

Assessment for Learning This third stage is carried out during the learning process; what is meant during the learning process is that the teacher can give this test when the subject matter is completed in one day, for example, daily assignments. The technique used in this stage is formative assessment. The test given can be multiple choice, essay, or even case. By this stage, students can construct their knowledge based on the given cases by teachers. After this stage, the teacher provides feedback to students about their learning understanding and how to improve learning understanding; the technique used in this feedback is face-to-face/direct comment. **Assessment of Learning:** an assessment conducted after all learning has been completed; the technique used in this assessment is a summative test and can be given at the end of the semester. This assessment is used to determine future learning goals and pathways for students. After this assessment stage, the teacher also provides feedback written on notes. The teacher can use the results of this assessment to see if the students' abilities have reached

the goals and standards of learning. Reflection: The last stage is reflection; at this stage, students reflect on themselves about what they have learned, what they understand, and what they have not understood. This reflection stage can be done at the end of the semester.

Impact of Students' Skills Toward the Implementation of Constructivist Feedback-Based Assessment Method

Implementing the constructivist feedback-based assessment method in learning activities can effectively develop students' adaptive capacity, decision-making, problem-solving, and creativity. This is in line with the findings of (Gulikers et al., 2013), which state that Feedback-Based Assessment contributes to developing students (Furtak et al., 2008) and added that students' creativity and problem-solving skills can be improved through Feedback-Based Assessment.

The Impact on Adaptive Capacity

The data analysis results on the impact of the Constructivist Feedback-Based Assessment Method on the adaptive capacity instrument showed that the "strongly agree" score was the highest percentage among all items (Table 3). The item "Students can provide several alternative solutions to solve problems" achieved the highest score ($M=67.8$, $SD=84.9$), with 62.3% of students at the very adaptable level and 24.6% at the adaptable level. Furthermore, "Students can control changes and support my friends" received the lowest score of the five items ($M = 64.8$, $SD = 62.6$); 41% of students are competent, and 45.9% can control changes.

Table 3. Data Analysis of Adaptive Capacity Rubric on Control Group

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	M	SD
Post-test							
Students are adaptable and work with different groups	20 (33.3%)	0 (0%)	0 (0%)	11 (18.3%)	30 (50%)	30,5	47,5
Students can accept change as a challenge	15 (25%)	1 (1.6%)	0 (0%)	18 (30%)	27 (45%)	28,8	34,8
Students can provide several alternative solutions to solve the problem	16 (26.67%)	1 (1.6%)	1 (1.6%)	18 (30%)	25 (41.67%)	30,8	36,2
Students can control change and support friends	10 (16.67%)	0 (0%)	0 (0%)	15 (25%)	36 (60%)	20,0	24,5
Students can work towards a goal	15 (25%)	0 (0%)	1 (1.6%)	10 (16.67%)	35 (58.3%)	24,5	34,8
Pre-test							
Students are adaptable and work with different groups	0 (0%)	0 (0%)	1 (1.6%)	27 (45%)	33 (55%)	18	24,5
Students can accept change as a challenge	0 (0%)	0 (0%)	0 (0%)	27 (45%)	34 (56.6%)	17,6	25,1
Students can provide several alternative solutions to solve the problem	0 (0%)	0 (0%)	1 (1.6%)	24 (40%)	36 (60%)	17,4	22,9
Students can control change and support friends	0 (0%)	0 (0%)	2 (3.3%)	27 (45%)	32 (53.3%)	18,4	23,9
Students can work towards a goal	0 (0%)	0 (0%)	1 (1.6%)	29 (48.3%)	31 (51.7%)	18,4	25,7

Based on the data analysis in Table 3, it can be concluded that the control group that did not implement the Constructivist Feedback-Based Assessment Method of learning has not improved students' adaptive capacity, which can be seen as the most of highest scores in the 'never.' Data analysis of the

adaptive capacity rubric on an experimental group can be seen in Table 4.

Table 4. Data Analysis of Adaptive Capacity Rubric on Experimental Group

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	M	SD
Post-test							
Students are adaptable and work with different groups	29 (47.5%)	15 (24.6%)	10 (16.4%)	7 (11.5%)	0 (0%)	62.3	58.4
Students can accept change as a challenge	32 (52.5%)	20 (32.8%)	9 (14.8%)	0 (0%)	0 (0%)	66.8	70.5
Students can provide several alternative solutions to solve the problem	38 (62.3%)	15 (24.6%)	5 (8.2%)	3 (4.9%)	0 (0%)	67.8	84.9
Students can control change and support friends	25 (41%)	28 (45.9%)	6 (9.8%)	2 (3.3%)	0 (0%)	64.8	62.6
Students can work towards a goal	30 (49.2%)	31 (50.8%)	0 (0%)	0 (0%)	0 (0%)	68.5	79.8
Pre-test							
Students are adaptable and work with different groups	1 (1.6%)	1 (1.6%)	10 (16.4%)	26 (42.6%)	23 (37.7%)	22,8	19,8
Students can accept change as a challenge	0 (0%)	0 (0%)	11 (18%)	26 (42.6%)	24 (39.3%)	21,8	22,3
Students can provide several alternative solutions to solve the problem	0 (0%)	1 (1.6%)	8 (13.1%)	26 (42.6%)	26 (42.6%)	21,2	20,8
Students can control change and support friends	0 (0%)	0 (0%)	6 (9.8%)	28 (45.9%)	27 (44.3%)	20,2	23,2
Students can work towards a goal	0 (0%)	0 (0%)	9 (14.7%)	25 (40.9%)	27 (44.3%)	20,8	21,2

Based on the data analysis in Table 3, it can be concluded that implementing the Constructivist Feedback-Based Assessment Method of learning has improved students' adaptive capacity, which can be seen in the highest scores. The significant differences between the pre-test and post-test analysis of the control and experimental groups can be seen in Table 5 in detail.

Table 5. Analysis of Adaptive Capacity T-test Results

Observations	Groups	N	Paired Sample T-test			
			Mean Differences	t	df	P
Pretest-Posttest analysis of adaptive capacity instrument	Experimental Group	61	21.6	6.961	60	0.000
	Control Group	60	7.48	0.758	59	0.412
Post-test comparison analysis of adaptive capacity instrument			Independent Sample T-test			
			M	t	df	P
	Experimental Group	61	64.23	5.864	120	0.000
	Control Group	60	49.68			

Table 5 showed a significant difference between the experimental and control groups on adaptive capacity ($df=120$, $t=5.864$, $pvalue=$, $p<0.05$). It indicates that the experimental group had a higher mean adaptive capacity at the post-test than the control group. Therefore, the impact of the treatment was already evident in the post-test scores after the implementation of the Constructivist Feedback-Based Assessment Method in the experimental group. It can be seen in the P-value; if the P-value > 0.05 , then

the null hypothesis is rejected. Based on the data above, it can be interpreted that H0 is rejected, which means there is a significant difference between the experimental and control groups on the post-test score. The results of this study indicate that the Constructivist Feedback-Based Assessment Method can improve adaptive capacity. Alt et al., (2023) found that through the Constructivist Feedback-Based Assessment Method, students can get feedback from the teacher that will affect logical thinking and reflective thinking and provide explanations. This increase in logical thinking can improve students' adaptive capacity (Arsovic and Stefanovic, 2020; Handrayani et al., 2023; Wulansari and Nabawi, 2021).

The Impact on Decision-Making

The results on the impact of the Constructivist Feedback-Based Assessment Method on Decision-Making showed that the score of "very often" was the highest percentage among all items (Table 5). The item "Students can make the right decision when trying to choose between various alternative solutions to a problem" achieved the highest score (M=57.4, SD=105.6), with 80.3% of students very often and 13.1% of students often discussing with the teacher. Moreover, "Students do not make decisions based on emotional factors" got the lowest score of the four items (M = 54.4, SD = 77.9), namely 60.7% of students very often and 27.9% of students often do not make decisions based on emotional factors.

Table 6. Data Analysis of Decision-Making Rubric on Control Group

Item	Very often	Often	Sometimes	Rare	Never	M	SD
Post-test							
Students discuss with the teacher to make a decision	20 (33.3%)	0 (0%)	3 (5%)	0 (0%)	37 (61.7%)	29,2	42,4
Students do not make decisions based on emotional factors	23 (38.3%)	0 (0%)	0 (0%)	0 (0%)	37 (61.7%)	30,4	49,9
Students can discuss the consequences of various alternative decisions	15 (25%)	0 (0%)	7 (11.7%)	5 (8.3%)	34 (56.7%)	28	29,2
Students can make informed decisions when choosing between various alternative solutions to a problem.	18 (30%)	0 (0%)	4 (6.7%)	3 (5%)	36 (60%)	28,8	36,8
Pre-test							
Students discuss with the teacher to make a decision	0 (0%)	0 (0%)	7 (11.7%)	12 (20%)	41 (68.3%)	17,2	17,5
Students do not make decisions based on emotional factors	0 (0%)	0 (0%)	6 (10%)	12 (20%)	42 (42%)	16,8	17,7
Students can discuss the consequences of various alternative decisions	0 (0%)	0 (0%)	2 (3.3%)	20 (33.3%)	38 (63.3%)	16,8	20,4
Students can make informed decisions when choosing between various alternative solutions to a problem.	0 (0%)	0 (0%)	6 (10%)	19 (31.7%)	35 (58.3%)	18,2	18,3

Based on the data analysis in Table 6, it can be concluded that the control group that did not implement the Constructivist Feedback-Based Assessment Method of learning did not improve students' decision-making, which can be seen as the most of highest scores in the 'never.' Data analysis of the decision-making rubric on the experimental group can be seen in Table 7.

Table 7. Data Analysis of Decision-Making Rubric on Experimental Group

Item	Very often	Often	Sometimes	Rare	Never	M	SD
Post-test							
Students discuss with the teacher to make a decision	38 (62.3%)	17 (27.9%)	3 (4.9%)	0 (0%)	3 (4.9%)	54	81.0
Students do not make decisions based on emotional factors	37 (60.7%)	17 (27.9%)	5 (8.2%)	2 (3.3%)	0 (0%)	54.4	77.9
Students can discuss the consequences of various alternative decisions	48 (78.7%)	3 (4.9%)	7 (11.5%)	3 (4.9%)	0 (0%)	55.8	103.3
Students can make informed decisions when choosing between various alternative solutions to a problem.	49 (80.3%)	8 (13.1%)	2 (3.3%)	2 (3.3%)	0 (0%)	57.4	105.6
Pre-test							
Students discuss with the teacher to make a decision	0 (0%)	1 (1.6%)	9 (14.8%)	12 (19.7%)	39 (63.9%)	18,8	16,4
Students do not make decisions based on emotional factors	0 (0%)	0 (0%)	4 (6.6%)	22 (36.1%)	36 (59%)	18,4	20,5
Students can discuss the consequences of various alternative decisions	0 (0%)	0 (0%)	7 (11.5%)	7 (11.5%)	47 (77%)	16,4	19,4
Students can make informed decisions when choosing between various alternative solutions to a problem.	0 (0%)	0 (0%)	5 (8.2%)	10 (16.4%)	46 (75.4%)	16,2	18,9

Based on the data analysis in Table 7, it can be concluded that implementing the Constructivist Feedback-Based Assessment Method of learning has improved students' decision-making skills. The significant differences between the pre-test and post-test analysis of the control and experimental groups can be seen in Table 8 in detail.

Table 8. Analysis of Decision-Making T-test Results

Observations	Groups	N	Paired Sample T-test			
			Mean Differences	t	df	P
Pretest-Posttest analysis of adaptive capacity instrument	Experimental Group	61	2.11	6.872	60	0.001
	Control Group	60	6.16	0.976	59	0.633
Post-test comparison analysis of adaptive capacity instrument			Independent Sample T-test			
			M	t	df	P
	Experimental Group	61	51.05	6.375	120	0.000
	Control Group	60	38.29			

Table 8 showed a significant difference in decision-making skills between the experimental and control groups ($df=120$, $t=6.375$, $p\text{-value}=, p<0.05$). It shows that the experimental group has a higher mean decision-making score in the post-test than the control group. Therefore, the impact of the treatment was already evident in the post-test scores after the implementation of the Constructivist Feedback-Based Assessment Method in the experimental group. It can be seen that at the $P\text{-value} > 0.05$, the null hypothesis is rejected. Based on the data above, it can be interpreted that H_0 is rejected, which means there is a

difference in the decision-making skills of experimental and control group students after implementing the Constructivist Feedback-Based Assessment Method. This is in line with research conducted by (Fazel and Ali, 2022), which explains that feedback gives students an overview of their decisions. They can see the positive and negative aspects of their decisions. By realizing the consequences of the decisions, students become more cautious and consider their choices better. It also helps students understand how to solve problems arising from their decisions (Torres et al., 2020). They can see the impact of their decisions on the situation and learn how to overcome the problems that arise (Teräs et al., 2020).

The Impact on Problem-Solving

The data analysis result of the impact of the Constructivist Feedback-Based Assessment Method on problem-solving showed that the "strongly agree" score was the highest percentage among all items (Table 7). The item "Students can make good decisions in solving problems to achieve goals" achieved the highest score ($M=57.8$, $SD=103.2$), with 78.7% of students at the very capable level and 16.4% of students at the capable level of making good decisions. Furthermore, "Students can consider a variety of solutions" got the lowest score of the four items ($M = 55.4$, $SD = 79.7$); 60.7% of students are capable, and 32.8% can consider different solutions.

Table 9. *Data Analysis of Problem-Solving Rubric on Control Group*

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	M	SD
Post-test							
Students can identify problems that arise	28 (46.7%)	1 (1.7%)	5 (8.3%)	10 (16.7%)	15 (25%)	38,8	56,9
Students can make good decisions in solving problems to achieve goals	19 (31.7%)	0 (0%)	3 (5%)	13 (21.7%)	25 (41.7%)	31	37,4
Students can solve complex problems well	16 (26.7%)	1 (1.7%)	3 (5%)	17 (28.3%)	23 (38.3%)	30	30,3
Students can consider a range of different solutions.	23 (38.3%)	0 (0%)	4 (6.7%)	10 (16.7%)	23 (38.3%)	34	46,1
Pre-test							
Students can identify problems that arise	0 (0%)	0 (0%)	4 (6.7%)	9 (15%)	47 (78.3%)	15,4	19,3
Students can make good decisions in solving problems to achieve goals	0 (0%)	0 (0%)	0 (0%)	12 (19.7%)	48 (80%)	14,4	21,5
Students can solve complex problems well	0 (0%)	0 (0%)	2 (3.3%)	12 (19.7%)	46 (76.7%)	15,2	19,8
Students can consider a range of different solutions.	0 (0%)	0 (0%)	2 (3.3%)	13 (21.7%)	45 (75%)	15,4	19,7

Based on the data analysis in Table 9, it can be concluded that the control group that did not implement the Constructivist Feedback-Based Assessment Method of learning did not improve students' problem-solving, which can be seen as the highest scores in the 'never.' Data analysis of the problem-solving rubric on the experimental group can be seen in Table 10.

Table 10. Data Analysis of Problem-Solving Rubric on Experimental Group

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	M	SD
Post-test							
Students can identify problems that arise	39 (63.9%)	20 (32.8%)	0 (0%)	2 (3.3%)	0 (0%)	55.8	85.0
Students can make good decisions in solving problems to achieve goals	48 (78.7%)	10 (16.4%)	3 (5%)	0 (0%)	0 (0%)	57.8	103.2
Students can solve complex problems well	38 (62.3%)	16 (26.2%)	3 (5%)	4 (6.6%)	0 (0%)	54.2	80.1
Students can consider a range of different solutions.	37 (60.7%)	20 (32.8%)	4 (6.7%)	0 (0%)	0 (0%)	55.4	79.7
Pre-test							
Students can identify problems that arise	0 (0%)	0 (0%)	10 (16.4%)	2 (3.3%)	49 (80.3%)	16,6	22,0
Students can make good decisions in solving problems to achieve goals	0 (0%)	0 (0%)	4 (6.7%)	12 (19.7%)	45 (73.8%)	16,2	18,9
Students can solve complex problems well	0 (0%)	0 (0%)	3 (5%)	10 (16.4%)	48 (78.7%)	15,4	20,0
Students can consider a range of different solutions.	0 (0%)	0 (0%)	3 (5%)	11 (18%)	47 (77%)	15,6	19,7

Based on the data analysis in Table 10, it can be concluded that implementing the Constructivist Feedback-Based Assessment Method of learning has improved students' problem-solving skills. The significant differences between the pre-test and post-test analysis of the control and experimental groups can be seen in Table 11 in detail.

Table 11. Analysis of Problem-Solving T-test Results

Observations	Groups	N	Paired Sample T-test			
			Mean Differences	t	df	P
Pretest-Posttest analysis of adaptive capacity instrument	Experimental Group	61	2.74	6.286	60	0.001
	Control Group	60	4.82	0.885	59	0.736
Post-test comparison analysis of adaptive capacity instrument			Independent Sample T-test			
			M	t	df	P
	Experimental Group	61	57.42	5.582	120	0.001
	Control Group	60	36.01			

Table 11 showed a significant difference in problem-solving ability between the experimental and control groups ($df=120$, $t=5.582$, $p\text{-value}=$, $p<0.05$). It showed that the experimental group had a higher mean problem-solving score in the post-test than the control group. Therefore, the impact of the treatment was already apparent in the post-test scores after the implementation of the Constructivist Feedback-Based Assessment Method in the experimental group. It can be seen in the $P\text{-value}> 0.05$ that the null hypothesis is rejected. Based on the data above, it can be interpreted that H_0 is rejected, which means there are differences in the problem-solving skills of experimental and control group students after implementing the Constructivist Feedback-Based Assessment Method. The feedback assessment method has a significant impact on students' problem-solving skills. By providing excellent and directed feedback, students can better develop their problem-solving skills (Mubai et al., 2020). Menurut (Kardoyo

et al., 2020) also explains that students learn to evaluate their proposed solutions through feedback. They can see the advantages and disadvantages of their solutions and understand the criteria for good evaluation (Lacey and Minnis, 2020). These skills are essential in choosing the best solution from various possible alternatives. Also, feedback gives students an idea of their approach to the problem. They become more aware of the strategies they choose and realize if there are weaknesses in their approach (Taherdoost, 2022).

The Impact on Creativity

The analysis of the impact of the Constructivist Feedback-Based Assessment Method on creativity showed that the score of "strongly agree" was the highest percentage among all items (Table 9). The item "Students can analyze their ideas to optimize results" achieved the highest score ($M=57.2$, $SD=100.7$), with 77% of students at the very capable level and 16.4% at the capable level of analyzing ideas. Moreover, "Students are curious and interested in learning new things" received the lowest score of the four items ($M=54.6$, $SD=76$), where 59% were very curious, and 29.5% were curious and interested in learning new things.

Table 12. Data Analysis of Creativity Rubric on Control Group

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	M	SD
Post-test							
Students are interested in learning new things	28 (46.7%)	1 (1.7%)	6 (10%)	5 (8.3%)	20 (33.3%)	38,4	57,2
Students can analyze their ideas to optimize results	18 (30%)	1 (1.7%)	4 (6.7%)	18 (30%)	30 (50%)	34,4	33,7
Students can create new ideas based on limited information	17 (28.3%)	16 (26.2%)	1 (1.7%)	13 (21.7%)	27 (45%)	29,8	32,6
Students efficiently implement their new ideas into a project.	17 (28.3%)	1 (1.7%)	17 (28.3%)	6 (10%)	19 (31,7%)	34,2	33,5
Pre-test							
Students are interested in learning new things	0 (0%)	0 (0%)	3	10	47	15,2	19,6
Students can analyze their ideas to optimize results	0 (0%)	0 (0%)	10	16	34	19,2	17,6
Students can create new ideas based on limited information	0 (0%)	0 (0%)	2	15	43	15,8	19,6
Students efficiently implement their new ideas into a project.	0 (0%)	0 (0%)	4	13	43	16,2	18,4

Based on the data analysis in Table 12, it can be concluded that the control group that did not implement the Constructivist Feedback-Based Assessment Method of learning has not improved students' creativity, which can be seen as the most of highest scores being in the 'never.' Data analysis of the creativity rubric on the experimental group can be seen in Table 13.

Table 13. Data Analysis of Creativity Rubric on Experimental Group

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	M	SD
Post-test							
Students are interested in learning new things	36 (59.0%)	18 (29.5%)	7 (11.5%)	0 (0%)	0 (0%)	54.6	76.0
Students can analyze their ideas to optimize results	47 (77.0%)	10 (16.4%)	3 (4.9%)	1 (1.6%)	0 (0%)	57.2	100.7
Students can create new ideas based on limited information	39 (63.9%)	20 (32.8%)	0 (0%)	2 (3.3%)	0 (0%)	55.8	85.0
Students efficiently implement their new ideas into a project.	36 (59.0%)	10 (16.4%)	15 (24.6%)	5 (8.2%)	0 (0%)	55	72.5
Pre-test							
Students are interested in learning new things	0 (0%)	0 (0%)	6 (9.8%)	12 (19.7%)	43 (70.5%)	17	18,1
Students can analyze their ideas to optimize results	0 (0%)	0 (0%)	1 (1.6%)	15 (24.6%)	45 (73.8%)	15,6	20,7
Students can create new ideas based on limited information	0 (0%)	0 (0%)	2 (3.3%)	17 (27.9%)	42 (68.9%)	16,4	20,1
Students efficiently implement their new ideas into a project.	0 (0%)	0 (0%)	5 (8.2%)	11 (18%)	41 (67.2%)	15,6	17,1

Based on the data analysis in Table 13, it can be concluded that implementing the Constructivist Feedback-Based Assessment Method of learning has improved students' creativity ability. The significant differences between the pre-test and post-test analysis of the control and experimental groups can be seen in Table 14 in detail.

Table 14. Analysis of Creativity T-test Results

Observations	Groups	N	Paired Sample T-test			
			Mean Differences	t	df	P
Pretest-Posttest analysis of adaptive capacity instrument	Experimental Group	61	3.76	7.719	60	0.000
	Control Group	60	6.29	0.674	59	0.736
Post-test comparison analysis of adaptive capacity instrument			Independent Sample T-test			
			M	t	df	P
	Experimental Group	61	56.11	6.264	120	0.000
	Control Group	60	37.07			

Table 14 showed a significant difference in creativity skills between the experimental and control groups ($df=120$, $t=6.261$, $p\text{-value}=$, $p<0.05$). It showed that the experimental group had a higher average creativity value in the post-test than the control group. Therefore, the impact of the treatment was already apparent in the post-test scores after the implementation of the Constructivist Feedback-Based Assessment Method in the experimental group. It can be seen in the $P\text{-value} > 0.05$ that the null hypothesis is rejected. Based on the data, it can be interpreted that H_0 is rejected, which means there are differences in the creativity skills of experimental and control group students after implementing the Constructivist Feedback-Based Assessment Method. This is in line with research conducted by (Jawad et al., 2021), which states that implementing feedback assessment methods significantly impacts the

development of students' creativity abilities. Feedback given to students can stimulate the exploration of new ideas. By understanding the positive aspects of their creative ideas, students become more motivated to try different approaches and expand the boundaries of their creativity (Balakrishnan, 2022); when students get positive feedback and feel supported in their creative ideas, they feel more ownership of that creativity. This sense of ownership increases the motivation to continue developing and expressing their creativity (Cai et al., 2020). Feedback assessment methods can expand and enrich students' creativity skills by providing constructive and supportive feedback. This is not only beneficial in the context of formal education but also prepares students to face creative challenges in daily life and the future (Fortuna et al., 2023; Sansi et al., 2023).

Linear Regression Analysis

Linear regression analysis is a statistical method to understand a study's relationship between two or more variables. In linear regression, the main objective is understanding how the dependent variable (y) relates to one or more independent variables (x). This relationship can be linear, which means that constant changes in the independent variables can explain changes in the dependent variable. In this study, there are four independent variables, namely adaptive capacity (X1), decision-making (X2), problem-solving (X3), and creativity (X4), and one dependent variable, namely Constructivist Feedback-Based Assessment Method (Y). So, the linear regression equation is as follows.

$$y = a + bx_1 + bx_2 + bx_3 + bx_4 + \varepsilon \quad (1)$$

Here, y is the dependent variable, x is the independent variable, a is the intercept (the value of y when x = 0), b is the regression coefficient (shows how much change is expected when increasing by one unit), and ε is the prediction error. Before conducting a linear regression analysis, the analytical prerequisite tests of normality (Figure 3a) and linearity (Figure 3b) must be performed first.

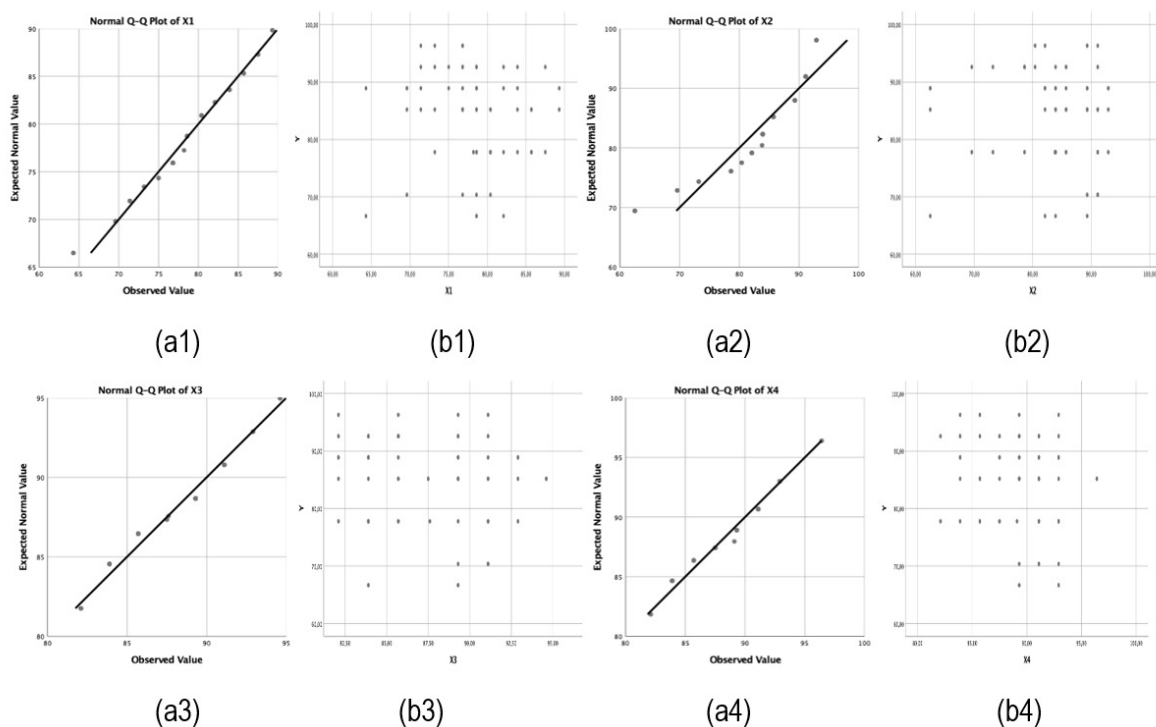


Figure 3. Results of QQ-Plots Normality (a) and Scatter Plots Linearity (b) of research variables

Figure 3 above shows that the distribution of research data was normal and linear. Based on the results of the Saphiro-Wilk analysis, the adaptive capacity variable (Figure 3a1) [$p > 0.05$, $W = 0.76$], the decision-making variable (Figure 3a2) [$p > 0.05$, $W = 0.92$], the problem-solving variable (Figure 3a3) [$p > 0.05$, $W = 0.81$], and the creativity variable (Figure 3a4) [$p > 0.05$, $W = 0.79$] indicate that the research data are normal. In addition, the scatter plot illustration on each variable shows that the observation

points are evenly distributed, indicating that the linearity assumption has been met. Therefore, it can be concluded that this research data is eligible for parametric analysis, namely linear regression analysis (Table 11), because it meets the analysis requirements test.

Table 15. Linear Regression Analysis Results

	B	t	Sig.	r ²
Constant	16.577			
Adaptive Capacity	0.740	9.166	0.000	0.71
Decision-Making	0.766	8.460	0.000	0.75
Problem-Solving	0.806	9.376	0.001	0.82
Creativity	0.788	9.643	0.000	0.77
Sample	121			
P-Value	0.000			
F Value	18.784			
Regression Equation	$y = 16.577 + 0.740x_1 + 0.766x_2 + 0.806x_3 + 0.788x_4 + \varepsilon$			

In this Linear Regression analysis, the pre-test was used to compare adaptive capacity, decision-making, problem-solving, and creativity abilities between the experimental and control groups after being given a pre-test before and post-test after treatment. The Linear Regression Analysis presented in Table 15 showed that there is a significant difference between the experimental group and the control group after implementing the Constructivist Feedback-Based Assessment Method treatment ($F(1, 119) = 18.784$, $p < 0.05$). There was a significant difference between the experimental group students and the control group in the ability of adaptive capacity ($p < 0.05$), decision-making ($p < 0.05$), problem-solving ($p < 0.05$), and creativity ($p < 0.05$), where the experimental group students have better abilities than the control group (Figure 4) after the implementation of Constructivist Feedback-Based Assessment Method. Table 15 also showed that 71% adaptive capacity, 75% decision-making, 82% problem-solving, and 77% creativity influence Constructivist Feedback-Based Assessment Method.

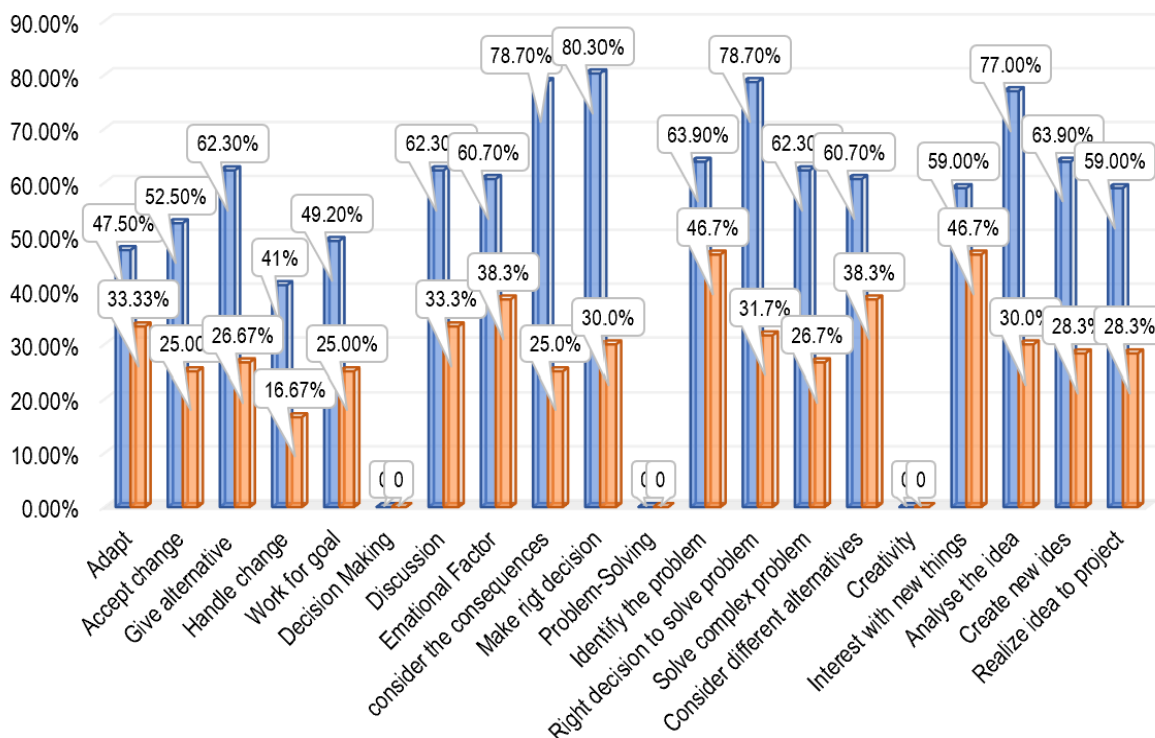


Figure 4. Comparison of Experimental and Control Class Skill Percentages

This study's results align with (van der Kleij, 2019), which explains that feedback assessment provides positive results on student skills. Implementing constructivist feedback-based assessment methods allows learners to know what and why they will learn to become active participants in the passive learning process. When introducing a new topic, learners must share the objectives they need to get good results and notes (Oliveira et al., 2021). From the beginning of learning, learners are responsible for their learning, allowing each to create their knowledge of the subject, cooperate with their peers and educators, expand their framework, and move towards better knowledge and understanding of complex subjects (Falloon, 2020). One of the benefits of sharing learning objectives with learners is that they will be given tasks that match the learning objectives. According to (Ibarra-sáiz et al., 2020), effective assessment is applied by providing feedback during learning to regulate the teaching and learning process to improve learners' achievement. According to (Tang et al., 2020), assessment can be considered a valid and essential part of integrating teaching and assessment. Assessments inform educators about whether learners have learned, and they have qualifying indicators of how educators should plan subsequent lessons (Firestone and Donaldson, 2019). There are four main components to assessment (Morales, 2022): (i) clarifying learning objectives and success criteria; (ii) improving the quality of inquiry/dialogue; (iii) improving the quality of marking/feedback/recording; and (iv) using self and peer assessment.

One of the key elements of assessment is asking questions (Guangul et al., 2020). Educators can use one-third of their teaching time to ask learners questions (Alt et al., (2023)). Asking questions in the form of a feedback-based assessment is essential for gaining information about learners' learning and understanding. This goal can be achieved if questions are active and influential in determining and constructing the learner's depth of knowledge (Mohammed et al., 2020). Feedback is at the heart of this assessment method (Waskito et al., 2023). The impact of this assessment method arises from the power of feedback given to learners about their learning (Brown, 2019). According to Shute [49], feedback is information sent to learners that enables or encourages them to regulate thoughts or behaviors to improve learning. According to (Brown, 2019), feedback provided through assessment significantly benefits learners' motivation, helps learners improve the quality of learning, strengthens learners' memory, and gives learners a profile of learning.

Conclusions

This study developed the Constructivist Feedback-Based Assessment Method. It looked at the effectiveness of implementing the Constructivist Feedback-Based Assessment Method on students' adaptive capacity, decision-making, problem-solving, and creativity. The results show that the Constructivist Feedback-Based Assessment Method effectively improves students' adaptive capacity, decision-making, problem-solving, and creativity. It also proves that a suitable assessment method can affect students' skills. This research contributes to existing knowledge, especially on assessment in learning, where this research provides a constructive assessment method that can be used as a consideration for teachers to apply to learning. The limitation of this research is that the constructivist feedback-based assessment method that has been developed has only been applied to see the students' adaptive capacity, decision-making, problem-solving, and creativity. It is hoped that this constructivist feedback-based assessment method can be applied for future research to see its effectiveness on other students' skills and abilities.

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Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions

Conceptualization, W.W., R.E.W.; Methodology, W.W., R.R., R.E.W.; Formal analysis, R.E.W., A.F.; Validation, A.N., writing—original draft preparation: W.W., R.E.W.; writing—review and editing, R.E.W.,

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Preservice Teachers' Level of Knowledge on Elements and Rationale for Nature of Science: Towards Advancing Quality Instruction

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Abstract: This study investigates preservice teachers' knowledge of elements and rationale for Nature of Science (NOS). Skill gap is established in the literature on pedagogical practices of preservice as well as novice teachers of science, reflecting deficiency in their professional training and eventual classroom practice. Examining preservice teachers' knowledge in these aspects (elements & rationale) of NOS through a quasi-experiment of one-group pretest and post-test design was done. Instructional intervention over two years along with assignments and presentation with researchers as moderators on the science pedagogy module (History of Science and Philosophy of Science) serves as stimuli over the period. Three research questions and two hypotheses were raised to guide this study. One hundred and thirty-six (112 Life Science and 24 Physical Science) preservice teachers were the participants. Element of NOS (ENOS) and Rationale for NOS (RNOS) were the instruments. Reliability of the instruments yielded Cronbach alpha values of .83, .91 and .86 across dimensions of clarity, coherence and relevance by fifteen experienced science educators. Data was analysed using t-test and ANCOVA. The study found the intervention to effectively improve the knowledge of elements and rationale for NOS. Better prepared teachers (More Knowledge Order [MKO] have the potential to improved Zone of Proximal Development [ZPD] in learners) by implication have the competence to guide learners for qualitative and effective learning. The instruments in this study is recommended for foundational training of preservice teachers on NOS for enhanced instruction.

Keywords: *elements, NOS, preservice teachers, rationale, instruction.*

Introduction

This opening paragraph provides basic knowledge of Nature of Science (NOS) to novice audience to assist their understanding of succeeding paragraphs. Culture may be regarded as a way of life of a people. Such people are known for their traits, practices and ways which distinguishes them from others. Culture and tradition are amalgamated into history. Like other fields of knowledge or discipline, science is with its culture, tradition and history. In this instance, scientist have observation and experimentation as means of drawing inferences. The inferences drawn culminate into new knowledge which assist in better understanding of nature. Postulation, hypotheses (assumptions), theories and laws are traditional to science, and it processes. New knowledge often evolves from an assumption which is usually the starting point. However, the technology available for discovery at a particular time determines the extent of knowledge evolution. The umbrella name for culture, tradition and history is characterised as nature. The culture, tradition and history of science may literarily mean Nature of Science (NOS) without denouncing its philosophical and epistemological limits. Impacting the knowledge of science is science education, and science educator/teachers own this prerogative. Integrating NOS into classroom practices of science teachers for instruction has gained prominence. Storytelling, rote memorisation and field trip were ways of impacting the knowledge of science before now. Inquiry, argumentation among others have proven to better support learners' needs in recent time.

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Positions in the literature have established the need to improve the teaching of science through NOS integration (Bartos and Lederman, 2014; Clough, 2018; Mesci, 2020; Nouri and McComas, 2019; Yacoubian, 2021). Previous scholarly arguments have evolved the contexts [contextualised and decontextualised] (McComas, 2020; Mulvey and Bell, 2017; Wahbeh and Abd-El-Khalick, 2014; Wheeler et al., 2019), approaches [implicit and explicit] (McComas and Clough, 2020; Nouri and McComas, 2019; Nouri et al., 2021; Sweeney and McComas, 2022; Yacoubian, 2021) and explicit reflective integration (Hanuscin, 2013; Lederman et al., 2019; Vygotsky and Cole, 1978, p. 86; Wahbeh and Abd-El-Khalick, 2014). There is no doubt on the need to improve the way science is taught owing to growing demand and the need for expertise in Science Technology Robotics Engineering Arts (aesthetics) and Mathematics (STREAM) and the responsibility therewith (Abd-El-Khalick and Lederman 2000; Clough, 2018). Furthermore, attempts have been made by stakeholders to up-skill practising teachers to integrate NOS in their instruction. An effort which is usually driven by on-the-job training which deviates from the traditional way preservice content are structured. Those effort mostly arose from capacity building workshops, training and occasional self-development (Badmus and Jita, 2022). Substantively, what is required of science teacher educators and trainers for the training of preservice teachers on NOS instruction for improved practice has a place in the literature. In addition, science teacher educator in research and practice have identified competencies required by teachers for NOS integration (Nouri et al., 2021).

Developing preservice science teachers' NOS integration capacity to better facilitate students' learning and conceptualisation remain important in science education. For this goal to be achieved, teacher training and development should be prioritised. Recent studies have provided guidance on NOS integration (Alameh et al., 2023, Alameh and Abd-El-Khalick, 2018; Lederman and Lederman, 2019), NOS competencies (Nouri et al., 2021), structural elements of scientific explanations as well as models for teaching NOS and questionings (Allchin, 2017; Khishfe, 2022) to guide science teachers practices. Positions deducible from literature suggest that sizeable attention has been given to teacher development on the job and not teacher training before certification with respect to NOS integration. The study of Vygotsky and Cole, 1978, p. 86) identified convergent, divergent and evaluative questioning in student-centred classroom while Alameh et al., (2023) researched the nature of scientific explanations with emphasis on goodness and quality of explanations by college students, teachers and scientist to emphasize the importance of qualitative scientific explanations. Answers have also been availed in the literature regarding the construction of scientific explanations to suit students' conceptualisation of science (National Research Council [NRC], 2012). A shift from teacher development to Students' knowledge of NOS through socio-scientific issues has also added to the debate on NOS and its integration (Kahn and Zeidler, 2019; Khishfe, 2017, 2019, 2022; Lederman et al., 2014). Arising from the forgoing, adequate attention is required in preservice science teacher training especially when guidance on competencies, quality of explanations and more are well grounded within scholarly depth.

Teacher training forms the basis upon which professional and further development are built, especially for science teachers and science teacher educators. As such, preservice teacher training on NOS integration, competencies, models, templates and frameworks for pedagogical and didactic synchronisation with the curriculum is yet to gain prominence. Admittedly, possible variations may exist with respect to implementation and the universality of the curriculum components. However, presently lacking in the literature are foundational templates to guide the training of preservice teachers on the rationale and elements for NOS and its modes of assessment. Today's teachers are a product of prior academic and professional development. Evidently, inadequacies have been established in the literature regarding classroom practices of science teachers with respect to the quality of explanations students are availed (Alameh and Abd-El-Khalick, 2018; Mesci and Schwartz, 2017n with more capable peers'; Tang, 2016). To substantiate the afore-stated, Erduran (2006) documented the difficulties both students and teachers encounter when constructing scientific explanations. Furthermore, scholars have posited the existence of competence gap in teachers as reflected in explanations provided to students in science on scientific processes. It becomes imperative to improve science teacher training for preservice teachers on NOS, especially its integration to improve their pedagogical and didactic skills.

Theoretical Framework

Vygotsky defined zone of proximal development as 'the distance between the actual development

level (of the learner) as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers' (Vygotsky and Cole, 1978, p. 86)

Lev Vygotsky in 1978 proposed the theory of learning and development with More Knowledge Order (MKO) and Zone of Proximal Development (ZPD) at the time. While the goal of every teacher is to provide appropriate support for learners to develop learning experiences to realise their full potential. It is also imperative to understand that learner must be coming from a place of inferior knowledge or assumptions. That said, there needs to be knowledge difference for learning to take place (MKO). NOS integrated instruction provides appropriate and deliberate pedagogical support to equip teachers on ways to better assist individual learner based on their peculiarities. According to Vygotsky, teaching precedes development, as such, adequate attention is deserved of science teacher training considering the advancements in pedagogical research in science and science education. Collaboration is essential in NOS integration as well as ZPD with respect to thinking, pairing and sharing of knowledge and ideas. In addition, inquiry and argumentation have roles in both NOS integration and ZPD in nurturing and automating a scaffold to assist learners. Teachers in training otherwise known as preservice teachers must be open enough to negotiate learning in their classrooms for learners' internalisation and autonomy. The state of science teaching research is an aberration from past practice in terms of expected outcomes from all learners. Knowledge currently is individualised and contextualised, as such, preservice and in-service teachers are now more than ever required to know the best ways to support learners to maximise their potentials.

Vygotsky's theory has since evolved to accommodate possibilities of potential development among learners of equal peers, less capable peers and those working alone within their ZPD using learning strategies. However, teachers as experts have the advantage of accommodating learners' views through discussion and collaboration especially among learners themselves. As teachers, recruiting learners' interest is imperative to mastery, as such, both cognitive and affective domains must be supported to assist learners in developing self-efficacy, motivation, engagement and willingness in a socially mediated space. With NOS integration, teachers are better equipped with the requisite capacity and skill to support the development of learners through culture, history and tradition of science that allows for mastery of not only the knowledge of science but the mastery of science processes. ZPD is not static, when properly guided, learner ZPD are more sensitive to learning. How intellectual development is assisted through social interaction with peers and expert (teacher) to remediate the inadequacy of learners in science is our focus.

Literature Review

For teachers of science and those in training (preservice teachers), the construct from which inferences are made on scientific issues for classroom practice is germane. Subsequently important, is the construction of explanations for learners' appropriate conceptualisation of socio-scientific issues and scientific literacy which is embedded in NOS. The essence of learning science is to be functional enough to take informed decision as literates. Positions in the literature are explored here to aggregate scholarly findings on NOS with respect to why, what and how it is necessary in classroom practices of science teachers. Alameh et al., (2023) researched quality of scientific explanation among scientist, science teachers and college students. Scientific phenomena as explained by the three categories of participant were analysed along the Nature of Scientific Explanations (NOSE). The study found scientist to provide superior explanations to scientific phenomena than teachers and college students. The type of explanations provided in the study by these categories share construct similarities but differs in dimensions. An analytical framework was devised in the study to examine the construct and types of scientific explanation which by implication could assist in the training of both teachers and preservice teachers of science on elements and constructs of scientific explanations.

In a similar study, Mesci et al., (2023) emphasized the need for early professional development of teachers in training by advancing argumentation-based NOS instruction influence on preservice teachers' views and practices in a single experimental design with multiple data sources-like Views on Nature of Science [VNOS] (Lederman et al., 2002), interview, argumentation-based NOS report and research note. Explicit reflective method was adopted over a two-semester period among 41 preservice teachers at

a state university in Turkey. It was found that preservice teachers lesson planning and argumentation-based teaching improved significantly despite their inability to teach correctly at their first attempt. The study affirms the need for consistent practice of NOS knowledge in training for preservice teachers to perfect their NOS knowledge transfer to teaching. The position of [Mesci et al., \(2023\)](#) advanced the state of literature from [Abd-El-Khalik and Akerson, 2004](#) which emphasized a conceptual change in the views of preservice teachers on NOS. Earlier study identified mediating factors which may hinder training while the later study avail literature the progress made so far in preservice teacher training on NOS and its integration.

Secondary science preservice teachers were examined along contextualised and decontextualised NOS instruction to elicit data on conception and instructional intentions by [Bell et al., \(2016\)](#). The study sampled from two cohort of seventy master of teaching program where participants had explicit instruction on NOS conceptions using varied degree of contextualised which accommodated conceptual change principle in the first year of instruction. Evaluation of pre- and post-conception was done using VNOS-C questionnaire ([Lederman et al., 2002](#)) and interview. Participants' conceptions were categorised based on degree of alignment with NOS conception. Unlike the present study which sought to evaluate rationale for NOS among preservice teachers with a separate instrument, Bell and colleagues sought and reported significance in alignment to NOS instruction between pre and post conception. There was a shift in the conception of participants to plan future NOS instruction with sufficient rationale for integration especially in the teaching of evolution. The research substantiates the need for scaffolding in NOS lessons to change conception and instructional intention of preservice teachers with recommendations for future research in post-method course and post-program NOS instruction.

Problem Statement

Strengthening preservice teachers' knowledge of the Nature of Science (NOS) to achieve a thorough understanding for deliberate and thoughtful integration into their future classroom practices has garnered attention from scholars ([Alameh et al., 2023](#); [Alameh et al., 2023](#)). Within the realm of science education, teachers are expected to possess not only content knowledge but also pedagogical expertise to effectively convey scientific principles and processes to students in a genuine and meaningful manner. Recent perspectives in science education have favored explicit and reflective integration over implicit methods ([McComas and Clough, 2018](#); [Mesci, 2020](#); [Mesci et al., \(2023\)](#); [Sweeney and McComas, 2022](#)). As a result, there's an expectation for a shift in science education pedagogy to address uncertainties regarding scientific processes, cultural aspects, and socio-scientific issues among future educators (preservice teachers).

The existing environment of science teacher training in South Africa reflects elements of detached and implicit teachings on NOS. To progress towards explicit and contextualized NOS education in teacher training, a revaluation of the history and philosophy of science is necessary to introduce course content capable of enhancing preservice teachers' capabilities. Various dimensions have been explored in assessing preservice teachers' understanding of NOS during their professional training ([Alameh et al., 2023](#); [Alameh et al., 2023](#); [Mesci et al., \(2023\)](#)). The study focus sits in creating assessment tools pointing at the elements and rationale behind NOS for preservice teachers in their second and third years, aiming to evaluate the adequacy of their knowledge in this domain.

Aim

To devise and test assessment instruments to guide preservice teachers' training on Nature of Science elements and rationale.

Objectives

1. To devise templates to assess preservice teachers' knowledge of elements and rationale for NOS.
2. To validate assessment templates on elements and Rationale for NOS.
3. To investigate the effect of instructional intervention among preservice teachers' knowledge of elements and rationale for NOS.

Questions

1. Is the Assessment template on elements and rationale for NOS reliable across dimensions (Relevance, coherent and Clarity)?
2. Do preservice teachers possess adequate knowledge of element and rationale for NOS for eventual classroom integration?
3. Does difference exist in the knowledge of NOS integration between physical and life science preservice teachers?

Hypothesis

H₀₁: Instructional intervention will not significantly influence preservice teachers' knowledge of elements and rationale for NOS.

H₀₂: There is no significant difference in the post-test score of physical and life science students' knowledge of elements and rationale for NOS.

Materials and Methods

Design

This study adopts quasi-experiment design of one-group pre-test and post-test design to evaluate preservice teachers' knowledge of elements and rationale for NOS from a positivist paradigm (Cohen, Manion and Morrison, 2020), to examine the effect of the review of course content in history and philosophy of science from second year to third year (two years intervention). The review included the knowledge of elements and rationale for NOS and Nature of Scientific Explanations [NOSE] (Stimulus).

Experimental O1 X O2

Context of the Study

One hundred and thirty-six second year Physical and Life Science education students from a public university were the participants in the study. Science pedagogy modules (History and Philosophy of Science) which spanned from second year to the third was the intervention (stimulus). Aspect of this study was embedded in second- and third-year courses on history and philosophy of science as part of course review to improve preservice teachers' didactic skills. Participants knowledge of element and rationale for NOS were tested before the commencement of the intervention to ascertain their level of knowledge on elements and rationale for NOS. The choice of these participant was informed by the need to update science preservice teacher training to accommodate contextualised, explicit and reflective NOS for their eventual classroom practices. Argumentation, inquiry and problem-based methods were favoured in students' presentation on assignments where they were divided into three groups. The grouping took into account spread in both physical and life sciences education by making sure that there was fair representation. One hundred and twelve (112) students were in life sciences and twenty-four in physical sciences education. The twenty-four participants were shared into three groups of eight (physical sciences), 37 participants each joined the first and second group while 38 participants joined the last group from students studying life sciences. Prior to the module review, History and Philosophy of science is a compulsory pedagogical course for second- and third-year preservice teachers. The course review added Nature of Science and Nature of Scientific explanations with emphases on argumentation, inquiry and Problem-based Methods.

The participants and the researchers (moderators/facilitators) agreed to select one difficult topic in Physical (Electricity & Magnetism) and two topics in Life sciences (Transport Systems in Mammals & Human Evolution) curricula at Further Education and Training [FET] phase of Curriculum and Assessment Policy Statement [CAPS] to accommodate integration of NOS, as well as construction of scientific explanations. The three groups were opportune to present on each of the three topics where moderators provided guidance. Each group were to use argumentation, inquiry and Problem-based Methods in each of the topic presentations at different times. i.e., each group employed one of the three methods for

their presentation and assignments. For emphasis, learning outcome 3 on page 32 of physical sciences curriculum [<https://www.education.gov.za/Portals/0/CD/SUBSTATEMENTS/Physical%20Science.pdf?ver=2006-08-31-122200-000>] and life sciences [https://www.education.gov.za/Portals/0/CD/National%20Curriculum%20Statements%20and%20Vocational/CAPS%20FET%20_%20LIFE%20SCIENCES%20_%20GR%2010-12%20Web_2636.pdf?ver=2015-01-27-154429-123%20] on page 22 reiterated the need for NOS, construction and application of scientific knowledge.

Instruments

Table 1. *Internal consistency by experts across dimensions*

Dimensions	Clarity	Coherence	Relevance
Elements of NOS	.83	.91	.86
Rationale for NOS	.87	.90	.84

The criteria for selecting experts were- Ph.D. holders in Science Education, hold a faculty position in a department of science education or an equivalent in a university, must be teaching science pedagogy module for at least 2 year and should be willing to assess the instruments. A total of 15 experts judged the 12 items each on both elements and rationale for NOS. As shown on Table 1, the two instruments (ENOS & RNOS) were reliable as the internal consistency from the Cronbach's Alpha values across the dimensions of clarity, coherence and relevance show strong degree of agreement among experts. All the values obtained were above .70 in each of the instances indicating acceptable internal consistency and reliability.

Analysis

In the rating of the items, we assigned 1 to agree while neutral, disagree and don't know were assigned 0 in both ENOS and RNOS. Analysis was done using mean and standard deviation as descriptive statistics to make meaning of the research questions while inferential statistics of Analysis of Covariance (ANCOVA) and t-test was employed to test the hypotheses.

Procedure

The administration of the pretest (ENOS & RNOS) was done after the introductory class of the second year for all the participants. Data was coded in Microsoft Excel while the teaching of the reviewed course content History of Science (HOS) which included the introduction of NOS, scientific process and Nature of Scientific Explanations (NOSE) commenced. HOS is a prerequisite to third-year course titled Philosophy of Science (POS), wherein, a continuation of NOS, scientific process and NOSE were elaborated. Assignments and presentations were done by the groups on the selected topics. The researchers were moderators of the sessions. At the end of the classes in the third year, the instruments (ENOS & RNOS) were post-tested. The data obtained from the post-test was coded in Microsoft Excel and analysed with SPSS.

Ethical considerations

Participants voluntarily signed the consent forms to participate in this study. Purpose, procedure, confidentiality, risk, benefits, rights to volunteer as respondents were explained in the consent form. Pseudonyms were used to encrypt the identity of participants. This research was approved by the Ethical Committee of the University of the Free State with clearance number: UFS-HSD2022/1029/22/3.

Results

Table 2. Descriptives and demography

Participants		Mean	Std. Deviation	N
Pretest on Elements of NOS	Physical Sciences	3.08	1.640	24
	Life Sciences	2.61	2.072	112
	Total	2.69	2.006	136
Post-test on Elements of NOS	Physical Sciences	10.12	1.624	24
	Life Sciences	10.37	1.605	112
	Total	10.32	1.605	136
Pretest on Rationale for NOS	Physical Sciences	2.83	1.736	24
	Life Sciences	4.27	1.786	112
	Total	4.01	1.854	136
Post-test on Rationale for NOS	Physical Sciences	11.17	.637	24
	Life Sciences	11.57	1.096	112
	Total	11.50	1.040	136

A total of one hundred and thirty-six preservice teachers took part in this study. From the sample, one hundred and twelve of the participants were Life Sciences major while twenty-four of the respondents were majoring in Physical Sciences. Table 2 shows the demography of the participants as well as the pretests and post-tests on both elements and rationale for NOS. Deducible from Table 2, preservice teachers were not knowledgeable in both instances of elements and rationale in the pretest with their mean scores far below the average of 6 from 12 items in each of the instance. However, after the intervention, rapid improvement is noticeable through the mean scores which is above 10 within the two groups and in each of the instance.

Hypotheses Testing

H_{01} : Instructional intervention will not significantly influence preservice teachers' knowledge of elements and rationale for NOS.

Table 3. *t*-test of pre and post-test on elements of NOS

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Score Element	Equal variances assumed	9.209	.003	-34.650	270	.000
	Equal variances not assumed			-34.650	257.621	.000

Table 3 shows significant difference in the pre and post-test scores of preservice teachers on elements of NOS. The confidence interval in this case is 95% which implies that a test of significance is measured at $p < .05$. As seen on Table 3, the p value (.003) is less than .05. By implication, the null hypothesis is rejected. This means that there was significant difference between the pretest and post-test score of preservice teachers on elements of NOS as against the null hypothesis. Instructional intervention significantly influenced the knowledge on elements of NOS.

Table 4. *t*-test of pre and post-test on rationale for NOS

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Score Rationale	Equal variances assumed	50.113	.000	-41.067	270	.000
	Equal variances not assumed			-41.067	212.307	.000

Table 4 reports significant difference in the pre and post-test score of preservice teachers on rationale for NOS. The confidence interval in this case is also 95% which implies that a test of significance is measured at $p < .05$. From Table 4, the p value (.00) is less than .05. This means that the null hypothesis in this case is also rejected. There was significant difference between the pretest and post-test score of preservice teachers on rationale for NOS as against the null hypothesis. Instructional intervention had significant influence on preservice teachers' knowledge on rationale for NOS.

H₀₂: There is no significant difference in the post-test score of Physical and Life Science preservice teachers' knowledge of elements and rationale for NOS.

Table 5. *ANCOVA on elements of NOS*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	44.697a	2	22.348	9.807	.000	.129
Intercept	4414.794	1	4414.794	1937.412	.000	.936
TotalPrE	43.548	1	43.548	19.111	.000	.126
Students	.219	1	.219	.096	.757	.001
Error	303.068	133	2.279			
Total	14842.000	136				
Corrected Total	347.765	135				

a. R Squared = .129
(Adjusted R Squared = .115)

Table 5 reveals the analysis of covariance of post-test scores between preservice teachers of Life Science and Physical Science using the pretest as covariate on elements of NOS. From Table 5, the table value (.757) is greater than p value (.05). By implication, the hypothesis which states that there is no significant difference in the post-test score of Physical Science and Life Science preservice teachers' knowledge of elements of NOS is retained. No statistical significance is recorded in the post-test score of preservice teachers in both Life and Physical Science on element of NOS.

Table 6. *ANCOVA on rationale for NOS*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14.290 ^a	2	7.145	7.457	.001	.101
Intercept	3470.835	1	3470.835	3622.116	.000	.965
TotalPrR	13.817	1	13.817	14.419	.000	.098
Students	3.090	1	3.090	3.224	.075	.024
Error	127.445	133	.958			
Total	18266.000	136				
Corrected Total	141.735	135				

a. R Squared = .101 (Adjusted R Squared = .087)

Table 6 shows the analysis of covariance of post-test scores between preservice teachers of Life Sciences and Physical Sciences using the pretest as covariate on rationale for NOS. The table value

(.075) is slightly greater than p value (.05). Consequent from Table 6, the hypothesis which states that there is no significant difference in the post-test score of Physical Science and Life Science preservice teachers' knowledge on rationale for NOS is not rejected. Statistical significance is not recorded in the post-test score of preservice teachers in both Life and Physical Sciences on rationale for NOS.

Discussion

The aim of this study was to devise and test instruments to guide preservice teachers' training for improved teaching and eventually learning. Better prepared science teachers (with knowledge of [NOS & NOSE]) have the potential to enhance the quality of teaching through explanations they afford their learners (Abd-El-Khalik and Akerson, 2004; Alameh et al., 2023). The knowledge of element and rationale for NOS could be assumed non-existent in the participants before the intervention in this study owing to the mean scores obtained in the pretest. Early professional training as done in this study for preservice science teachers on elements and rationale for NOS has proven to influence the views, conceptual change and practices of preservice teachers in the literature Mesci et al., (2023). While the studies of Mesci et al., (2023) and Lederman et al., 2002 measured intervention on professional development of preservice teachers through argumentation-based teaching and VNOS respectively, the intervention in this study took different approach, method and locale but all on NOS. Instructional intentions are expected to be pre-determined by teachers of science, as such, the development of preservice teachers to focus on knowledge negotiation with their learners through inquiry, argumentation and problem-based methods is encouraged. This intervention will allow for preservice teachers to contextualise future teaching within NOS to improve scientific literacy as posited in the study of Bell et al., (2016) on science method courses.

Positive outcome of the intervention in this study as relayed provide preservice teachers with enhanced capacity to better support learners as emphasised through Vygotsky' framework on MKO and ZPD. Furthermore, science education literature has supported efforts to enhance science teacher training through NOS as is in the studies of Mesci, 2020; Nouri and McComas, 2019, Yacoubian, 2021. Particularly and most recently, the studies of Alameh et al (2023), Khishfe (2022), Mesci et al., (2023) and Sweeney and McComas (2022) supported the position of this study on the need for and influence of NOS on preservice teachers' conceptual change, long-term retention, competency and quality of explanations constructed. Difficulties experienced by learners in science can be better managed through integration of NOS explicitly and contextually (Mesci, 2020). The intention of professional development is to influence classroom practices, however, measuring the impact of this development remains futuristic.

Integrating scientific practices in the classroom through NOS in preservice teacher training is encouraged in this study. Previous scholarly positions emphasised the need for teachers to be equipped with the knowledge of both elements and rationale for NOS (Clough, 2018; Lederman et al., 2002; Mesci et al., (2023); Nouri et al., 2021), as in this study. In addition, the teaching of the inter-relationship, appropriateness and quality of science knowledge require foundational basics for novice teachers and preservice teachers. Hence, the knowledge of NOS as examined in this study serves as a guide to the development of pedagogical skills required for competent science teacher training (Hanuscin, 2013; Mesci and Schwartz, 2017). Past and present literature have reported inadequacy in the knowledge of science content among novice and expert teachers, as well as the need to intensify efforts to resolve the inadequacy through training (Mulvey and Bell, 2017; Wahbeh and Abd-El-Khalick, 2014). However, content knowledge inadequacy may not be as impactful as pedagogical inadequacy. NOS provides a guide to narrate, discuss, inquire, argue and problematise the teaching of science to sustain interest, provide quality explanations and impact meaningfully and contextually.

Conclusion

Preservice teachers training on NOS remains germane to improving the quality of explanations constructed and conceptualisation for meaningful learning in science. Practical approach to explanations through argumentation, inquiry and problem-based approaches enhanced preservice teachers' preparation for eventual classroom practice. Admittedly, the instruments (ENOS & RNOS) were to provide a foundational template to understanding and assess the knowledge of science among preservice

teachers. However, the presentations allowed for moderators to assist preservice teachers to improve the quality of explanations in the three topics trailed. These instruments assisted in assessing preservice teachers' knowledge of elements and rationale for NOS before and after the intervention.

Contribution to Teaching and Learning

Teachers are most likely going to teach the way they are taught. Better prepared teachers have the potential to impact qualitative learning. This study contributes to science teacher training for improved explanation and classroom practice. The instrument designed and the rating provides a newer way to assess preservice teachers' knowledge of elements and rationale for NOS. Testing preservice teachers' knowledge in these areas over 2 years proved significant improvement in their knowledge. The group assignments and presentation allowed for practical demonstration of their knowledge within inquiry, argumentation and problem-based methods which assisted their ability to construct scientific explanations for their eventual classroom practice at the fourth/final year for teaching practice and further practice.

Author Contributions

Olalekan Taofeek Badmus - Conceptualization, methodology, formal analysis, writing—original draft preparation; Loyiso C. Jita - writing—review and editing, Validation, Funding acquisition. All authors have read and agreed to the published version of the manuscript.

Conflict of interests

The authors declare no conflict of interest.

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Management and Organization of Human Resources in Science and Technology of the Republic of Serbia

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Abstract: The subject of this paper is human resources in the field of science and technology in the Republic of Serbia. The aim is to establish the state and tendencies regarding the number and structure of human resources in the mentioned field. Accordingly, several research questions were defined. Open data (2018-2021) of the Statistical Office of the Republic of Serbia were used. The results showed that the average number of employees who have either higher education or are employed in the field of science and technology was 991.9 thousand and on average their number was growing. The majority were women, whose number and share increased on average. The average number of employees who have higher education and are employed in the field of science and technology was 501.4 thousand and their number was growing on average, including people of both genders. The majority were women, whose share was constant with a tendency to minimal decrease. The average number of employees aged 15-74 who are employed in the field of science and technology was 731.2 thousand and on average their number was growing, including persons of both genders. The majority were women, whose share was constant with a tendency to minimal increase. The most important sector in the field of science and technology was education. It is concluded that there are positive tendencies regarding the number of human resources in the field of science and technology in Serbia, especially when it comes to women.

Keywords: management, organization, human resources, science, technology.

Introduction

Human resources (*HR*) represent one of the most important success factors in the modern business world. Without people, no organization functions regardless of its size, as well as its other specifics. The reason for the above is that people are the basic elements of the organization, both in executive and management positions. They are the basis of both changing existing and developing completely new occupations. The role of human resources is indisputable in the field of science and technology, especially if viewed from the aspect of innovation and higher education. Adequate management of human resources is necessary precisely because of their importance. Human resource management (*HRM*) is "the field of study and practice that focuses on people in organizations" (Stewart and Brown, 2020, p. 4). Its roles include both people and processes (Stewart and Brown, 2020, p. 4).

Management and organization of human resources in science and technology are elements that drive all other factors of the socio-economic system, primarily due to innovations created by science and technology. Management in science is related to management in education, especially in higher education. Accordingly, the term management in science and technology can be explained using the definition of management in education (Šormaz et al., 2019), partially modified and adapted. Therefore, management in science includes personnel who perform management activities of scientific institutions and organizations. Modern technologies are increasingly important in human resource management (Vrontis et al., 2022). Based on the above, and in accordance with the topic of this paper, the conclusion is that human resources management is important in the field of technology, but technology is also important in the field of human resources management.

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Science in Serbia is not a recent phenomenon. Its development can be traced from the period of the Middle Ages, through the period of stagnation (17th and 18th centuries), and up to the beginnings of modern science in Serbia, closely related to the gradual development of statehood (at the end of the 18th and during the 19th century) (Ivković and Maksimović, 2023). Nowadays, in Serbia, the policies of encouraging science and research follow world trends, and corresponding goals have been set in accordance with these trends. There are also certain activities accompanied by financial investments. During the previous decade, the set goals were partially achieved, and at the same time there was constant, but still slight progress in the sphere of the scientific research system. However, there is a constant lag in the analyzed indicators in relation to the member states of the European Union (EU). The small number of scientists engaged in the economy is perhaps one of the main problems. The above situation can be seen both as a cause and as a consequence of insufficient cooperation and connection between science and business (Stančetić and Tmušić, 2023). In contrast to the mentioned situation, it is undeniable that Serbia has opportunities for successful cooperation between science and business, but these opportunities are currently not sufficiently utilized. One of the reasons for the above is the orientation of people from the scientific and research field almost entirely towards scientific work (Stošić et al., 2019).

The analysis of innovative organizational design in scientific and research organizations in Serbia showed that “external and internal environment, project portfolio, resources, monitoring and methods and techniques influence organizational design”, but also that these are important elements of strategic project management (Mosurović et al., 2023). Special attention should be paid to them in the further development of science and technology in Serbia.

The four strategies are among the most significant documents in the field of science and technological development in Serbia. The mentioned strategies refer to: a) scientific and technological development (Government of the Republic of Serbia, 2021b), b) startup ecosystems (Government of the Republic of Serbia, 2021a), c) smart specialization (Government of the Republic of Serbia, 2020) and d) artificial intelligence (Government of the Republic of Serbia, 2019).

The topic that attracts special attention is the position of women, first in education, and then in employment in the field of “Science, Technology, Engineering, and Mathematics” (STEM). There are many problems and challenges that women workers in the field of science and technology face on a daily basis. Among others, these can be problems with working hours, opportunities for further development and professional voice, the period during and after pregnancy, etc. (Wang et al., 2023). Both personal and environmental characteristics affect the professional career of women in the STEM field, and at the same time many challenges arise – organizational culture based on gender, stereotypes, work-private life balance, etc. (Makarem and Wang, 2020). Many women have left a great impact in the sphere of science and technology, but there are still efforts to involve as many women as possible in the STEM field where their number is at best constant (Bauer et al., 2020). The conclusion is that in certain parts of the world, gender can be one of the important factors of inclusion and success in the field of science and technology. When it comes to the situation in Serbia, Lazarević-Moravčević et al. (2023) conclude that there is gender inequality in scientific and research activity, whereby the gender segregation present in education is also transferred to the sphere of science, with the simultaneous existence of vertical gender segregation.

The subject of the paper is human resources in the field of science and technology in the Republic of Serbia. The aim is to establish the state and tendencies regarding the number and structure of human resources in the field of science and technology in the Republic of Serbia. Several research questions have been defined based on the subject and objective:

1. What is the current situation and what are the trends regarding the number of employees who have completed higher education and/or are employed in the field of science and technology in Serbia?
2. What is the current situation and what are the trends regarding the gender structure of employees who have completed higher education and/or are employed in the field of science and technology in Serbia?
3. What is the current situation and what are the trends regarding the number of employed persons in the field of science and technology in Serbia?
4. What is the current situation and what are the trends regarding the gender structure of employees in the field of science and technology in Serbia?
5. What is the current situation and what are the trends regarding the structure of employees in the field

of science and technology according to the sectors of activity in Serbia?

A business venture in the field of science and technology can be seen as “a ship in a great sea that, regardless of its size, the winds and waves that hinder it, tries to find its right path, tries to maintain the course that leads it to the desired goal, but it is possible only if the captain and all crew members are united in their decision – there is no giving up” (Garabinović, 2017, p. 445). Answers to the above questions help to better understand the structure of employees in the field of science and technology in the Republic of Serbia, which is the basis for future improvements in human resources management in this field.

Materials and Methods

The analysis is based on the use of open data. Open data is data that can be viewed from two aspects. According to the first point of view, i.e. the broader point of view, open data is “open” to the public, i.e. it is publicly available. In accordance with the stated point of view, open data are data in any format if they meet the condition of availability to the public. According to the second point of view, i.e. a narrower and stricter point of view, open data is data that, as in the first point of view, meets the condition of public availability, but unlike the first point of view, the format of the data is of great importance. In accordance with the stated point of view, open data is publicly available data that can be downloaded in a format suitable for direct processing in appropriate application programs. One of the main specificities of open data is “machine readability”. It implies that certain data can be (automatically) processed and then analyzed using some software (Blagojević et al., 2020). Among the specialized portals in Serbia, the most important are data.gov.rs and data.stat.gov.rs. Some of the formats in which data can mainly be downloaded are JSON, CSV, XML, SDMX, SDMX DSD, Excel and others.

Data for “Human resources in science and technology (HRST)” are available in the open data base of the Statistical Office of the Republic of Serbia in the field of “Science, technology and innovations”. Appropriate data available for gender and other significant categories for the period 2018-2021 were extracted from the aforementioned database (Statistical Office of the Republic of Serbia, 2022a, 2022b, 2022c, 2022d).

Results and Discussions

The number of employed persons aged 15 to 74, who meet the condition that they either have completed higher education or are employed in the field of science and technology in the other analyzed years (2019, 2020 and 2021) was higher compared to 2018 (Table 1). The highest growth was in 2021 (4.8%), when this indicator had its maximum value. Analyzing the annual data for this indicator compared to the previous year, it can be seen that in 2019 there was an increase compared to 2018. After that, there was a decrease in 2020. In 2021, there was the highest growth compared to the previous year (3.4%). Looking at the analyzed indicator by gender, there are certain differences that are explained in more detail below.

Table 1. Number of “employed persons aged 15-74 who have either completed tertiary education or are employed in the field of science and technology” by gender (authors’ calculations – [Statistical Office of the Republic of Serbia, 2022a](#))

	Year	Number (in thousands)	Change compared to			
			the base year		the previous year	
			No.	%	No.	%
Total	2018	972.2	-	-	-	-
	2019	991.1	18.9	1.9	18.9	1.9
	2020	985.2	13.0	1.3	-5.9	-0.6
	2021	1019.0	46.8	4.8	33.8	3.4
Male	2018	456.0	-	-	-	-
	2019	452.5	-3.5	-0.8	-3.5	-0.8
	2020	448.5	-7.5	-1.6	-4.0	-0.9
	2021	466.4	10.4	2.3	17.9	4.0
Female	2018	516.2	-	-	-	-
	2019	538.6	22.4	4.3	22.4	4.3
	2020	536.7	20.5	4.0	-1.9	-0.4
	2021	552.6	36.4	7.1	15.9	3.0

The number of employed men was lower in 2019 and 2020 compared to 2018. Both the largest decrease (-1.6%) and the minimum value were in 2020. In 2021, the highest growth (2.3%) and maximum value was recorded. Analyzing the annual data for this indicator compared to the previous year, it is noted that a decrease was recorded in 2019 and 2020. After that, the year 2021 saw the highest growth compared to the previous year (4.0%).

The number of employed women in the other analyzed years (2019, 2020 and 2021) was higher compared to 2018. The highest growth was in 2021 (7.1%), and in the same year this indicator had its maximum value. Analyzing the annual data for this indicator compared to the previous year, it is noted that in 2019, compared to 2018, there was the highest growth (4.3%). After that, in 2020 there was a decrease, and in 2021 there was a renewed growth.

Women made up the majority of “employed persons aged 15-74 who have completed higher education or are employed in the field of science and technology during all analyzed years (Table 2). The share of women compared to 2018 was higher in all other observed years. The largest increase compared to the base year was in 2020. Comparing each year with its previous year, it was found that the only decrease was in 2021. The lowest share of women was in 2018, and the highest in 2020. The share of men has opposite tendencies.

Table 2. Percentage of “employed persons aged 15-74 who have either completed tertiary education or are employed in the field of science and technology” by gender (authors’ calculations – [Statistical Office of the Republic of Serbia, 2022a](#))

	Year	%	Change compared to	
			the base year	the previous year
Male	2018	46.9	-	-
	2019	45.7	-1.2	-1.2
	2020	45.5	-1.4	-0.1
	2021	45.8	-1.1	0.2
Female	2018	53.1	-	-
	2019	54.3	1.2	1.2
	2020	54.5	1.4	0.1
	2021	54.2	1.1	-0.2

In the period 2018-2021, the average annual number of employed persons aged 15-74 who have completed higher education or are employed in the field of science and technology was 991.9 thousand. The average annual change compared to the base year was 26.2 thousand, i.e. 2.7%. The average annual change compared to the previous year was 15.6 thousand, i.e. 1.6%. Below are the data for both women and men. Below is the data on the analyzed category of employees by gender.

There were on average 455.9 thousand men. The average annual change compared to the base year was -0.2 thousand, i.e. 0.0%. The average annual change compared to the previous year was 3.5 thousand, i.e. 0.8%.

There were on average 536.0 thousand women. The average annual change compared to the base year was 26.4 thousand, i.e. 5.1%. The average annual change compared to the previous year was 12.1 thousand, i.e. 2.3%.

The average share of women was 54.0%, and men 46.0%. The average change in the percentage of women compared to the base year was 1.3, or 0.4 compared to the previous year.

The number of persons aged 15 to 74 who have completed higher education and are employed in the field of science and technology in the other analyzed years (2019, 2020 and 2021) was higher compared to 2018 (Table 3). The highest growth was in 2021 (6.0%) and in the same year this indicator had its maximum value. Analyzing the annual data for this indicator in comparison with the previous year, it is noted that there was an increase in 2019 compared to 2018. After that, there was a decrease in 2020. In 2021, the highest growth compared to the previous year was recorded (5.2%). Looking at the analyzed indicator by gender, there are certain differences that are explained in more detail below.

Table 3. Number of "employed persons aged 15-74 who have completed tertiary education and are employed in the field of science and technology" by gender (authors' calculations – [Statistical Office of the Republic of Serbia, 2022b](#))

	Year	Number (in thousands)	Change compared to			
			the base year		the previous year	
			No.	%	No.	%
Total	2018	491.6	-	-	-	-
	2019	497.1	5.5	1.1	5.5	1.1
	2020	495.5	3.9	0.8	-1.6	-0.3
	2021	521.2	29.6	6.0	25.7	5.2
Male	2018	209.0	-	-	-	-
	2019	210.4	1.4	0.7	1.4	0.7
	2020	207.5	-1.5	-0.7	-2.9	-1.4
	2021	225.3	16.3	7.8	17.8	8.6
Female	2018	282.6	-	-	-	-
	2019	286.7	4.1	1.5	4.1	1.5
	2020	288.0	5.4	1.9	1.3	0.5
	2021	295.9	13.3	4.7	7.9	2.7

The number of employed men was lower only in 2020 compared to 2018. Both the largest decrease (-0.7%) and the minimum value were in 2020. Both the highest growth (7.8%) and the maximum value were in 2021. Analyzing the annual data for this indicator in comparison with the previous year, it is noted that only in 2020 a decrease was recorded (-1.4%). After that, the year 2021 saw the highest growth compared to the previous year (8.6%).

The number of employed women in the other analyzed years (2019, 2020 and 2021) was higher compared to 2018. The highest growth was in 2021 (4.7%) and in the same year this indicator had its maximum value. Analyzing the annual data for this indicator in relation to the previous year, it is noted that there was constant growth. The highest growth was in 2021 (2.7%).

Women made up the majority of persons aged 15-74 who have completed higher education and are employed in the field of science and technology during all analyzed years (Table 4). The share of women compared to 2018 decreased only in 2021 (-0.7%). The largest increase compared to the base year was

in 2020 (0.6%). Comparing each year with its previous year, the only decrease was in 2021 (-1.4%). The lowest share of women was in 2021, and the highest in 2020. The share of men has opposite tendencies.

Table 4. Percentage of “employed persons aged 15-74 who have completed tertiary education and are employed in the field of science and technology” by gender (authors’ calculations – [Statistical Office of the Republic of Serbia, 2022b](#))

	Year	%	Change compared to	
			the base year	the previous year
Male	2018	42.5	-	-
	2019	42.3	-0.2	-0.2
	2020	41.9	-0.6	-0.4
	2021	43.2	0.7	1.4
Female	2018	57.5	-	-
	2019	57.7	0.2	0.2
	2020	58.1	0.6	0.4
	2021	56.8	-0.7	-1.4

In the period 2018-2021, the average annual number of employed persons aged 15-74 who have completed higher education and are employed in the field of science and technology was 501.4 thousand. The average annual change compared to the base year was 13.0 thousand, i.e. 2.6%. The average annual change compared to the previous year was 9.9 thousand, i.e. 2.0%. Below is the data on the analyzed category of employees by gender.

There were 213.1 thousand men on average. The average annual change compared to the base year was 5.4 thousand, i.e. 2.6%. The average annual change compared to the previous year was 5.4 thousand, i.e. 2.6%.

There were on average 288.3 thousand women. The average annual change compared to the base year was 7.6 thousand, i.e. 2.7%. The average annual change compared to the previous year was 4.4 thousand, i.e. 1.5%.

The average share of women was 57.5%, and men 42.5%. The average change in the percentage of women compared to the base year was 0.0, or -0.2 compared to the previous year.

The number of employed persons aged 15 to 74 who are employed in the field of science and technology was lower (-0.1%) only in 2022 compared to 2018 (Table 5). The highest growth was in 2021 (4.1%) and in the same year this indicator had its maximum value. Analyzing the annual data for this indicator in comparison with the previous year, it is noted that there was an increase in 2019 compared to 2018. After that, there was a decrease in 2020. The highest growth compared to the previous year was in 2021 (4.2%). Looking at the analyzed indicator by gender, there are certain differences that are explained in more detail below.

Table 5. Number of “employed persons aged 15-74 that are employed in the fields of science and technology” by gender (authors’ calculations – [Statistical Office of the Republic of Serbia, 2022c](#))

	Year	Number (in thousands)	Change compared to			
			the base year		the previous year	
			No.	%	No.	%
Total	2018	723.0	-	-	-	-
	2019	726.8	3.8	0.5	3.8	0.5
	2020	722.4	-0.6	-0.1	-4.4	-0.6
	2021	752.5	29.5	4.1	30.1	4.2
Male	2018	324.3	-	-	-	-
	2019	320.5	-3.8	-1.2	-3.8	-1.2
	2020	316.8	-7.5	-2.3	-3.7	-1.2
	2021	338.0	13.7	4.2	21.2	6.7
Female	2018	398.7	-	-	-	-
	2019	406.3	7.6	1.9	7.6	1.9
	2020	405.6	6.9	1.7	-0.7	-0.2
	2021	414.5	15.8	4.0	8.9	2.2

The number of employed men was higher only in 2021 compared to 2018, and the maximum value was recorded in the same year. Both the largest decrease (-7.5%) and the minimum value were in 2020. Analyzing the annual data for this indicator compared to the previous year, it is noted that the increase was only in 2021 (6.7%).

The number of women in the other analyzed years (2019, 2020 and 2021) was higher compared to 2018. The highest growth was in 2021 (4.0%) and in that year this indicator had its maximum value. Analyzing the annual data for this indicator compared to the previous year, it is noted that the decrease was only in 2020 (-0.2%). The highest growth was in 2021 (2.2%).

Women made up the majority of employed persons aged 15-74 who are employed in the field of science and technology (Table 6). The share of women compared to 2018 decreased only in 2021. The largest increase compared to the base year was in 2020. Comparing each year to its previous year, the only decrease was in 2021. The lowest share of women was in 2018 and 2021, and the highest in 2020. The share of men has opposite tendencies.

Table 6. Percentage of employed persons aged 15-74 that are employed in the fields of science and technology by gender (authors’ calculations – [Statistical Office of the Republic of Serbia, 2022c](#))

	Year	%	Change compared to	
			the base year	the previous year
Male	2018	44.9	-	-
	2019	44.1	-0.8	-0.8
	2020	43.9	-1.0	-0.2
	2021	44.9	0.1	1.1
Female	2018	55.1	-	-
	2019	55.9	0.8	0.8
	2020	56.1	1.0	0.2
	2021	55.1	-0.1	-1.1

In the period 2018-2021, the average annual number of employed persons aged 15-74 who are employed in the field of science and technology was 731.2 thousand. The average annual change compared to the base year was 10.9 thousand, i.e. 1.5%. The average annual change compared to the previous year was 9.8 thousand, i.e. 1.4%. Below is the data on the analyzed category of employees by gender.

There were 324.9 thousand men on average. The average annual change compared to the base year was 0.8 thousand, i.e. 0.2%. The average annual change compared to the previous year was 4.6 thousand, i.e. 1.5%.

There were 406.3 thousand women on average. The average annual change compared to the base year was 10.1 thousand, i.e. 2.5%. The average annual change compared to the previous year was 5.3 thousand, i.e. 1.3%.

The average share of women was 55.6%, and men 44.4%. The average change in the percentage of women compared to the base year was 0.6, or 0.0 compared to the previous year.

In Serbia, it is possible to single out several subfields within science and technology. Their significance is different in terms of the number of employees. The letter designations listed in Figure 1 are used instead of the full names of the activity sectors in the following text.

Science and technology																				
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply, sewerage, waste management and remediation activities	Construction	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Accommodation and food service activities	Information and communication	Financial and insurance activities	Real estate activities	Professional, scientific and technical activities	Administrative and support service activities	Public administration and defence, compulsory social security	Education	Human health and social work activities	Arts, entertainment and recreation	Other service activities	Activities of households as employers, undifferentiated goods- and services-producing activities of households for own use	Activities of extraterritorial organisations and bodies

Figure 1. Sectors of activity in the field of science and technology (authors based on – [Statistical Office of the Republic of Serbia, 2022d](#))

In all the years covered by this analysis, three sectors occupy the first three places when it comes to employed persons aged 15-74 who are employed in the field of science and technology (Table 7):

1. Education,
2. Human health and social work activities,
3. Manufacturing.

Table 7 . Number and percentage of “employed persons aged 15-74 that are employed in the field of science and technology by sectors of activity in which they work” (authors’ calculations – [Statistical Office of the Republic of Serbia, 2022d](#))

	Year	Number (in thou- sands)	Change compared to				%	Change compared to	
			the base year		the previous year			the base year	the previous year
			No.	%	No.	%			
A	2018	5.3	-	-	-	-	0.7	-	-
	2019	5.9	0.6	11.3	0.6	11.3	0.8	0.1	0.1
	2020	6.7	1.4	26.4	0.8	13.6	0.9	0.2	0.1
	2021	5.9	0.6	11.3	-0.8	-11.9	0.8	0.1	-0.1
B	2018	7.8	-	-	-	-	1.1	-	-
	2019	7.1	-0.7	-9.0	-0.7	-9.0	1.0	-0.1	-0.1
	2020	8.1	0.3	3.8	1.0	14.1	1.1	0.0	0.1
	2021	7.4	-0.4	-5.1	-0.7	-8.6	1.0	-0.1	-0.1
C	2018	77.5	-	-	-	-	10.7	-	-
	2019	79.1	1.6	2.1	1.6	2.1	10.9	0.2	0.2
	2020	78.9	1.4	1.8	-0.2	-0.3	10.9	0.2	0.0
	2021	83.6	6.1	7.9	4.7	6.0	11.1	0.4	0.2
D	2018	13.4	-	-	-	-	1.9	-	-
	2019	12.6	-0.8	-6.0	-0.8	-6.0	1.7	-0.1	-0.1
	2020	11.7	-1.7	-12.7	-0.9	-7.1	1.6	-0.2	-0.1
	2021	9.8	-3.6	-26.9	-1.9	-16.2	1.3	-0.6	-0.3
E	2018	11.2	-	-	-	-	1.5	-	-
	2019	11.1	-0.1	-0.9	-0.1	-0.9	1.5	0.0	0.0
	2020	7.4	-3.8	-33.9	-3.7	-33.3	1.0	-0.5	-0.5
	2021	7.2	-4.0	-35.7	-0.2	-2.7	1.0	-0.6	-0.1
F	2018	16.3	-	-	-	-	2.3	-	-
	2019	20.5	4.2	25.8	4.2	25.8	2.8	0.6	0.6
	2020	22.5	6.2	38.0	2.0	9.8	3.1	0.9	0.3
	2021	25.1	8.8	54.0	2.6	11.6	3.3	1.1	0.2
G	2018	54.6	-	-	-	-	7.6	-	-
	2019	55.3	0.7	1.3	0.7	1.3	7.6	0.1	0.1
	2020	57.0	2.4	4.4	1.7	3.1	7.9	0.3	0.3
	2021	62.3	7.7	14.1	5.3	9.3	8.3	0.7	0.4
H	2018	21.0	-	-	-	-	2.9	-	-
	2019	21.1	0.1	0.5	0.1	0.5	2.9	0.0	0.0
	2020	15.6	-5.4	-25.7	-5.5	-26.1	2.2	-0.7	-0.7
	2021	17.4	-3.6	-17.1	1.8	11.5	2.3	-0.6	0.2
I	2018	7.9	-	-	-	-	1.1	-	-
	2019	5.8	-2.1	-26.6	-2.1	-26.6	0.8	-0.3	-0.3
	2020	4.1	-3.8	-48.1	-1.7	-29.3	0.6	-0.5	-0.2
	2021	5.5	-2.4	-30.4	1.4	34.1	0.7	-0.4	0.2
J	2018	53.7	-	-	-	-	7.4	-	-
	2019	54.5	0.8	1.5	0.8	1.5	7.5	0.1	0.1
	2020	62.5	8.8	16.4	8.0	14.7	8.7	1.2	1.2
	2021	78.2	24.5	45.6	15.7	25.1	10.4	3.0	1.7

	Year	Number (in thou- sands)	Change compared to				%	Change compared to	
			the base year		the previous year			the base year	the previous year
			No.	%	No.	%			
K	2018	22.6	-	-	-	-	3.1	-	-
	2019	25.6	3.0	13.3	3.0	13.3	3.5	0.4	0.4
	2020	24.7	2.1	9.3	-0.9	-3.5	3.4	0.3	-0.1
	2021	18.4	-4.2	-18.6	-6.3	-25.5	2.4	-0.7	-1.0
L	2018	2.2	-	-	-	-	0.3	-	-
	2019	3.1	0.9	40.9	0.9	40.9	0.4	0.1	0.1
	2020	1.5	-0.7	-31.8	-1.6	-51.6	0.2	-0.1	-0.2
	2021	2.7	0.5	22.7	1.2	80.0	0.4	0.1	0.2
M	2018	77.2	-	-	-	-	10.7	-	-
	2019	68.2	-9.0	-11.7	-9.0	-11.7	9.4	-1.3	-1.3
	2020	66.0	-11.2	-14.5	-2.2	-3.2	9.1	-1.5	-0.2
	2021	75.4	-1.8	-2.3	9.4	14.2	10.0	-0.7	0.9
N	2018	7.7	-	-	-	-	1.1	-	-
	2019	6.9	-0.8	-10.4	-0.8	-10.4	0.9	-0.1	-0.1
	2020	9.5	1.8	23.4	2.6	37.7	1.3	0.3	0.4
	2021	11.2	3.5	45.5	1.7	17.9	1.5	0.4	0.2
O	2018	61.0	-	-	-	-	8.4	-	-
	2019	62.3	1.3	2.1	1.3	2.1	8.6	0.1	0.1
	2020	58.5	-2.5	-4.1	-3.8	-6.1	8.1	-0.3	-0.5
	2021	58.0	-3.0	-4.9	-0.5	-0.9	7.7	-0.7	-0.4
P	2018	132.8	-	-	-	-	18.4	-	-
	2019	135.3	2.5	1.9	2.5	1.9	18.6	0.2	0.2
	2020	135.9	3.1	2.3	0.6	0.4	18.8	0.4	0.2
	2021	129.0	-3.8	-2.9	-6.9	-5.1	17.1	-1.2	-1.7
Q	2018	114.9	-	-	-	-	15.9	-	-
	2019	116.2	1.3	1.1	1.3	1.1	16.0	0.1	0.1
	2020	117.2	2.3	2.0	1.0	0.9	16.2	0.3	0.2
	2021	120.5	5.6	4.9	3.3	2.8	16.0	0.1	-0.2
R	2018	25.2	-	-	-	-	3.5	-	-
	2019	28.0	2.8	11.1	2.8	11.1	3.9	0.4	0.4
	2020	24.5	-0.7	-2.8	-3.5	-12.5	3.4	-0.1	-0.5
	2021	25.5	0.3	1.2	1.0	4.1	3.4	-0.1	0.0
S	2018	9.8	-	-	-	-	1.4	-	-
	2019	7.7	-2.1	-21.4	-2.1	-21.4	1.1	-0.3	-0.3
	2020	9.6	-0.2	-2.0	1.9	24.7	1.3	0.0	0.3
	2021	9.3	-0.5	-5.1	-0.3	-3.1	1.2	-0.1	-0.1
T	2018	0.0	-	-	-	-	0.0	-	-
	2019	0.0	0.0	-	0.0	-	0.0	0.0	0.0
	2020	0.0	0.0	-	0.0	-	0.0	0.0	0.0
	2021	0.0	0.0	-	0.0	-	0.0	0.0	0.0
U	2018	1.0	-	-	-	-	0.1	-	-
	2019	0.0	-1.0	-100.0	-1.0	-100.0	0.0	-0.1	-0.1
	2020	0.0	-1.0	-100.0	0.0	-	0.0	-0.1	0.0
	2021	0.0	-1.0	-100.0	0.0	-	0.0	-0.1	0.0

In order to obtain data more suitable for mutual comparison of activity sectors, average values were calculated (Table 8).

Table 8. Average number and percentage of “employed persons aged 15-74 that are employed in the field of science and technology by sectors of activity in which they work” (authors’ calculations – [Statistical Office of the Republic of Serbia, 2022d](#))

	Number (in thou- sands)	Change compared to				%	Change compared to	
		the base year		the previous year			the base year	the previous year
		No.	%	No.	%			
A	6.0	0.9	16.4	0.2	4.3	0.8	0.1	0.0
B	7.6	-0.3	-3.4	-0.1	-1.2	1.0	-0.1	0.0
C	79.8	3.0	3.9	2.0	2.6	10.9	0.3	0.1
D	11.9	-2.0	-15.2	-1.2	-9.8	1.6	-0.3	-0.2
E	9.2	-2.6	-23.5	-1.3	-12.3	1.3	-0.4	-0.2
F	21.1	6.4	39.3	2.9	15.7	2.9	0.8	0.4
G	57.3	3.6	6.6	2.6	4.6	7.8	0.4	0.2
H	18.8	-3.0	-14.1	-1.2	-4.7	2.6	-0.4	-0.2
I	5.8	-2.8	-35.0	-0.8	-7.2	0.8	-0.4	-0.1
J	62.2	11.4	21.2	8.2	13.8	8.5	1.4	1.0
K	22.8	0.3	1.3	-1.4	-5.2	3.1	0.0	-0.2
L	2.4	0.2	10.6	0.2	23.1	0.3	0.0	0.0
M	71.7	-7.3	-9.5	-0.6	-0.2	9.8	-1.2	-0.2
N	8.8	1.5	19.5	1.2	15.1	1.2	0.2	0.1
O	60.0	-1.4	-2.3	-1.0	-1.6	8.2	-0.3	-0.2
P	133.3	0.6	0.5	-1.3	-0.9	18.2	-0.2	-0.4
Q	117.2	3.1	2.7	1.9	1.6	16.0	0.2	0.0
R	25.8	0.8	3.2	0.1	0.9	3.5	0.1	0.0
S	9.1	-0.9	-9.5	-0.2	0.0	1.2	-0.1	0.0
T	0.0	0.0	-	0.0	-	0.0	0.0	0.0
U	0.3	-1.0	-100.0	-0.3	-	0.0	-0.1	0.0

Average growth trends in the number of employees in relation to both the base year and the previous year were seen in sectors A, C, F, G, I, L, N, Q and R, and in relation to the base year in sectors K and P. The average changes in the share of sectors were not were large, which is best indicated by the fact that sector J had the biggest change in relation to both the base (1.4) and the previous year (1.0).

Conclusions

Management in science and technology includes a wide range of activities, but also requires a wide range of expertise and knowledge. One of the undeniable characteristics of modern business is volatility. Changes in the environment disturb the established practice and require a reaction. The best managers act with their decisions not only reactively, but primarily proactively, creating changes that others need to respond to. Changes have become everyday, as have the challenges that changes bring. Human resources in science and technology are a key element of success, because the development of this field, despite numerous technological advances, especially in the field of artificial intelligence, cannot be achieved without the participation of people as carriers of “natural human intelligence” and as creators of change. It is precisely for this reason that it is necessary to monitor trends related to employees. Only with an insight into the real situation can optimal decisions be made aimed at solving problems, improving business performance and overall success.

The analysis performed in this paper provides data on the state and dynamics of human resources in the field of science and technology in the Republic of Serbia. These data are the starting point for the

further development of human resources management in the field of science and technology. Differentiation according to gender and sector of activity is particularly significant.

The results show that the number of employees who have either higher education or are employed in the field of science and technology has grown on average. The majority were women. Their number and share on average grew.

The number of employees who have higher education and are employed in the field of science and technology has grown on average. The above applies to both women and men. The majority in this category were women, but their average percentage participation was at approximately the same level with a minimal tendency to decrease.

The number of employees aged 15-74 who are employed in the field of science and technology has grown on average. The above applies to both women and men. The majority in the mentioned category were women. Their share can be described as stable with a tendency of minimal increase.

According to the criterion of the number of employees, education was the most important scientific and technological sector of activity. Changes in the number of employees by individual scientific and technological sectors were present, but the average change in their percentage participation was small.

Through the conducted analyzes and consideration of the obtained results, the subject and aim of the paper were achieved and at the same time answers were given to the research questions. The general conclusion is the existence of positive tendencies regarding the number of human resources in the field of science and technology in Serbia. The aforementioned tendencies are particularly significant when it comes to the position of women in science and technology.

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Conflict of interests

The authors declare no conflict of interest.

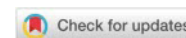
Author Contributions

Conceptualization, O.M., S.A., D.G. and M.B.; methodology, O.M., S.A., D.G. and M.B.; formal analysis, O.M., S.A., D.G. and M.B.; writing—original draft preparation, O.M., S.A., D.G. and M.B.; writing—review and editing, O.M., S.A., D.G. and M.B. All authors have read and agreed to the published version of the manuscript.

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Measuring Inclusion in Vocational Education and Training through the Prism of Justice of Education

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Abstract: The highest possible level of inclusion and justice are the primary goals of most contemporary education systems, including vocational education and training. The Index for Inclusion, which was developed two decades ago, defines inclusion on three levels, i.e. policy, culture and practice, and provides a methodological framework for measuring the inclusive orientation of schools. This paper raises the question of whether the selected Index for Inclusion indicators can be used to also measure different dimensions of justice, which is defined as a multidimensional concept. The just redistribution of basic goods is complemented by recognition, representation and relationality. A study with the aim to determine the multidimensionality of the implementation of inclusivity in Vocational Education and Training institutions using statistical analysis was carried out. An online questionnaire was created and completed by 427 education professionals (head teachers, teachers and school counsellors) employed in vocational education and training. The dimensionality of the measured constructs was checked using a set of 28 variables with factor analysis, i.e. the Maximum Likelihood method and Varimax rotation. It was found that the statements that had been formulated on the basis of the Index for Inclusion can also be used to measure different dimensions of justice. The final version of the questionnaire (modified questionnaire), which contains a set of twenty items, adequately measures the redistribution and recognition aspects of justice, whereas the representation and relational aspects have proven to be two-dimensional concepts. A modified questionnaire could be a suitable starting point both for the self-evaluation of schools and a general measurement of inclusion in terms of justice.

Keywords: inclusion, justice, redistribution, recognition, representation, relationality.

Introduction

Over the past three decades, aspirations towards greater inclusion of the education system have marked many theoretical discussions (Banks, 2023; Haug, 2017; Opertti, Brady, and Duncombe, 2009; Reindal, 2015; Thomas, 2013; Warnock, 2010). In fact, two decades ago, they were the reason for developing the Index for Inclusion (Booth and Ainscow, 2002) in the UK, which can be used both to evaluate and foster efforts for more inclusive schools. The Index for Inclusion anticipates measures for the operation of an educational institution at three levels (Booth and Ainscow, 2002):

1. the policy level by establishing systemic solutions and defining the rights of those who often face exclusion,
2. the culture level by establishing and consolidating inclusive community values,
3. the practice level as didactic support for those who often face exclusion and as the nurturing of relationships.

The Index for Inclusion constitutes a framework for identifying attitudes, obstacles, potentials and efforts to establish a more inclusive culture, policy and practice in a certain educational institution, which can also use it as a self-evaluation tool (Ainscow, 2023).

Ainscow (2023, p. 6) argues that inclusion is a matter of two interconnected dimensions. 'First, it is a matter of *fairness*, which implies ensuring that personal and social circumstances – for example,

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gender, socio-economic status or ethnic origin – are not an obstacle to achieving success in learning. Second, it is to do with inclusion, which is about ensuring the presence, participation and achievement of all children and young people.’ (Ainscow, 2023, p. 6) The coherence of the two concepts, inclusion and justice, has been explored by a variety of other authors (Banks, 2023; Burke, Goriss-Hunter, and Emmett, 2023; Cochran-Smith and Stringer Keefe, 2022; Skubic Ermenc, Jeznik, and Mažgon, 2019; Kielblock and Woodcock, 2023; Lynch, Kalaitzake, and Crean, 2021; Opertti, Brady, and Duncombe, 2009).

The UNESCO document titled *Reimagining our Futures Together: A New Social Contract for Education* (2021, p. 3) includes the following statement: ‘Any new social contract must build on the broad principles that underpin human rights – inclusion and equity, cooperation and solidarity, as well as collective responsibility and interconnectedness’. In addition to an analysis of the situation, the document contains several complex proposals for reforming education, which relate to the issue of pedagogy and didactics, the school as an institution, and interpersonal relations within the school. In fact, the first chapter Towards more equitable educational futures focuses precisely on the issue of justice in education: ‘If education is to help transform the future, it must first become more inclusive by addressing past injustices. Factors that shape these inequalities and exclusions must be clearly identified if policies and strategies are to support marginalised students, especially those who experience compounded disadvantages.’ (Reimagining our Futures Together: A New Social Contract for Education, 2021, p. 23) It highlights access to education as a fundamental right for all, while also noting that it is incomplete and unjust. In poverty-stricken countries, one in four adolescents is still illiterate, one in five children does not even attend primary school, and the situation is even worse in secondary education (Reimagining our Futures Together: A New Social Contract for Education, 2021, p. 23).

A brief summary of the UNESCO document draws attention to the complexity and multidimensionality of the core concepts, which are also studied in this paper. As noted by Akkan and Buğra (2020, p. 143) the life chances of individuals from minority groups depend on the feeling of belonging to an inclusive education system. Exclusion that results from inequality in opportunities to access quality education and the experience of alienation and discrimination due to non-recognition affects an individual’s performance and reduces the added value of education when it comes to developing the abilities of children from groups that are often subject to exclusion. Inclusive education systems are supposed to recognise children’s diversity, while also recognising parents’ choices about their children’s education and what it should be like. According to the aforementioned, this should also have an impact on the development of children’s abilities (Akkan and Buğra, 2020).

The second part of this paper provides an analysis of the validity and reliability of the measurements of inclusion in vocational education and training based on the data from the survey titled *Inclusion in Vocational Education and Training* (Inkluzija v poklicnem in strokovnem izobraževanju, 2022), which was conducted in spring 2022 under the auspices of the Institute of the Republic of Slovenia for Vocational Education and Training. The aim of the study was to examine the situation in terms of the implementation of inclusion in Slovenian vocational education and training. The Index for Inclusion (Booth and Ainscow, 2002) has not yet been translated into Slovenian language, and no methodologically validated tool to measure inclusiveness at the school and system level is available. The population of students enrolled in vocational education and training* is heterogeneous. According to the official statistics from the Ministry of Education 24,9 % of students enrolled in lower vocational education (2-year programs), 19,6 % of students enrolled in vocational education (3-year programs) and 9,9 % of students enrolled in vocational education (4-year programs) have special educational needs. Only 4,9 % such students are enrolled in general secondary education (grammar schools). The data on immigrants enrolled in secondary education refer to a variety of educational programs, both vocational and general. In 2022, 6.5% of students enrolled in secondary education were immigrants (Strategy for integrating foreigners who are not citizens of the European Union into the cultural, economic and social life of the Republic of Slovenia, n.d.). Various studies point to the impact of low SES on the educational trajectories of students, which is becoming increasingly evident (Cankar and Zupanc, 2020; Pedagoški inštitut, 2023). This has led to the survey with the aim of measuring the state of inclusion in schools, and to develop a valid and reliable instrument that can be used by the schools in the future to self-evaluate the field or that can be used at system level as a tool for measuring inclusion in the prism of justice.

A total of 427 education professionals employed in vocational education and training (head teachers,

* In Slovenia, this refers to the upper-secondary level of education.

school counsellors and teachers) from all over Slovenia took part in the survey. Individual indicators were selected from the Index for Inclusion (Booth and Ainscow, 2002) based on the theoretical assumption that inclusion can be implemented in a more holistic way by taking into account the multidimensional concept of justice (Fraser, Dahl, Stoltz, and Willig, 2004; Lynch, Baker, and Lyons, 2009; Lynch, Kalaitzake, and Crean, 2021; Lesar, 2013; Lesar, 2019). The index defines inclusion on three levels (policy, culture and practice), the multidimensional concept, however, not only views justice at the level of meritocracy and redistribution, but also highlights three other aspects, i.e. recognition, representation and relationality. This paper analyses the data used to substantiate the theoretical assumption about the relationship between the concepts of inclusion and justice, and examines whether the selected Index for Inclusion indicators can be used to also measure different dimensions of justice.

Definition of inclusion

There is no single definition of inclusion. The definition depends on a particular environment, the historical circumstances of education, the initial education methods of education professionals and many other factors (Banks, 2023). However, what is common to various present-day definitions is that they are characterised by a departure from the medical discourse and a special educational approach to individuals who often face exclusion towards community-centred and general pedagogical and didactic approaches and strategies intended for everyone. Several authors (Ainscow, 2023; Burke, Goriss-Hunter, and Emmett, 2023; Skubic Ermenc, Jeznik, and Mažgon, 2019; Haug, 2017; Lesar, 2019) have pointed out that the general educational concept of inclusion goes beyond the focus on individuals and groups that traditionally receive different, usually special educational treatment within the school environment (e.g. individuals with special needs). Baglieri et al. (2011 in Burke, Goriss-Hunter, and Emmett, 2023, p. 18) have identified three important cornerstones of inclusive education:

1. inclusive education *should be aimed at everyone* and not just minority groups, such as persons with special needs;
2. learning and teaching should be *participatory and inclusive* and should not be based solely on physical integration;
3. inclusive education should be supported by *democratic principles and principles of social justice*, anchored in educational practices.

The way cultural, ethnic, linguistic, religious, racial, sexual and other diversity is dealt with in the education system also determines the degree of its inclusion, which can promote the belonging or alienation of students from minority communities (Akkan and Buğra, 2020). Burke, Goriss-Hunter, and Emmett, 2023) pointed out that while diversity and inclusion are increasingly emphasised in educational environments across the globe, the pedagogical and didactic approaches to teaching are still distinctly homogenous and based on a normative image of learners. The extent of diversity may remain invisible, and teachers may remain unprepared to use more inclusive pedagogical approaches. The authors also pointed out that not all people are equally different from one another. Some groups have been traditionally disadvantaged even within the education system in some way: 'Diversity, however, is complicated and difficult to identify and describe in its complexity, meaning that single aspects of identified differences often become the focus of any programme or intervention.' (ibid., p. 19)

Inclusion through the prism of justice

Mel Ainscow (2023, p.127), co-author of the aforementioned Index for Inclusion, argues that the extent of inclusive and just experiences not only depends on educational practices, but also on various interlinked processes that form 'an ecology of equity' (Ainscow, 2023). Attention should be paid to the following:

1. *within-school factors*, such as existing policies and practices,
2. *between-school factors* that arise from the characteristics of local school systems,
3. *beyond-school factors*, including the demographics, economics, cultures and histories of local areas – all with a focus on reducing inequalities.

In the latter part of the paper, the interconnectedness between inclusion and justice is substantiated through the multidimensional model of justice (Fraser, Dahl, Stoltz, and Willig, 2004; Lynch, Baker, and Lyons, 2009; Lynch, Kalaitzake, and Crean, 2021; Lesar, 2019), which is based on four dimensions:

redistribution, recognition, representation and relationality. Each of these four dimensions highlights a certain way of individuals' inclusion. Hence, the assumption is that inclusion is a concept that can be implemented in a more just way by taking into account all four dimensions of justice.

The foundations of redistributive justice were laid five decades ago by [John Rawls \(1971\)](#). At the forefront of his *Theory of Justice* is a just distribution of basic liberties and goods, including universal access to public education. Both individuals and society benefit from this – individuals because they can realise their potential, while society benefits from promoting social cohesion and trust in public institutions through education ([Christodoulou, et al., 2022](#)). Rawls' *Theory of Justice* ([Rawls, 1971](#)) is based on two requirements. The first is that each person is to have an equal right to achieving the basic liberties in the broadest sense of the word. The second is that social and economic inequalities between people are to be arranged in such a way that one can expect the measures introduced to benefit everyone. Rawls further divides the original two requirements into three principles: the equal opportunity principle or meritocracy, the principle of fair equality of opportunity or positive discrimination, and the difference principle. On a practical level, these principles commit us to acting in a way that will provide everyone, regardless of their position, with equal conditions for success and that the only differences between us that are just are those that bring benefits to the most disadvantaged individuals in society ([Rawls, 1971](#)). In terms of identity, this means that the identity of a group or an individual should not be an obstacle to achieving social positions, goods, rights and liberties ([Jeznik, 2015](#)), and a just society takes care of the weakest individuals first.

As early as the 1990s, ([Fraser, Dahl, Stoltz, and Willig, 2004](#); [Fraser and Honneth, 2003](#); [Knijn, Theuns, and Miklós, 2020](#)) pointed out that socioeconomic deprivation is significantly interwoven with cultural differences. Thus, they added two more dimensions to redistributive justice: first, recognition and later representation. Recognition basically means respect for different lifestyles, worldviews, life circumstances, health situations, etc., i.e. not only in terms of recognising certain rights and liberties, as assumed by the redistributive dimension of justice. [Fraser and Honneth \(2003\)](#) argue that not all concrete forms of social injustice can be reduced to violations of the equal opportunity principle or the difference principle, which underpin the redistributive dimension of justice. They analyse the cases of individuals with atypical gender identities, proving that these identities must often be hidden in order for these individuals to be exposed in visible (political) decision-making positions within society.

[Fraser \(2007\)](#) also draws attention to the limitations of recognition. He points out two things: misrecognition and non-recognition, which can be illustrated using an example of the schooling of students from migrant backgrounds and their integration into the education system. An immigrant may suffer serious damage to their identity if, as education experts, we have a stigmatised view of them (misrecognition), which can consequently lead to the immigrant developing a negative self-concept and prevent them from developing a healthy identity. To be more specific, this is a matter of connecting individual's personality traits with stereotypical beliefs about a certain culture, linguistic community, nationality, etc., which is highly problematic in the context of an educational system. [Fraser \(2007\)](#) notes that it is similarly problematic if an individual's identity position is invisible. In this case, this is a matter of non-recognition. In this kind of situation, for various reasons, a person's right to different treatment is not recognised due to them being underprivileged.

The injustices experienced by minority groups are often divided between the misrecognition of diversity, including ethnic, religious or racial differences, and the redistribution of inequality. The dynamics of exclusion created by inequalities that exist in access to quality education, as well as the experience of alienation due to non-recognition, affect student achievement and limit the value of education, which is supposed to help develop the abilities of children from minority groups. [Lynch and Baker \(2005\)](#) point out that in education this can be noticed in a null and hidden curriculum or in poor evaluation of certain knowledge, as well as in a culture that is usually reproduced through the education system as a culture of middle-class values.

[Fraser, Dahl, Stoltz, and Willig \(2004\)](#) therefore added another dimension to redistribution and recognition, namely representation, which strives for different social groups and individuals to be involved in decision-making in terms of their power and influence on positions within the community. [Akkan and Buğra \(2020\)](#) argue that actual representation is often limited and individuals do not have the opportunity to adequately express their demands and challenge stereotypes and stigmatisation related to their values or cultural value. Equal participation, trust and representation are important concepts in understanding the

role education plays in the creation of a good society and democracy, as pointed out by Dewey in the early 20th century. Sometimes the values of different groups are almost incompatible and cultural transmission is very difficult, requiring the coordination of the demands of family and society (Akkan and Buğra (2020)). A similar observation was made by Julie Allan in relation to children's voice and rights in special education (Allan, 2023, p. 31).

Lynch, Baker and Lyons (2009) added a fourth dimension to the three-dimensional model of justice (redistribution, recognition and representation), i.e. relationality. In fact, the three-dimensional model is based on the perception of an independent adult and disregards the importance of emotional interpersonal relations. It is unclear if, how and when individuals who at a given moment are very dependent on others due to old age, poor health, etc. hold any power and significance. The authors also raised the question of the relationship between those who receive care and those who provide it. This is a political issue that mainly concerns the female part of the population, the commonly unpaid or underpaid care workers (Lynch, Kalaitzake, and Crean, 2021, p. 56). Since relationality is not a social derivative, it is subordinated to economic, political or cultural relations in social life. It represents ethically based, care-relational relationships that are expressed differently in different cultures, their main purpose, however, is to be with others and co-build relationships in a way that is not alienating or exploitative (Lynch, Kalaitzake, and Crean, 2021, p. 58). While the three-dimensional theory of justice paved the way for questions of social justice in the social sciences, relationality opens up space for new scientific analyses (Lynch, Kalaitzake, and Crean, 2021, p. 62).

With its inclusion and exclusion practices, education, on the one hand, reinforces existing social inequalities, while on the other, it plays an important role in fighting against injustices and eliminating social injustice and inequality. Despite some criticism, further research into the various dimensions of justice is important mainly because socioeconomic inequalities can also affect access to education. Poverty is thus still considered one of the causes and consequences of inequality in education, which lead to early school leaving and affect the opportunities of children from disadvantaged backgrounds; not only poverty, but also many other personal circumstances, such as gender, race, ethnicity, culture, religion, etc. (Akkan and Buğra (2020)). Despite the limitations of the model that they pointed out (positivism and formalism), Knijn, Theuns and Miklós (2020) view the multidimensional model of justice as an adequate basis that can be used to support research in this field while also offering a useful heuristic tool for interdisciplinary and empirically based consideration of the different demands for justice.

Materials and Methods

The following part of the paper empirically shows that the concepts of inclusion and justice can be considered together based on the data obtained as part of a survey on inclusion in vocational education and training. The aim of the authors of this paper was to learn whether the selected Index for Inclusion indicators can also be used as a starting point for measuring individual dimensions of justice, i.e. redistribution, recognition, representation and relationality. We opted for a quantitative approach with the aim to explore the dimensionality of the implementation of inclusivity in Vocational Education and Training institutions through statistical analysis, i.e. factor analysis.

The national survey included 427 education professionals (teachers, head teachers and school counsellors) employed in vocational education and training. A questionnaire for measuring inclusion in vocational education and training, which was designed for the purposes of the survey, was used for data collection. Data collection was carried out between 27 June and 14 July 2022 using an online data collection tool.

Most of the survey participants in the survey sample are teachers, whereof just over a fifth are male. The school counsellors are predominantly female. The structure of the sample by gender gives a realistic picture of the population. The sample is also very representative in terms of the education professionals' experience. More than half of the sample is represented by professionals with more than twenty years of work experience in education.

Table 1. Sample Description

	All	Teachers	Head Teachers	School Counsellors
N	427	354	44	29
Gender				
Male	21.2%	21.6%	29.3%	3.7%
Female	75.0%	74.1%	68.3%	96.3%
Prefer not to answer	3.8%	4.3%	2.4%	0.0%
Years of work experience in education				
Up to 5 years	8.9%	8.6%	0.0%	25.9%
6–10 years	9.4%	10.1%	2.4%	11.1%
11–20 years	23.3%	23.9%	14.6%	29.6%
More than 20 years	58.5%	57.5%	82.9%	33.3%

For research purposes, a questionnaire was designed for measuring inclusion in vocational education and training. The questionnaire was based on the multidimensional model of justice and the Index of Inclusion by [Booth and Ainscow \(2002\)](#). The Index of Inclusion includes a set of indicators for measuring inclusion at the level of inclusive policy, culture and practice. Those indicators that, in the authors' opinion, also reflect a certain dimension of justice were selected from the index. The selected indicators were operationalised with statements and the respondents specified their level of agreement on a four-point scale with the following answers: *not true at all*, *mostly not true*, *mostly true* and *absolutely true*. The respondents had the option of not answering, i.e. choosing the answer *I prefer not to answer*, if they did not have sufficient information about the situation to be able to provide an answer. The questionnaire, which was given to education professionals to fill out, contained a total of 28 statements (Inkluzija v poklicnem in strokovnem izobraževanju [[Inclusion in Vocational Education and Training](#)], 2022, p. 89–93).

In this paper the focus is on checking the dimensionality of the measured constructs, which was carried out by means of factor analysis.

Results

The dimensionality of the measured constructs was checked using a set of 28 variables. The design of the questionnaire was based on the assumption that measuring the inclusion of schools is a four-dimensional construct, consisting of redistribution, recognition, representation and relationality. The multidimensionality of the measured construct was checked with factor analysis, i.e. the Maximum Likelihood method and Varimax rotation.

Several versions of factor solutions were created, this paper, however, describes the final solution, which is the most appropriate in terms of measurement validity and reliability.

After excluding the variables whose loadings were low, a 5-factor structure was obtained; in terms of content, this structure is more compatible with the assumed (theoretical) structure. Twenty items were kept in the analysis and were used to measure the inclusion of vocational education and training.

Bartlett's Test ($X^2 = 2350.9$; $df = 190$; $p < 0.001$) shows that the correlation matrix is not an identity matrix, which means that dimension reduction can be used. The high Kaiser-Meyer-Olkin (KMO) Measure values indicate that the data are suitable for performing factor analysis.

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.898
Bartlett's Test of Sphericity	X ²	2350.873
	df	190
	p	< 0.001

The first factor explains a 14.8% variance of the measured construct, the second factor 13.6% and the third factor 11.8% variance of the measured construct. The fourth extracted factor explains a variance of 10.1% and the last factor, i.e. the fifth, a variance of less than 10% of the measured construct. All five factors together explain a variance of 60% of the measured construct.

Table 3. Percentage of Explained Variance

Factor	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	2.960	14.798	14.798
2	2.715	13.573	28.371
3	2.353	11.765	40.135
4	2.029	10.145	50.280
5	1.939	9.696	59.976

The table below illustrates the factor loadings for each variable from the rotated factor matrix. Those variables that clearly load one of the five extracted factors were kept in the analysis.

Tabel 4. Rotated Factor Matrix

	Factor				
	1	2	3	4	5
Employees at our school strive to remove the obstacles students face in achieving their goals in all areas (learning, extracurricular activities, personal development, career, etc.).	.216	.529	.251	.145	.214
The school fund resources are used sensibly to ensure equal opportunities for students.	.281	.455	.213	.146	.127
Our school's development plan and related practices effectively reduce learning- and participation-related obstacles for all students.	.165	.684	.155	.320	.102
We help all new students get used to the school as soon as possible.	.193	.552	.111	.160	.232
At our school, we intentionally discuss the meaning of the concept of inclusion.	.306	.217	.129	.826	.132
At our school, we have a uniform understanding of an inclusive school.	.279	.225	.185	.855	.097
The teacher-parent cooperation at our school is good.	.261	.570	.273	-.026	.126

The definition of inclusion/inclusive school and the resulting practices (lesson organisation, lesson accommodations and modifications, etc.) are included in our school's development plan.	.371	.468	.119	.393	.152
Students at our school help one another.	.260	.257	.387	.148	.215
When it comes to planning the teaching process, the employees at our school successfully accommodate all students, regardless of their differences.	.450	.410	.207	.111	.208
I ensure I include topics related to the understanding of diversity in my teaching work.	.459	.335	.042	.193	.134
The employees at our school work with one another in planning, teaching and evaluating the teaching process for students with special needs.	.712	.248	.239	.235	.201
The employees at our school work with one another in planning, teaching and evaluating the teaching process for students from migrant backgrounds.	.818	.186	.141	.191	.114
The employees at our school work with one another in planning, teaching and evaluating the teaching process for low-SES students.	.766	.279	.176	.231	.111
Standards of ethical conduct at our school are very high.	.153	.315	.408	.151	.474
At our school, we immediately respond to various exclusionary practices among students.	.183	.282	.283	.077	.689
At our school, we immediately respond to various exclusionary practices adopted by employees when dealing with students.	.174	.167	.199	.115	.880
At our school, there is mutual respect between employees and students.	.122	.105	.814	.068	.225
At our school, students respect one another.	.070	.219	.658	.084	.058
At our school, employees respect one another.	.204	.165	.620	.138	.216

The first factor is strongly and clearly loaded by the variables that were at the outset assumed to measure recognition. Factor analysis revealed that recognition is a one-dimensional construct defined by the following elements:

1. accommodating different students when planning the teaching process
2. making sure teaching work includes topics related to the understanding of diversity
3. planning, teaching and evaluating the teaching process for students with special needs
4. planning, teaching and evaluating the teaching process for students from migrant backgrounds
5. planning, teaching and evaluating the teaching process for low-SES students

The second factor is loaded by the variables that were at the outset assumed to measure redistribution, however, at the same time it is also loaded by two variables from the representation set. Considering that these two dimensions are not compatible in terms of the content, it was decided that the variables that clearly load the second factor would be treated as part of two dimensions. The first is called redistribution, which is defined by the following elements:

1. striving to remove the obstacles students face in achieving their goals in all areas
2. using school fund resources to ensure equal opportunities for students
3. the effectiveness of reducing learning- and participation-related obstacles of all students
4. helping new students get used to the school

The second dimension, as part of the second factor, is defined by two variables that were used to measure representations. Representation is a two-dimensional construct, where two variables load the second factor (and two variables the fourth factor). The two elements in question are:

1. teacher-parent cooperation
2. an inclusive orientation of the school's development plan

Two variables that were at the outset assumed to measure representations load the fourth factor:

1. intentionally discussing the meaning of the concept of inclusion
2. a uniform understanding of an inclusive school

The third factor is loaded by the variables that were at the outset assumed to measure relationality, namely:

1. mutual respect between students and employees
2. mutual respect among students
3. mutual respect among employees
4. students' mutual help

The fifth factor is loaded by the variables that were at the outset assumed to measure relationality, namely:

1. high standards of ethical conduct
2. immediate response to various exclusionary practices among the students
3. immediate response to various exclusionary practices adopted by employees when dealing with students

Relationality has thus proven to be a two-dimensional construct, which encompasses the relational aspect on the one hand, and the functioning of schools on the other.

Factor analysis revealed that an inclusive orientation through the prism of justice of schools is a six-dimensional construct defined by the elements shown in the table below. The reliability of the measurement of dimensions was checked in terms of their internal consistency, and Cronbach's alpha coefficient was calculated to this end. Cronbach's alpha coefficients are provided next to the name of each dimension.

Table 5. *Extracted dimensions of an inclusive orientation through the prism of justice with the internal consistency coefficient, the definition of dimensions and their operationalisation*

DIMENSION	DEFINITION (ITEMS)	OPERATIONALISATION
REDISTRIBUTION ($\alpha = 0.748$)	Striving to remove the obstacles students face in achieving their goals in all areas	Employees at our school strive to remove the obstacles students face in achieving their goals in all areas (learning, extracurricular activities, personal development, career etc.).
	Using school fund resources to ensure equal opportunities for students	The school fund resources are used sensibly to ensure equal opportunities for students.
	The effectiveness of reducing learning- and participation-related obstacles for all students	Our school's development plan and related practices effectively reduce learning- and participation-related obstacles for all students.
	Helping new students get used to the school	We help all new students get used to the school as soon as possible.
REPRESENTATION (the functioning-of-school aspect) ($\alpha = 0.603$)	Teacher-parent cooperation	The teacher-parent cooperation at our school is good.
	Inclusive orientation of the school's development plan	The definition of inclusion/inclusive school and the resulting practices (lesson organisation, lesson accommodations and modifications, etc.) are included in our school's development plan.
REPRESENTATION (declarative aspect of school) ($\alpha = 0.904$)	Intentionally discussing the meaning of the concept of inclusion	At our school, we intentionally discuss the meaning of the concept of inclusion.
	A uniform understanding of an inclusive school	At our school, we have a uniform understanding of an inclusive school.
RECOGNITION ($\alpha = 0.846$)	Accommodating different students when planning the teaching process	When it comes to planning the teaching process, the employees at our school successfully accommodate all students, regardless of their differences.
	Making sure teaching work includes topics related to the understanding of diversity	I ensure I include topics related to the understanding of diversity in my teaching work.
	Planning, teaching and evaluating the teaching process for students with special needs	The employees at our school work with one another in planning, teaching and evaluating the teaching process for students with special needs.
	Planning, teaching and evaluating the teaching process for students from migrant backgrounds	The employees at our school work with one another in planning, teaching and evaluating the teaching process for students from migrant backgrounds.
	Planning, teaching and evaluating the teaching process for low-SES students	The employees at our school work with one another in planning, teaching and evaluating the teaching process for low-SES students.
RELATIONALITY (functioning of the school) ($\alpha = 0.804$)	High standards of ethical conduct	Standards of ethical conduct at our school are very high.
	Immediate response to various exclusionary practices among students	At our school, we immediately respond to various exclusionary practices among the students.
	Immediate response to various exclusionary practices adopted by employees when dealing with students	At our school, we immediately respond to various exclusionary practices adopted by employees when dealing with students.
RELATIONALITY (relational aspect) ($\alpha = 0.762$)	Students' mutual help	The students at our school help one another.
	Mutual respect between students and employees	At our school, there is mutual respect between employees and students.
	Mutual respect among students	At our school, students respect one another.
	Mutual respect among the employees	At our school, employees respect one another.

Cronbach's alpha coefficients indicate a sufficiently high internal consistency of the measured constructs. The consistency of the representation factor is somewhat lower from the declarative aspect, where Cronbach's alpha coefficient is at the lower limit of consistency, however, this result was attributed to a small number of items used to measure the factor.

Discussions

The aim of this paper was to check the dimensionality of the measured constructs. It was revealed that justice is a multidimensional construct that can be measured by means of the indicators of the Index for Inclusion by [Booth and Ainscow \(2002\)](#).

The survey has provided the first comprehensive insight into the state of inclusion in the prism of justice in vocational education and training in Slovenia. A valid and reliable methodological tool for measuring the domain in the future has been developed. It can be used for identification of the state of inclusion in the prism of justice at the school level on the one hand, and for the evaluation of the impact of systematic support in the field of inclusion and justice on the other hand. Many challenges in this area remain and some are highlighted below.

As defined in the first part of the paper based on [Rawls' Theory of Justice \(1971\)](#), the redistribution of various basic goods is the foundation for the way justice is viewed in Western societies. It is based on asserting individual rights, which are ensured by redistributing goods and providing access to social positions – at school, this is achieved by enabling conditions necessary for optimal learning outcomes, i.e. by removing obstacles and offering additional support to those who need it. The differences in rights are justified if they benefit the most disadvantaged individuals (positive discrimination). The research in this paper has revealed that the redistribution of basic goods can be inferred on the basis of (1) the efforts to remove the obstacles students face in achieving their goals in all areas, (2) the use of school fund resources to ensure equal opportunities for students, (3) the effectiveness of reducing learning- and participation-related obstacles for all students, and (4) helping new students get used to school. The assessments by head teachers, school counsellors and teachers of the implementation of inclusion in terms of redistribution was comparable to this (Inkluzija v poklicnem in strokovnem izobraževanju [[Inclusion in Vocational Education and Training](#)], 2022). They assessed that new students were getting a great deal of help in getting used to school and that school employees made considerable efforts to remove obstacles students face in achieving their goals in all areas (learning, personal development, career, etc.) The respondents also mostly confirmed a sensible use of school fund resources to ensure equal opportunities for all students. This is a standard aid measure for students from low-SES families and a typical positive discrimination measure, which can also have a downside. On the one hand, the redistribution of rights can indeed constitute support for individuals' inclusion, while on the other, as pointed out in the first part of this paper, such measures can lead to even greater stigmatisation of those who often face exclusion ([Akkan and Buğra, 2020](#); [Fraser, Dahl, Stoltz, and Willig, 2004](#); [Fraser and Honneth, 2003](#); [Knijn, Theuns, and Miklós, 2020](#)). The research also found that schools' development plans and the resulting practices are to a lesser extent aimed at effectively reducing the learning- and participation-related obstacles for all students. This can be attributed to the fact that, in general, teachers are sometimes unfamiliar with all the documents that guide their work. Even if the documents as such do not have a direct impact on their actual pedagogical practice, detailed familiarity with these documents can be a prerequisite for improving the quality of pedagogical work.

Recognition foregrounds the rights of traditionally overlooked cultures. At school, just recognition is manifested, for instance, as the discourse of inability (negative recognition) being replaced by the discourse of obstruction (positive recognition) ([Fraser and Honneth, 2003](#)). It was found that the implementation of recognition in vocational education and training can be implied on the basis of (1) accommodating different students when planning the teaching process, (2) the inclusion of topics related to the understanding of otherness in teaching work, (3) school employees working with one another in planning, teaching and evaluating the teaching process for students with special needs, (4) [...] for students from migrant backgrounds, and (5) [...] for low-SES students. The report *Inclusion in Vocational Education and Training* (Inkluzija v poklicnem in strokovnem izobraževanju [[Inclusion in Vocational Education and Training](#)], 2022) shows that school employees work most with one another in planning, teaching and evaluating the teaching process when it concerns students with special needs, less so when it concerns students from

migrant backgrounds, and even less so when it concerns students from low-SES families. When it comes to discussing recognition and looking for an answer to the question of which students to pay more attention to, it would be necessary to take a step away from certain groups of students whose schooling is relatively well regulated to those groups who often face exclusion (Ainscow, 2023; Lynch and Baker, 2005). In practice, recognition is also directly related to the implementation of various accommodating measures that are the result of the rights enjoyed by students who often face exclusion. The respondents' answers show that among the school practices focused on accommodating the students' differences, those related to knowledge assessment and evaluation are the most common, as are those related to planning and adapting the teaching process to different students and including topics related to the understanding of diversity into school lessons. In the future, other research approaches should be used to study the specific accommodation practices used by education professionals in schools.

Representation stems from the equality of conditions for (political) power in taking part in (co) decision-making at different levels of social life and for different social groups (Akkan and Buğra, 2020; Fraser, Dahl, Stoltz, and Willig, 2004). At school, this is manifested as everyone being involved in various decision-making processes. Factor analysis has revealed representation to be a two-dimensional construct and should be considered as such. In terms of the functioning of a school, representation includes (1) teacher-parent cooperation, and (2) definitions of inclusion and the resulting practices being included in the school's development plan. The two items that were used to measure representation in terms of the functioning of a school saturate the factor that very clearly measures redistribution. However, based on the content of these items, it was decided that representation in terms of the functioning of a school should be kept as a separate dimension. Representation from the declarative aspect of school includes (1) intentionally discussing the meaning of the concept of inclusion, and (2) a uniform understanding of an inclusive school. The report *Inclusion in Vocational Education and Training* (Inkluzija v poklicnem in strokovnem izobraževanju, 2022) shows that the respondents assessed cooperation with the students' parents as good. Intentional discussions about the meaning of the concept of inclusion, however, are present to a lesser extent, and a uniform understanding of an inclusive school is weak (ibid.). Considering the complexity of the concept, the findings come as no surprise. In the future, even more attention should be paid to defining it as precisely and unambiguously as possible.

Relationality also proved to be a two-dimensional construct. Relationality arises from the question of how to structure a just social environment in order to stimulate the development of individuals' ability to (co-)live in a community. At school, this is manifested as nurturing an accepting, respectful and supportive culture of coexistence between children/adolescents and adults (Lynch, Kalaitzake, and Crean, 2021). The research revealed that it is necessary to look at relationality from two aspects: the relational aspect and the functioning-of-school aspect. The former is defined by respect (1) among students, (2) among employees, and (3) between students and employees, as well as (4) students' mutual help, which was initially hypothesised to be a measure of representation. The findings show (Inkluzija v poklicnem in strokovnem izobraževanju [Inclusion in Vocational Education and Training], 2022) a relatively low level of mutual respect between school employees and students, and a similarly low level of mutual respect was also found among school employees themselves. Above all, however, the respondents believe that the level of mutual respect is low among students. This might be interpreted as a consequence of the fact that education professionals often pay more attention to conflicts between students and to peer violence, or that they are more likely to notice inappropriate rather than appropriate communication. This might result in their belief that there is no respect among students.

Relationality that relates to the functioning of a school is defined by (1) the implementation of high standards of ethical conduct and immediate response to various exclusionary practices (2) among students, and (3) adopted by employees when dealing with students. The findings (Inkluzija v poklicnem in strokovnem izobraževanju [Inclusion in Vocational Education and Training], 2022) suggest that only a little over one third of the respondents believe that the standards of ethical conduct at their school are high, which is actually also connected with the presence of students with special needs and low-SES students. In fact, the larger the number of these groups of students, the lower the standards of ethical conduct. The research also revealed that more than a half of the education professionals stated that their respective schools' response to various exclusionary practices among students and exclusionary practices adopted by employees when dealing with students is not immediate.

It can be concluded that inclusion in terms of justice is not only a four-dimensional concept, but

rather a six-dimensional one. There are other theoretical discussions of justice, e.g. restorative justice (González, 2012; Sellman, Cremin, and McCluskey, 2014; Thorsborne and Blood, 2013), hence this finding does not come as much of a surprise. In the future, it would thus make sense to supplement the existing dimensions and the statements used to measure them, both in terms of the theoretical concepts and research conducted, which would further increase the set of Index for Inclusion indicators, which can also be used to draw conclusions about the justice of school environments.

Conclusions

Based on a review of 225 relevant studies, Kielblock and Woodcock (2023) concluded that none of the existing instruments measures inclusiveness appropriately. Hence, a new instrument that would measure the attitude towards inclusive education for all students is needed. Taking into account inclusion viewed as a concept that is intended for everyone, this paper has shown that the Index for Inclusion can not only be used as a tool for measuring inclusion, but also as a starting point for designing a tool to be used for measuring the multidimensional concept of justice. Despite the perceived need to modify the questionnaire, which was completed by education professionals employed in Slovenian vocational education and training, the paper confirmed a connection between the two complex concepts, i.e. justice and inclusion. This connection was substantiated both theoretically and empirically.

One of the research limitations that needs to be highlighted is the unclear loading of the items that have been shown to measure representation in terms of the functioning of schools. In fact, factor analysis showed a correlation between the items measuring teacher-parent cooperation and inclusion of the definition of inclusion and the resulting practices into schools' development plans, and the items used to measure redistribution. The decision to keep the factor as a separate dimension of representation was based on the content as the main decisive criterion, i.e. in terms of the content, the two items do not measure redistribution. The factor has borderline acceptable internal consistency, thus in future, it might be worthwhile to consider redefining the representation dimension in terms of the functioning of schools.

It would also make sense to upgrade such measurements through process-oriented activities to eliminate weak areas perceived when it comes to operation in specific educational institutions. These areas refer to viewing inclusion and justice as fundamental principles of school communities. When planning various activities aimed at promotion of inclusion and justice, it is imperative to use as much data as possible and to make sure the data is as diverse as possible. Moreover, the changes must include the organisational culture of institutions, as well as measures at the level of a wider community.

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Conflict of interests

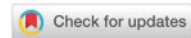
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Base Rate Neglect Bias: Can it be Observed in HRM Decisions and Can it be Decreased by Visually Presenting the Base Rates in HRM Decisions?

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Abstract: The aim of this experimental research was to explore if the future HR managers are susceptible to the base rate neglect (BRN) bias and if the visual presentation of the base rates improves their reasoning. The BRN bias is a tendency to disregard a priori probabilities that are explicitly given for the class of observed objects. In this study, BRN is seen as the case of decision-making bias in the work-related context. Although it is inevitable part of the decision-making processes concerning employees', the topic is not sufficiently studied. A total of 65 participants, enrolled in the master studies of HRM, were subjected to 4 different types of BRN tasks, in which five different HR activities were described. They were varied within subjects, representativeness of description, and format of base rate. Within each task there were five different situations that make 20 tasks in total. The two-way repeated-measures ANOVA revealed that the proportion of biased answers was significantly higher on the representative tasks when the tasks presented visually, with no interaction between representativeness and format of task. Results are in line with previous studies that observed an effect of BRN on decision-making process. Yet, unexpectedly, visual presentation of base rates did not facilitate unbiased reasoning implying that some other form of presentation might be more appropriate for the task.

Keywords: *base rate neglect, cognitive bias, HRM, decision-making, ecological rationality.*

Introduction

As a part of everyday private and work life, humans have to reason about different problems and situations. Irrespective of whether our reasoning is based on its functionality or exactness, scholarly attention is turning toward studying the viability of decision-making practices and the validity of their outcomes. Given the costly consequences of ineffective decisions, decision-making in business-like contexts are of special interest, and scholars and practitioners struggle to find strategies to optimize them. The particularly sensitive part is when it concerns people at workplace often challenging human resource managers rationality.

The fact that human resource managers oversee recruitment, selection, employee appraisal, career development, promotional decisions, training, and compensation and all these activities involve decision-making as a function of perceptions and judgments (Storm et al. 2023). The consequences of such decisions in this domain might be felt at the individual level — affecting someone's future career (Swider, Harris, and Gong 2022), at the process level — rejecting potentially effective candidates and accepting ineffective ones (Whyte and Sue-Chan 2002), as well as on the organizational level leading to unintentional expenses (Ceschi et al. 2019). Therefore, it seems to be of great importance to identify and account for different factors that impact effective decision-making for human resources management. If we focus on individual decision-makers in this context, we see that they must make decisions rapidly in restrained circumstances using very limited cues about concrete objects of perception, which is typical situation of using heuristics in the social context (Marsh 2002).

Over decades of research, cognitive psychologists identified numerous heuristics that individuals

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utilize in decision-making contexts. Dale (Dale 2015) describes several fundamental heuristics: availability, anchoring and adjustment, representative simulation, peak-and-end, base rate, and AIM (affect-as-information). As HRM activities occur in a social setting, common biases are based on the social phenomenon of focusing on the similarities with other individuals. Marsh (2002) identified the following heuristics in the HRM context: search, assessment, and selection. Ceschi and colleagues (2019) use factor analysis to extract three factors referring to biased decision-making: mindware gaps, valuation biases (positive illusions and negativity effect), and anchoring and adjustment.

Palmucci (Palmucci 2023) claims that the most detrimental effect of bias comes in the form of individuals developing a “blind spot,” in which an individual holds an illusion that he/she is immune to biases. As a matter of fact, errors are often based on a systematic bias due to an individual sticking to an unsuccessful strategy. These errors happen when an individual sticks to a prior preconception while ignoring alternatives and is insensitive to outcome probabilities. Similarly, Sartori and colleagues (Sartori, Costantini, and Ceschi 2020) found that two key cognitive biases in employee assessments are the illusion of control and the overconfidence effect.

Although base rate neglect is well known phenomenon, previous studies were more focused on some other domains of decision-making processes in medicine (Stengård et al. 2022), law (Dahlman, Zenker, and Sarwar 2016) or banking industry (Kang and Park 2019). As Swider and colleagues' (Swider, Harris and Gong, 2022), claim that biases in work context have their own pace, purpose, and, there are some indices that they have to be analyzed more thoroughly in order to gain understanding of its patterns and mechanisms and potential contextual particularities.

Biases in Human Resource Management HRM

Although it seems to be an important practical issue, there are fewer studies of the problem than might be expected. Yet, as it is already stated, almost all aspects of organizational life are susceptible to biased decision-making, especially those concerning people, or employees. For example, Swider and colleagues (Swider, Harris and Gong, 2022) in their comprehensive study of first impression effects identify its occurrences in the processes of selection, socialization, leader-subordinate relationships, job performance and in team dynamics.

In the employee recruitment processes, biases could occur at any stage, starting with biased evaluation of candidates' resumes, forming biased impressions that result in ineffective decisions (Derous and Ryan 2019). Several studies confirm the similar effect between recruiters and candidates (Erlandsson 2019). Especially sensitive situation for biased decision-making to occur is selection interview. In such short time circumstances, people are prone to use heuristics, such as relying on information that comes easily to mind (Huffcutt, Van Iddekinge, and Roth 2011). Also, assessors might formulate assumptions as a function of the information, they review before making decisions (e.g., formulating assumptions from information gathered prior to conducting a candidate interview), or they might be under the effect of subjects' attractiveness (Anderson, Adams, and Plaut 2008; Swider et al. 2022). Thus, researchers should analyze the perspective of interviewed candidates that were “victims” of halo effect, personal prejudice, first impression and central tendency errors (Karunaratna et al. 2010). Nevertheless, the majority of studies focus on the effects of gender, race, and minority stereotypes on personnel decision-making process (Auster and Prasad 2016; Guillén, Mayo, and Karelaia 2018), not only in the context of selection but along the worklife of employees.

Special attention should be paid to the process of performance appraisal, as one of the key HRM activities with consequences that goes beyond individual engagement. Lance and colleagues (Lance et al. 2008) in their study of 360-degree feedback refer to discrepancies of assessments between raters on different positions, implying that it is the result of different evaluators perspectives and judgment goals. Also, in one experimental study it was found that rating scores of subordinate employees were higher when raters are exposed to an anchor of higher value, while higher scores on one dimension initiated higher score on another just among female evaluators (Belle, Cantarelli, and Belardinelli 2017). Ordoyan (Ordoyan 2021) in his dissertation explores occurrences and effects of bias in appraisal process in one company focusing on spillover effect, halo, effect, horn effect, leniency and central tendency effect, the recency and primacy effect, as well as the effect of personal biases.

Swider and colleagues found the first impression effect explaining how people reason when judging

others focus on potential salient characteristics (cues based on appearance, communication, content and behavior), and then on motives. Similarly study of Dagger and colleagues (Dagger et al., 2013) corroborates the idea that some attributes are more relevant for forming biased decision. They demonstrate selective halo and spillover effects of side-personnels' interpersonal skills to other, less obvious aspects of health services.

Finally, these studies more or less explicitly impose the question of balance between accuracy and efficacy, vaguely concluding that it might be achieved by focusing on information with higher diagnostic validity and neglecting the irrelevant ones that are misleading. Furthermore, as part of employee staffing processes. Additionally, there is a strong effect of on decision-making. In one study, the idea that some attributes are more and others less susceptible to biases.

Controversies in interpreting biases in Human Resource Management (HRM)

Considering preceding empirical data and theoretical considerations, the discourse surrounding the potential utility or detriment of heuristics and biases, both in a general context and within the HRM domain, remains inconclusive. Currently, there are at least two different broad perspectives on this problem. One group of theorists considering HRM topics advocate the idea that heuristics in human cognitive processes are economically sound, use as least as possible time and information (Marsh 2002) resulting in a sufficiently good solution (Gigerenzer 2008; Krabuanrat and Phelps 1998). Others see this path rather problematic (Derous and Ryan, 2019; John Bernardin et al., 2016; Karunarathna et al., 2010) leading toward decision errors and discrimination (Auster and Prasad, 2016).

Specific studies of "positive" orientation advocates that in scenarios characterized by certainty and an overwhelming volume of information, heuristics represent the appropriate pathway for reasoning (Hafenbrädl et al., 2016). In line with the interpretation of Gigerenzer and Hoffrage (Lance et al., 2008), the theorists within the first approach see heuristics and biases as the common organizational resource based on experience and captured in organizational routines that makes decisions and task accomplishments easier (Krabuanrat and Phelps 1998). In business like circumstances which refer to HR practice too, heuristics are valuable intellectual assets enabling employees to make decisions with less administration and costs. Due to its minimum requirements, heuristics are a natural choice in situations of limited rationality because they promptly offer the first satisfying solution. Also, it is less sensitive to manipulation from potential candidates or employees due to its simplicity that situational reduces noise and distractors (Hu and Wang 2014). In favor of the idea that heuristics are ecologically valid and thus more flexible, researches show that lack of congruency among multiple rating sources, in the case of 360 degree feedback, is not necessarily proof of error biases. The diverse viewpoints articulated herein reflect the varying perspectives of evaluators occupying different organizational positions and roles. Their disparate objectives shape their perceptions within the context of their respective agendas, affording them ecologically sound appraisals. Therefore, it should be regarded as 'valid general impression' rather than indicative of bias or error (Lance et al., 2008). The main problem then should be finding the optimal relation between the complexity of the situation and the correctness of the solution (Gigerenzer, 2008).

On the other hand, within another line of interpretation authors point to the fact that use of heuristics and biases leads toward specific erroneous outcomes that might endanger the business process and may harm the organization and employees (Auster and Prasad, 2016; Derous and Ryan, 2019; John Bernardin et al., 2016; Karunarathna et al., 2010). Such theorists see decision making based on prejudice and stereotypes as a potential risk and state that such solutions are not optimal for the organization. Therefore, in this research line the efforts are made to achieve the minimization of such reasoning. However, regardless of which perspective we take, it has to be admitted that, although there are cases of misjudgment, a lot of decisions made by heuristics turned out to be correct, in spite of imperfections of the cognitive processes they are based on (Gigerenzer, 2008; Gigerenzer and Hoffrage, 1995; Hoffrage et al., 2002).

Ceschi and colleagues (Ceschi et al., 2019) state that both forms of thinking, the analytic systematic one based on logic, and the one based on heuristics and intuitive cognition are prone to errors but based on a different mind gap and the erroneousness of decision is more the case of the situational unawareness than of using concrete strategy (Ceschi et al., 2019; Gigerenzer, 2008; Palmucci, 2023; Sartori, Constantini and Ceschi, 2020). Even the most sophisticated debiasing strategies using artificial intelligence and algorithms that are expected to be impartial and based on unbiased clear rules, are

actually proven to be an illusion. For example, if we use just quantified information about absenteeism, we might conclude that women are less reliable category of employees and not taking into a consideration the maternity leave, we could make a decision in favor of men (Tuffaha 2023). Similarly, overly and uncritically using scientific modelling of human behavior and mechanistic approaches to decision making problem based on pure algorithms, can lead us to constant and systematic errors. Some scholars call it an illusion in HRM (Vassilopoulou et al. 2022). The lack of recognition and apparent neutrality makes this issue more serious because this fallibility being integrated deep in the system. But the consequences are obvious.

Paradigms of measuring base rate neglect and phenomenon interpretation

Extensive research has been conducted on this phenomenon over time (Barbey and Sloman 2007; Bar-Hillel 1980; Kahneman 2011; Kahneman and Tversky 1973; Ohlert and Weißenberger 2015; Pennycook et al. 2014; Stengård et al. 2022; Tversky and Kahneman 1974, 1992; Wolfe and Fisher 2013). The number of different methodological and conceptual frameworks for studying base rate neglect has increased over time, somewhat deviating from the initial methodology described by Tversky and Kahneman (1974) and their explanation. In their pioneering work on base rate neglect, these authors identified the phenomenon using experimental and control groups, varying simple probabilities and the stereotype descriptions. They then observed the overestimation or underestimation of these probabilities by participants. In later research, base rate neglect began to be examined in a Bayesian context, where this phenomenon was equated with prior probability. Findings on base rate neglect indicated underestimation, and even ignorance, of prior probabilities, with an excessive reliance on posterior probabilities (Stengård et al. 2022). Apart from experimental approaches, there have been attempts to measure base rate neglect differentially (Teovanović 2013). Specifically, in the context of this attempt, the phenomenon is measured using multiple tasks saturated with stereotypes accompanying explicit base rate information. Any participant response deviating from the explicit probability in the direction of stereotypes is considered biased. The measure of participants is calculated as the proportion of biased responses, and this measurement paradigm has proven to be meaningful conceptually. The rate of biased responses in studies of base rate neglect has varied depending on manipulations of the difference in prior probability between categories (Tversky and Kahneman 1974), the strength of the causal relationship between base rate and described events (Ajzen 1977; Bar-Hillel 1980), and the presence of training or instruction (Goodie and Fantino 1999).

The initial explanation for base rate neglect was proposed by Tversky and Kahneman (1974), postulating the heuristic of representativeness. According to their interpretation, heuristic thinking involves unconscious rules guiding it, making it difficult to deliberately control. It is possible to recognize and learn situations in which thinking is biased, allowing for correction in those situations. Specifically, the representativeness heuristic involves the cognitive system being led by stereotypical rather than numerical information. This interpretation of base rate neglect is part of a broader approach to dual-process theories (De Neys and Pennycook 2019; Neys 2006; Pennycook et al. 2014; Reyna and Brainerd 1995; Tversky and Kahneman 1992). This approach postulates the existence of two types of thinking. Type 1 thinking is fast, intuition-based, not accessible to introspection, and often leads to responses deviating from rational norms. In contrast, Type 2 thinking is slower, deliberative, accessible to introspection, and often results in normatively correct responses. Within the framework of dual-process theories, there are disagreements regarding the interpretation of base rate neglect. For example, proponents of Cumulative Prospect Theory (Tversky and Kahneman 1992) argue that the cause of base rate neglect lies in the inadequate representation of probabilities in the cognitive system. On the other hand, adherents of the Fuzzy Trace Theory (Reyna and Brainerd 1995) believe that the human cognitive system does not actually operate with probabilities but extracts the gist, essential non-probabilistic information serving as a basis for reasoning. Finally, within the dual-process approach, the occurrence of cognitive biases is interpreted as the inability to inhibit fast and intuitive responses activated alongside analytical, correct responses (De Neys and Pennycook 2019; Neys 2006; Pennycook et al. 2014).

In addition to dual-process theories, cognitive biases have been investigated within the framework of ecological rationality approaches (Betsch et al. 1998; Gigerenzer 2008; Gigerenzer and Hoffrage 1995; Hoffrage et al. 2002). Gigerenzer and Hoffrage (1995) argue that heuristics and biases are not errors but adaptive properties of the cognitive system. When environmental information aligns with cognitive needs,

heuristics and biases represent useful and efficient problem-solving mechanisms. However, when the format of environmental information does not align with cognitive preferences, errors occur. For example, if information being reasoned about is presented in the form of absolute numbers, reasoning improves (Cosmides and Tooby 1996; Gigerenzer and Hoffrage 1995). These findings raise an important question related to base rate neglect: is it possible to present environmental information in a way that facilitates rational reasoning?

Several studies have aimed to mitigate the effect of various cognitive biases (e.g. Battaglio Jr et al., 2019; Cantarelli, Belle and Belardinelli, 2020; Ludolph and Schulz, 2018; Nagtegaal et al., 2020; Ohlert and Weißenberger, 2015; Singh, 2013). Visual interventions to reduce anchoring bias have proven effective in management reasoning (Nagtegaal et al., 2020). Similar interventions have been fruitful in weakening the effects of base rate neglect in the domain of medical reasoning (Ludolph and Schulz, 2018). These interventions generally presented base rate information in the form of differently colored dots representing absolute numbers, thereby visualizing their differences. However, systematic literature reviews (Korteling, Gerritsma, and Toet 2021) suggest a weak transfer of debiasing intervention effects when it comes to different biases or even the same bias in different reasoning domains.

Base rate neglect in HRM

Within the broad area of cognitive biases investigated, there is one interesting phenomenon understudied in the work related context. Base rate neglect is commonly identified as a cognitive bias that indicates a human inclination to underemphasize or even disregard explicitly provided numerical indicators. Instead, individuals tend to rely on specific stereotypic beliefs when making judgments about probabilities (Bar-Hillel 1980; Kahneman and Tversky 1973; Teovanović 2013; Tversky and Kahneman 1974, 1992). For instance, consider a group of 100 people comprising 30 teachers and 70 developers. The base rate information suggests that the probability of a randomly selected member being a teacher is 0.3. However, when describing a specific member as someone eager to work with people, fond of teaching, neat in appearance, and wearing suits, that member is perceived as more likely to be a teacher than a developer. This judgment is influenced by stereotypic depictions of a teacher, leading to the neglect of explicitly provided numeric information indicating a much higher probability for a random member to be a developer.

One potentially important domain in which the base rate neglect occurs is HRM. Although there are not many studies on the topic, this bias is quite usual in the HRM field. Business tasks are often performed by using different statistical tools and quantitative models to minimize error and maximize gain. This approach is derived from the so called “world of risk”, implying that we are aware of the probabilities of events. Yet, the social reality is more of the world of uncertainty (Hafenbrädl et al. 2016), which implies that the parameters for estimating different alternatives often cannot be measured. In such circumstances it is of great importance to explore to which extent the HRs’ estimations of probabilities are accurate and reliable.

Several studies of base rate neglect study in HRM, considering the concept are unequivocally prove the effect of neglecting the base rate information when facing the informative individual (personalized) data about others. Subjects were prone to make decisions about person’s group affiliation (as engineers or lawyers in this particular study) prevalently on their representative characteristics, neglecting objective probabilities (Argote, Devadas, and Melone 1990; Argote, Seabright, and Dyer 1986; Palmer and Loveland 2008). This tendency becomes stronger after group discussion (Argote, Seabright, and Dyer 1986), implying that this phenomena is susceptible to groupthink. The main problem here might not be the categorization but the consequences of it, as each categorization leads toward some judgment of the member’s attributes and causes of the behavior. It often provokes prejudices and stereotypes. Important findings in the study concern the nature of the personalized information. Argote and colleagues (Argote, Devadas, and Melone 1990) found that if the descriptions were not in the line with popular image (stereotype) of the profession, the base rate information became relevant and its effect to probability judgment was higher.

In one relevant study of the future HR managers’ judgements in the selection process, base rate data about candidates’ categories was less effective cue than it was interview scores (Whyte and Sue-Chan 2002). It was found that individual, personalized information was more relevant for experienced

respondents than prior probability of candidates' potentials to be successful. Although the base rate information is significant indicator of candidates' future performance, even forthcoming HR professionals make decisions neglecting exact statistical data and rely on less precise information. When we are facing, for example, with employees CV in the process of selection, there is information about their group affiliation, their profession and so on. We might have some preconceptions about that, as well as some statistical data referring to it. At the same time, we could gather information about some, apparently side characteristics of their life from LinkedIn or Facebook and decide which criteria are more relevant for us. All these data could then be overweighted related to key information contained in base rate information. Such cases might happen in the situation of performance evaluation or other aspects of HRM activities which are especially salient with concrete impressions, descriptions or behaviors of employees.

Problem of this research

Although base rate neglect is relatively well studied phenomenon among different contexts it is to certain extent understudied in the human resource management studies. Swider and colleagues (Swider, Harris and Gong, 2022) offer a review of studies concerning biases in organizational psychology, but focusing on first impression and related heuristics. Nevertheless, we mentioned one relatively recent study that considers base rate neglect bias in human resource management. Whyte and colleague (Whyte and Sue-Chan 2002) experimentally examined the presence of base rate neglect confirming the expectations based on similar studies in other domains. In order to go further into the understanding of the phenomena while trying to correct some limitations of their experimental design, we conducted our research. We started from the idea that targeting the only one domain of HR should be abandoned, and that the measurement method used by Whyte and Sue-Chan (2002) was considerably more complex and mathematically demanding than other presented. The main criticism towards their method is that it involves several different parameters that participants are supposed to count with. Furthermore, in this study the representativeness, which is considered to elucidate representativeness heuristic, was not varied, but only the proportion of the base rates. Therefore, we consider it important to experimentally investigate the phenomenon in various aspects of reasoning in the field of human resource management. Therefore, we consider it important to experimentally investigate the presence of this phenomenon in various aspects of reasoning in the field of human resource management.

The initial Tversky and Kahneman (1974) procedure is suitable due to the presence of both a control and an experimental group, although it fails to account for individual differences in the manifestation of base rate neglect. On the other hand, Teovanović (2013) successfully addresses individual differences, but a criticism of his measurement procedure could be the lack of a control situation against which the presence and intensity of base rate neglect could be more precisely determined.

Furthermore, although there are studies aimed at reducing the effect of base rate neglect in other reasoning domains, evidence of the weak transfer effect of debiasing procedures across domains (Korteling, Gerritsma and Toet, 2021) necessitates testing interventions with such a goal in this domain. Given that interventions involving visual representation of base rate information have proven fruitful (Ludolph and Schulz 2018) we believe that testing such interventions in the field of human resource management would be productive.

Taking all this into account, the goal of this study was to experimentally test the presence of base rate neglect in human resource management, using a new procedure that combines a design with an experimental and control situation, and to test the effect of visual representation of base rate information. Based on the assumptions of dual-process theories (e.g. De Neys and Pennycook, 2019; Gigerenzer and Hoffrage, 1995; Neys, 2006; Reyna and Brainerd, 1995), as well as research on effects, (a) we expected that in a situation where there is a stereotypical description of a specific person, the manifestation of bias would be higher than in a situation where such a description does not exist. Additionally, (b) we expected that the effect of base rate neglect would be reduced by visually representing base rate information.

Materials and Methods

Participants

The sample consisted of 65 participants (86.2% female, $M_{age} = 23.92$, $SD_{age} = 2.05$) – graduate students of human resources management at the University of Belgrade. In return for participating in the experiment, students were rewarded with points. Having in mind their current and future career interests we believed that sample was relevant for the topic.

Materials

For the purpose of this study, we developed Base Rate Neglect Tasks, so they reflect the issues in the Human Resources Management context. Each participant was exposed to five different hypothetical situations representing different activities in the human resources management domain. For each situation, participants were presented with a vignette and were instructed to imagine that they are human resources managers, supposed to resolve a certain problem. In the first part of each vignette the hypothetical situation was described, whilst the rest of the vignette consisted of the information on the concrete employee, participants were instructed to appraise. When participants completed the vignette reading, they were asked to assess the probability of the concrete employee's behaviour related to the topic described on a scale ranging from 0% to 100%, by swiping the slider over the 10% steps. Each hypothetical situation appeared four times, varying in its representativity and the information presentation format. Representativity referred to the vividness of the information about the concrete employee presented, while format referred to the visual or textual form of information presentation. In essence, the vignettes allowed for the specific depiction of employees either in a representative manner, invoking the representativeness heuristic by vivid description, or in a non-representative manner, by brief description. Information concerning base rates was presented either textually or visually. Consequently, each of the five hypothetical situations manifested in four distinct forms: representative and textual (RT), non-representative and textual (NT), visual and representative (RV), and visual and non-representative (NV). All four forms are shown in the Figure 1.

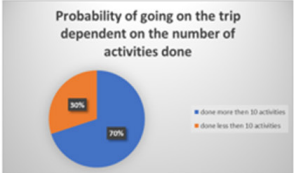
Design and stimuli		representativeness	
		representative	nonrepresentative
format	visual	RV  Sara has finished more than 10 activities in the present month. However, she is not so sociable, and prefers to work on her own. She rarely takes a coffee break with her colleagues	NV  Sara has finished more than 10 activities in the present month
	textual	RT The probability that an employee will go on the team building trip is 70%, if he/she has finished more than 10 activities. Sara has finished more than 10 activities in the present month. However, she is not so sociable, and prefers to work on her own. She rarely takes a coffee break with her colleagues	NT The probability that an employee will go on the team building trip is 70%, if he/she has finished more than 10 activities. Sara has finished more than 10 activities in the present month

Figure 1. Task example: The four iterations of base rate neglect tasks

Hence, all participants went through twenty different iterations of tasks. The base rate neglect bias was observed if participants attributed a probability to a particular employee that differed from the provided base rate, particularly when leaning towards a representative description. Conversely, if respondents

assigned a probability equal to or exceeding the base rate to a specific employee, we did not record it as a bias. The participants' scores were computed as the proportion of responses inclined towards base rate neglect related to 5 different situations, and in each of the four task iterations. Hence, for each participant 4 different proportions were counted (scores in RT, TNR, VR and VN stimuli). For example, if a participant answered biased in 4 out of 5 situations in RT form of the stimuli, that means that their proportion in RT form equals .8. Similarly, for this and each other participant, the other three proportions were counted.

Our measurement methodology for Base Rate Neglect (BRN) amalgamates two approaches, one derived from the pioneering research of [Tversky and Kahneman \(1974\)](#) concerning vignette representativeness. The second approach, stemming from endeavors to capture individual variations in the manifestation of cognitive biases ([Teovanović 2013](#)), is embodied in this study through the exposure of respondents to a broader array of situations and the computation of scores based on the proportion of tasks wherein bias was exhibited. We posit that the integration of these approaches is fruitful as it simultaneously provides insights into respondents' predispositions toward base rate neglect in situations where the representativeness heuristic is not directly elicited, as well as those situations where it is, while also attempting to gauge fundamental individual differences in the manifestation of this phenomenon, enabling a more detailed exploration of its correlates.

Design and procedure

The design employed here is the fully repeated factorial design, with two two-leveled factors: representativity and format. Participants were exposed to the experiment in controlled conditions, specifically in a computer laboratory at the Faculty of Organizational Sciences in Belgrade. Tasks were presented using the online experimental platform "SoSci Survey" (ref). Participants first provided their demographic information before proceeding to the Base Rate Neglect tasks. Given that each of the four versions of the same task comprised five different situations, these situations were presented to participants in a pseudorandomized order, ensuring that the same situation did not appear in two consecutive iterations. These tasks were counterbalanced with respect to both independent variables to nullify any potential effects of primacy and transfer. In this way, four variations of the task order emerged, generated using the Latin square method, as shown in the Figure 2. These four task order variations were created as four distinct questionnaires on the online platform, and the platform's algorithm randomly assigned participants to one of the four groups, with the condition that the number of completed questionnaires was equal across groups. Data are analyzed using JASP software.

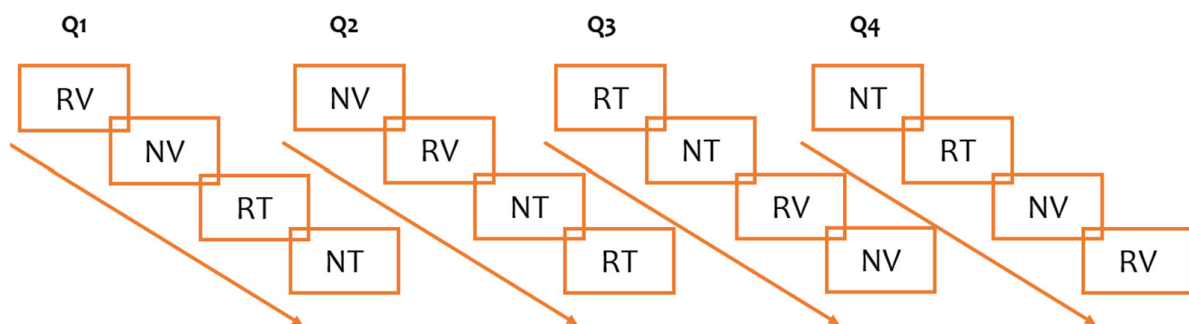


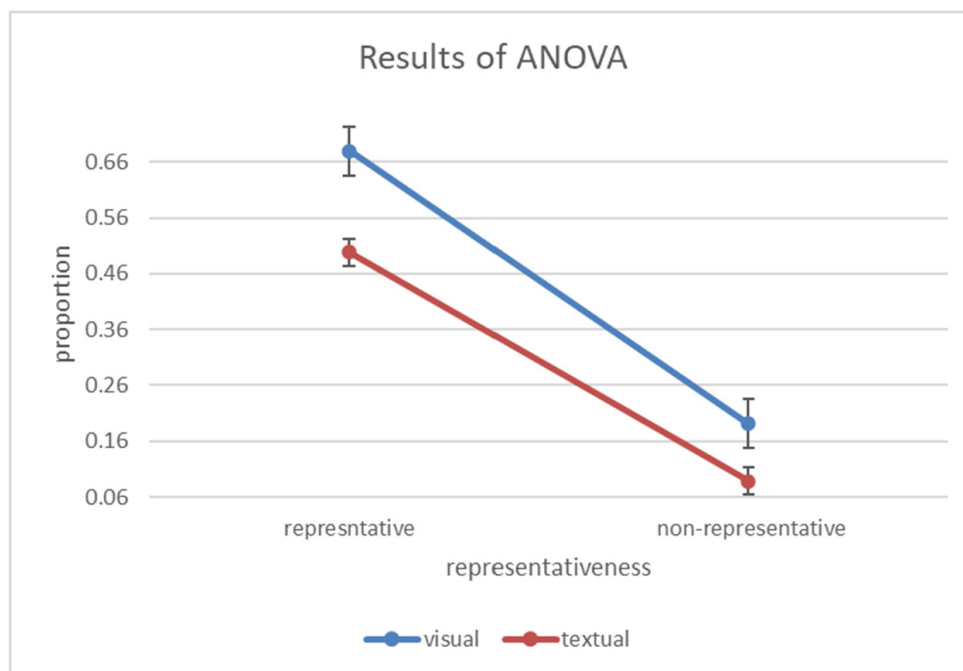
Figure 2. The four questionnaires randomly assigned to participants, representing the counterbalanced series of base rate neglect task variations

Results

The data were analyzed using JASP and R statistical softwares. The highest proportion of the base rate neglect was registered in the representative visual form of the task ($M = .680$, $SE = .044$), while the proportion of such answers in the representative textual form was $M = .498$ ($SE = .050$). The insight in the results shows that the proportion of the biased answers registered in the visual non-representative form equals $M = .191$, with $SE = .037$, whilst the non-representative tasks in textual form elucidated the lowest

proportion of such answers ($M = .089$, $SE = .024$).

The 2 way totally repeated ANOVA revealed that there was no effect of interaction between representativeness and format ($F(1,64) = 2.950$, $p = .091$, $\eta^2 = .004$). However, main effects of both representativeness and format were registered, suggesting that representativeness has moderate effect, explaining 47% of total variance ($F(1,64) = 117.870$, $p < .001$, $\eta^2 = .470$), which implies that participants answer generally more biased in representative than in non-representative iterations of the scenario. On the other hand, the weak effect of the format of base rate information presented, explains 4.7% of total variance ($F(1,64) = 20.742$, $p < .001$, $\eta^2 = .047$), but in reverse to our prior expectations – generally, when base rate information presented visually, participants answered significantly more biased than when information presented textually. Given that the dependent variable in this study is a proportion and that the assumption of homogeneity of variance is not satisfied, the results were validated using beta regression analysis in the statistical software R (“betareg” package). Initially, the measures of the dependent variable were subjected to a sigmoidal transformation. Subsequently, the following model was applied, where the proportion of biased participant responses served as the dependent variable. The effects of representativeness and format variables were tested, along with the examination of their interaction effect. Considering that the results of the beta regression revealed main effects of representativeness ($z = -2.662$, $p < .01$) and format ($z = 2.070$, $p < .05$), but not their interaction ($z = -1.099$, $p = .31$), it can be concluded that the ANOVA results were confirmed by a more robust analysis. Hence, Graph 1 displays the results of the ANOVA.



Graph 1. The results of the two-way totally repeated ANOVA

Discussion and Conclusions

Although in cognitive psychology biases are common research topic and studies often cover different fields of decision-making heuristics and biases applications, biases in human resource decision-making are still underresearched. Studies implying work-related issues focus on common biases concerning first impression (Swider, Harris and Gong, 2022; Wayne and Kacmar 1991), anchoring (Belle, Cantarelli and Belardinelli, 2017), halo effect (Dagger et al. 2013; Karunarathna et al. 2010; Palmer and Loveland 2008) and decisions relied on stereotypes (Auster and Prasad 2016; Guillén, Mayo and Karelaia, 2018). Occasionally, studies tackle the problem of rate base neglect (Argote, Devadas and Melone, 1990, 1986; Whyte and Sue-Chan 2002) resulting in establishing outperformed importance of subjective information over statistical data concerning the group membership. These studies also imply the enchainment of the effect in situations when contextual information is more in concordance with typical categories

characteristics. Moreover, the aforementioned procedures for registering base rate neglect exhibited certain deficiencies. Hence, we found this topic important and valid for understanding potential pitfalls in managerial decisions, especially when employees are involved. Recruitment, selection, employee appraisal procedures are social contexts where judgment and decision-making processes are essential (Storm et al. 2023). Additionally, these procedures are often led in scarcity of time and information, which make them typical environment for heuristics and biases to occur (Marsh 2002). Finally, potential decision errors in domain are costly and consequences might be serious.

In the examined sample, in accordance with our expectations, a robust representativeness heuristic effect was observed, explaining 47% of the total variance. This finding aligns with expectations derived from the dual-process theory approach and is consistent with prior literature (e.g., Bar-Hillel, 1980; De Neys and Pennycook, 2019; Neys, 2006; Pennycook et al., 2014; Tversky and Kahneman, 1974). The results obtained can be explained by the assumption that descriptions of employees saturated with vivid details elicit the representativeness heuristic (Tversky and Kahneman, 1974), which subsequently generates inaccurate responses in Base Rate Neglect Tasks in HRM. Furthermore, our findings indicate another domain in which this phenomenon manifests – the HRM domain. However, it is important to note that this interpretation of base rate neglect relies on the assumption that the ergodic hypothesis is sustainable. This hypothesis suggests that individuals are representative of groups and vice versa. However, it turns out that in social sciences, in particular, this hypothesis does not hold (Molenaar 2004). Along with the interpretation implicated by the lack of ergodic hypothesis in social sciences, the behavior of our participants which is here considered as irrational, would be considered as rational, given that they apply supplemental data when reasoning about particular persons. This explanation would be in agreement with the interpretation proposed by Gigerenzer and Hoffrage (1995), that highlights the usefulness and adaptiveness of such heuristical reasoning. However, taking into account that our study originates from the classical heuristics and biases approach, we decided to keep interpretation according to which participants' biased answers are considered to be irrational. Yet, although the phenomenon of base rate neglect does not aim to establish relationships between probabilities related to an individual and the group to which they belong, incorporating the implications of ergodic hypothesis into future experimental research, and guiding conceptualization can be areas of potential benefits.

Regarding attempts to mitigate the base rate neglect effect, our hypothesis did not find support in the data. What is more, we observed the inversed format effect, suggesting that participants provided more biased responses in the case of visual presentation of base rate information. Even though the variance explained by this factor is small (4.7%), this finding contradicts previous research reporting positive effects of visual presentation of the numerical data as the debiasing strategy (e.g. Ludolph and Schulz, 2018; Nagtegaal et al., 2020; Ohlert and Weissenberger, 2015; Singh, 2013). Our finding, in the context of the ecological rationality approach (Gigerenzer, 2008; Gigerenzer and Hoffrage, 1995), may be interpreted as a failure to adapt the form of environmental cues to our cognitive preferences. We believe that the ineffectiveness of our intervention lies precisely in its form. Specifically, during visual presentation of base rate information on the same page, participants could see task text and person description, as well as the visual representation of base rate. Given the numerous iterations of the task, it is possible that participants simply skipped or further neglected the visual representation of base rate information, leading to its ineffectiveness in this task variant. Additionally, another possible explanation for the unexpected, reversed effect may be found in the appearance of the visual representation. More precisely, the visual form of the task presentation shown in Figure 1 reveals that the intervention involved a pie chart displaying percentages relevant to each specific task. Such a display is not in line with the recommendations of Gigerenzer and Hoffrage (1995), who argue that absolute numbers are much more intuitive for reasoning than relative ones, considering that we exposed participants to percentages falling into the realm of relative numbers. Furthermore, the finding of Ohlert and Weissenberger (2015) supports this interpretation of the ineffectiveness of our intervention, as they achieved a significantly lower percentage of biased responses using a visualization based on absolute numbers. Additionally, it is noteworthy to mention that the difference between the research conducted by Ohlert and Weissenberger (2015) and ours lies in the presentation format. In their study, absolute values and their distribution across categories were displayed, which is additive. On the other hand, in our research, a pie chart was utilized to represent independent probabilities. More precisely, even though we acknowledge that when an employee achieves a specific numerical result predicting the exact probability (base rate) of a certain behavior, it does not

necessarily imply that the probability of the mentioned behavior not occurring is additive. Therefore, a significant critique of the debiasing strategy we employed can be attributed to the inadequacy of the visual tool type used in relation to the type of information that needed to be conveyed. Therefore, as a step for future debiasing interventions, we suggest attempting exposure of visualizations on a separate screen, as well as using visualizations based on absolute numbers. In addition to the limitations regarding our intervention, it is worth noting that our experiment is constrained by the sample size, and some relevant participant data, such as previous education, specific work experience, and additional personal characteristics, are not included. Finally, as an additional limitation of our study, the sample size could be mentioned. Sensitivity analysis in G*Power v3.1.9.2 program with alpha error equals .05, statistical power equals .95 and our sample size of 65 participants revealed that the maximum interaction effect size we were able to detect was $\eta^2 = .17$.

Experience is relevant in the context of the differences in approaches to the decision-making problem of experts and those who lack sufficient experience. Scholars found that novices are prone toward integrating and actively searching for additional information to elaborate them, while experts use "Pareto principle" (Hafenbrädl et al. 2016). That makes experts fast, but beginners could learn more from the process, even when motor activities are in question (Dundon et al. 2023). Additionally, Ceschi and colleagues (Ceschi et al. 2019) claim that cognitive ability helps avoid conjunction fallacy and base rate fallacy, but rather than cognitive ability, certain debiasing strategies bare more potential benefits in beating these phenomena.

It was found that there are differences in biasing tendencies and reactions based on personal variables. For example anchoring is more frequent among raters with higher openness to experience, while neuroticism is linked with risk aversion framing. Also, high agreeableness, low conscientiousness, less assertive traits in managers' result in their lenience bias on subordinate's appraisal task (John Bernardin et al. 2016). Even current states of evaluator might incline them toward some specific bias. For example, stress that he or she is experiencing might influence the process (Vanderpal and Brazie 2022). Also, group dynamics might intensify some biases, when discussing about the decision halo effect or polarization (based on the contrast effect) might increase previous position and lead toward less accurate judgment (Palmer and Loveland 2008). In the context of base rate neglect some of these personal predictors, as well as some other rationality measures, might be relevant too and future researches might focus on them.

Secondly, decision making in this experiment, although simulate the real life situations given in narratives and visualized, is artificial situation by default, and might not be the perfect representative of the authentic participants' behaviour. The genuine process of judging other people include reciprocal contact, when the object of observation is not passive and rather adjust behaviour based on feedback, with success that depends of self-monitoring ability.

In conclusion, it is possible to ascertain that the phenomenon of base rate neglect is present in the domain of human resource management. However, our attempt to mitigate it through visual intervention proved unsuccessful. Such a result could stem from the inadequate choice of a pie chart as a visual intervention tool. This, along with the small sample size, can be identified as the primary limitations of the presented study. Future research directions may involve refining visual interventions and exploring additional, diverse strategies for debiasing base rate neglect in the realm of human resource management.

Conflict of interests

The authors declare no conflicts of interest.

Author Contributions

Conceptualization: I. K; Data curation: I. K, M. M; Formal analysis: M. M, I. K; Funding acquisition: I. K; Investigation: I. K, M. M; Methodology: I. K; Project administration: I. K; Resources: I. K; Software: M. M; Supervision: I. K; Validation: I. K; Visualization: M. M; Writing/original draft: I. K; M. M; Writing/review and editing: I. K. All authors have read and agreed to the published version of the manuscript.

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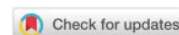
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Manipulative Potential of Humor in Business Media Discourse: Drawing up a “Starter Pack” for LSP Teaching

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Abstract: The article investigates the manipulative potential of humor in business media discourse and its application in Language for Specific Purposes (LSP) teaching. Recognizing humor as a tool for simplifying complex ideas and engaging a broad audience, the study aims to identify the functional-stylistic means through which humor is conveyed in business media, focusing on its capacity to influence audience perceptions and attitudes. Employing continuous sampling along with descriptive, comparative, and discursive methods, the research analyzes utterances from Russian- and English-language business media to explore humor's various functions – such as persuasion, focus-setting, and entertainment – and how these can be harnessed to facilitate linguistic manipulation. The findings reveal that humor, through rhetorical devices like metaphors, idioms, understatement, allusion, sarcasm, and oxymoron, plays a key role in making business concepts accessible and engaging. A “starter pack” of tools is identified for LSP education, equipping students to recognize and utilize humor's manipulative power in professional contexts. This toolkit aims to prepare future business communicators to craft and recognize humorous statements. Implications for LSP educators, students, and business communication professionals are significant, advocating for an integrated approach in curricula that balances the creative and manipulative implementation of humor. This prepares students for global business communication, emphasizing humor's strategic importance in effective leadership.

Keywords: *humor, business media discourse, mass media, functions of humor, linguistic manipulation.*

Introduction

Humor is a universal dimension of social life that can emerge in virtually any type of communicative contexts and discourses. As varied as it is, research on humor repeatedly brings up the question of its discursive application. Scholars argue in favor of examining authentic speech to understand the effectiveness of humor within linguistic frameworks: “By analyzing natural, unedited discourse one can identify the mechanics of humor directly associated with these linguistic models” (Thompson and Mulac, 1991, p. 314). Hence, one may hypothesize that by looking into a certain type of discourse to identify the nomenclature of most frequently used humor-inducing devices registered in this discourse, one might come up with a “starter pack” of language means to be taught in the classroom. Such a starter pack could be used by educators to develop students' skills of detecting and producing humorous statements.

Humor is evidenced in a variety of communicative contexts, including business media discourse which can offer some of the most vivid illustrations of its use. For instance, incorporating humor into media reports on key topics can both broaden the audience base and boost information dissemination as it makes complex subjects more engaging and more easily comprehensible. A targeted approach, particularly when examining specific themes, can prove informative, as observed in the use of humor in business-related media coverage. However, it's worth noting that the linguistic strategies underlying humor's effectiveness have yet to be thoroughly explored.

This study investigates the business media discourse to ascertain the functional-stylistic means that are instrumental in transferring humorous implications and identify the manipulative potential of humor

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that can be elicited from the corresponding material to be further used in LSP teaching. To examine humor as part of business media discourse, this study will investigate the functional potential of humor registered in business media discourse and analyze the means catering for humorous narration in business media discourse as a basis for their further integration in the classroom.

The study's methodological framework centers on integrating all parties involved in communication, along with their social and cultural experiences, into a cohesive whole. This integration is achieved by identifying and leveraging what can be described as the interactive capital of the participants, which encompasses their qualities and relationships (Bateman, 2017, p. 37). This includes cognitive, operational, and intentional components of personal experience.

Researchers view humor as a multifaceted and abstract concept that is closely linked to some form of contradiction. From the functional perspective, it appears as a manifestation of the comic – mostly good-natured and light-hearted – which is aimed to identify various types of singularities and contradictions of languages and cultures and to evoke positive emotions in the recipient (Raskin, 2012; Martin and Ford, 2018).

To conduct the research on humor, it is crucial to study its functional aspects. Analyzing humor through the lens of functional linguistics can show its rightful place as part of business media discourse secured via a wide variety of functional-stylistic means. Functional-stylistic means refer to the linguistic tools and strategies used by speakers or writers to achieve a specific effect or purpose in communication. These include rhetorical devices like metaphors, idioms, and sarcasm, each chosen to fulfill functions such as persuasion, entertainment, or emphasis in discourse.

As a social construct, humor serves various roles in interpersonal interactions as it adapts to the context and the speaker's communicative goals. These roles include establishing connection (phatic), informing (informative), entertaining, beautifying (aesthetic), controlling (regulating), protecting, concealing (disguising), convincing (persuasive), relieving tension, and asserting dominance (superiority assurance). The phatic function of language pertains to its use in establishing and maintaining social relationships rather than conveying information. In humor, the phatic function often involves creating a connection with the audience, ensuring engagement, and facilitating a conducive environment for the message (Agapova and Grishechko, 2016).

Awareness of discursive canons ensures identification of the information by the recipient, i.e., their orientation within the setting of a speech event. Apart from that, creating a message in accordance with the canons of this discourse, the speaker signals that they perceive this communicative situation as being relevant to a particular model and therefore position themselves as a performer of a certain speech role, signaling to the listener how they wish to be seen. Thus, the concept of business media discourse itself guides the interaction and emphasizes the importance of situating oneself within the framework of a speech event. In this case – orientation within the setting of a speech event (Malyuga, 2019).

Speech is a complex phenomenon influenced by multiple factors, which necessitates the examination of its connection to the cognitive and emotional realms of the communicators (Grishechko, 2023b). Theories on speech acts point out the central role of speech's primary intention in guiding the speech production process, specifying its structure through purposeful speech acts aimed at specific communicative objectives (Grishechko et al., 2015).

The concept of discursive motivation further exposes how frequently communicators use specific structures – a notion Budinčić and Zubkova (2003) described by noting the grammar's reflection of recurrent speaker actions. Volkov (2023) introduced the economy principle to advocate the selection of brief and efficient expressions under comparable conditions.

Media texts distinguish themselves not merely as information carriers but as tools for influencing public opinion, often via contentious narratives (Norrick and Chiaro, 2009; Grishechko, 2023a; Grishechko, 2024). Therefore, crafting business media discourse requires a thoughtful consideration of communication's key aspects to sway audience perception effectively. Notably, mass media targets a broad spectrum of viewers, from industry insiders to the general public. Thus, while business discourse is rich with specialized jargon, it remains accessible to the average listener as it purposefully uses specific terms (e.g., stocks, investments, manufacturing, infrastructure, financial matters) to convey complex ideas simply.

Humor in business media is essential in streamlining the dissemination of information and facilitating linguistic manipulation aimed at persuasion and behavioral influence. This manipulation, as extensively

discussed by Akopova (2013; 2016; 2023a; 2023b) and others, seeks to alter perceptions or actions through various communicative techniques, essentially guiding human behavior through both verbal and non-verbal means (Malyuga et al., 2016; Malyuga and McCarthy, 2021; Malyuga, 2023). Employing humor helps actualize three key manipulative principles: accessibility (making obscure information understandable and engaging), associativity (creating memorable associations for the audience), and expressiveness (showing enthusiasm, providing subjective evaluations, and inviting audience participation), thus ramping up the impact of business discourse (Sibul et al., 2019).

The research question under investigation is whether a detailed characterization of the nomenclature, functionality, and nature of humor in business media discourse can be instrumental in drawing up a set of functional-stylistic means to be taught in an LSP classroom as an introductory list of means catering for a manipulative humorous effect.

Materials and Methods

This study uses continuous sampling, descriptive, comparative, and discursive methods. The latter encompass the approaches and analytical techniques employed to examine how language is used in various forms of discourse. In the context of this study, discursive methods were applied to analyze how humor functions within business media discourse, focusing on the interaction between language choice, communicative intent, and audience reception.

Study material mostly covers statements made by business representatives, which allowed us to not only identify the functional-stylistic means of creating the humorous effect, but also additionally examine the manipulative potential of humor in business media discourse and pinpoint its distinctive features.

The examples of humor in business media discourse were selected based on their illustrative potential to demonstrate the manipulative capabilities of humor in a business context. The selection aimed to encompass a wide range of humor types, including but not limited to metaphors, idioms, understatement, and sarcasm, to ensure a full-scale exploration of humor’s diverse functions. This balanced cross-section was chosen to reflect both the effectiveness and prevalence of humor in business media, thus providing a representative sample of the humor landscape in this discourse. The categorization process involved a systematic analysis of the functional-stylistic characteristics of each humorous utterance, focusing on its intended communicative function (e.g., persuasion, focus-setting, entertainment) and the rhetorical devices employed. This methodological approach catered for a sophisticated uptake on how humor operates within business media discourse, serving the dual purpose of engaging and manipulating audience perceptions.

The study of functional-stylistic means utilized to create humorous effect in business media discourse relies upon the analysis of 299 instances from interviews, conversations, live talks, and news discussions that intentionally employ humor. This humor serves multiple purposes: it amplifies persuasiveness by increasing the compelling nature of the speaker’s monologue, it focuses attention by engaging and maintaining the audience’s interest, and it entertains by blending specialized information with humorous elements or intriguing facts. These functions, as we will argue, collectively cater for the manipulative potential of humor in business media discourse.

Results

Business media discourse is a complex subject for discussion, not in the least because getting a large audience interested is never an easy task as one will need to find ways to attract audience’s attention and adapt their narrative to make it more accessible and understandable. To simplify a text and “add some frills” to it speakers use metaphors associated with everyday reality but assuming new meanings in the business context.

A vivid illustration of this can be found in the way public figures often employ humor when referring to significant business initiatives or policies. For example, in this speech a business leader, addressing the need for business revitalization, quips: “*We’re planting the seeds for entrepreneurial growth, but unlike my garden at home, we’re expecting these to actually sprout jobs and opportunities*” (Brunner, 2023). Here,

humor is employed through a playful metaphor that contrasts the unpredictable nature of gardening with the intended certainty and productivity of business policies. This makes the message more relatable and memorable and manipulates the audience's perception, making them more receptive to the underlying message of optimism and action. The manipulative potential of such humor lies in its dual capacity to entertain and persuade. As the speaker draws parallels between everyday experiences and complex business concepts, they not only demystify the subject matter but also engender a positive emotional response from the audience. This emotional engagement is crucial, as it can shift audience perceptions, making them more aligned with the speaker's objectives.

In an interview, the CEO of AmplifyreHub stated: “Someone ones joked I got “sick with digitalization”. Far from it! In fact, it is the global business economy that is pregnant with digitalization, and pregnancy is, as you are aware, a normal state and not a sickness” (Amplifyre, 2021). In his remarks, the speaker uses two vivid image-metaphors, not merely for embellishment but to inject humor into the discourse. Initially, he responds as though the term “sick” were applied to him in its literal sense. He then compares the current wave of digitalization in the economy to “pregnancy,” discussing it as if it were a normal physiological condition. In his clever use of humor, the CEO of AmplifyreHub not only disarms the audience with laughter but also manipulates their perception towards digitalization. By framing digitalization as a “pregnancy” – a process that is natural, expected, and ultimately fruitful – he shifts the narrative from one of potential apprehension to anticipation and acceptance. Used this way, humor is gently guiding the audience's understanding and attitudes towards embracing digital transformation. The humor here does more than entertain – it acts as a conduit for change, illustrating the profound impact well-crafted humor can have in swaying public opinion on significant business trends.

Apart from that, business media discourse can be saturated with colloquial and idiomatic expressions, which help get the information across in a more accessible way, since in the conscience of native speakers there are solid semantic links between events of reality and linguistic expressions recorded in the phraseological corpus of their language (Liu, 2017; Malyuga and Akopova, 2021).

A notable use of colloquial language in business discourse was observed during a tech startup's pitch, where the CEO humorously remarked, “We're not just another tech company spinning its wheels. We're the grease in the wheels of the industry's progress” (O'Neill, 2017). This colloquial expression, “spinning its wheels”, commonly denotes futile effort or lack of progress, which the speaker contrasts with the idea of being the “grease” that facilitates movement. Employing this casual language, the speaker renders the concept of industry innovation more tangible and relatable and manipulates the audience's perception to view their company as a key player in technological advancement. The humor here lies in the unexpected shift from a negative to a positive image, which engages the audience's attention and predisposes them favorably towards the company's value proposition.

In addressing climate policy, the use of idiomatic expressions can significantly influence public and stakeholder perceptions, making complex and multifaceted issues more relatable. An illustrative case in point is the discussion on strategic diversity in response to climate change, encapsulated in the recommendation, “When it comes to climate policy, don't put all your eggs in one basket” (Visser, 2021). This idiomatic expression conveys the principle of not relying solely on one strategy or solution, but rather spreading efforts across a broad spectrum to mitigate risk and maximize resilience. The humor embedded in this idiom demystifies the challenges of climate policy and emphasizes the need for flexibility and the capacity to adapt to unforeseen circumstances. The statement draws on the simple and familiar concept of risk management depicted through the metaphor of diversifying one's investments – or, in this case, strategies – and guides the audience through the uncertainty inherent in climate change projections and solutions. This strategic use of idiomatic humor engages the audience and manipulates their understanding and acceptance of a pragmatic approach to climate policy. It emphasizes the importance of preparing for a range of possible futures, thereby facilitating a broader acceptance of adaptive and multifaceted strategies in the face of climate uncertainty.

Both examples illustrate the manipulative potential of humor in business discourse through colloquial and idiomatic expressions. By making complex ideas more accessible and engaging, speakers can shift audience attitudes and perceptions, leveraging humor not just for entertainment but as a strategic tool in shaping and guiding public opinion. This emphasizes the importance of humor's role in business communication and reveals its capacity to alter viewpoints and foster a positive reception of business policies, strategies, and innovations.

Humor can convey specific information in business media discourse, achieved through a range of functional-stylistic techniques. A particularly effective method is the use of paradox, where a statement is infused with a meaning that contradicts conventional wisdom or even defies logic. For instance, during the “Big Game” business talk show, the VTB Bank President and Chairman of the Board Andrey Kostin described the stock market situation during the pandemic using a notorious phrase coined by Viktor Chernomyrdin: *“Never has this happened before, and now it has happened again”* (Channel One, 2020). Obviously, the situation which has never taken place before may not repeat, therefore the combination of the lexemes “never” and “again” qualifies as humorous narrative. In this context, the phatic function of humor is fulfilled, as the speaker quotes the Soviet and Russian statesman at the very beginning of the show, thus winning the audience over. Importantly, the mechanism of engagement here varies with the viewer’s age. For individuals aged 16-45, the humor and engagement are primarily driven by the absurdity and illogical nature of the statement, relying on a linguistic foundation for its effect. For those over 45, a psychological dimension also plays a significant role. For instance, those who were adults during Viktor Chernomyrdin’s political emergence might remember his speeches, making them more inclined to engage with and recall the information presented due to a personal connection to the context, alongside the humor.

Understatement is another technique employed for humor, where the speaker deliberately minimizes the significance of an existing, often problematic, situation or pretends to underestimate it. Despite understanding the severity or significance of the matter, the speaker chooses a remarkably understated or neutral description. For instance, Indian economist Raghuram Rajan humorously comments on the scale of the U.S. response to the coronavirus-induced lockdown, saying: “The US has issued three trillion dollars’ worth of debt this year, and you know, a trillion here, a trillion there becomes real money very-very quickly” (BBC HARDtalk, 2020). Given that a trillion dollars represents a vast sum, Rajan’s remark on it quickly becoming “real money” is bound to elicit smiles for its understated implication of enormity. This method of understatement adds humor and serves a persuasive function, especially effective in cultures like the British, where reserved communication is appreciated and familiar. Through this delivery, humor builds a connection with the audience and reinforces the impact and reception of the message. In this context the infotainment function of humor is fulfilled, i.e., a business representative shares real statistical data in a simple language, while accompanying it with a humorous insertion, which, inter alia, allows the viewer to react to the information about the problem less sensitively, which means that humor in this statement performs an additional function of tension relief.

In corporate strategy discussions, experts frequently employ allusion as a rhetorical device to convey complex ideas with a touch of wit. A noteworthy instance of this technique was observed in a keynote address by a business strategist at an international business conference. The speaker remarked, *“As the ancient fable goes, the nimble fox knows many things, but the hedgehog knows one big thing. In our industry’s race, we’re choosing to be the hedgehog, focusing on our one big idea”* (Chute, 2022). Here, the speaker alludes to the famous parable attributed to the Greek poet Archilochus, leveraging it to draw a parallel between the strategic approaches of diversification (the fox) versus specialization (the hedgehog). This allusion enriches the narrative with depth and engages the audience on a more intellectual level, encouraging them to decipher the underlying message. The humor emerges from the juxtaposition of the animal kingdom with corporate strategy and invites the audience to reflect on the wisdom of adopting a singular focus in a competitive landscape. Such an approach lightens the tone of the discussion and manipulates the audience’s perception by endorsing the merits of specialization with a memorable analogy. The use of allusion in this context serves multiple functions: it entertains, provokes thought, and reinforces the speaker’s viewpoint, all while demonstrating an adeptness at weaving cultural literacy into business discourse. This example testifies to the effectiveness of allusion in business communication and reiterates its role in persuading and engaging stakeholders through the interplay of humor and wisdom.

Sarcasm is another popular stylistic device. Sarcastic utterances normally contain criticism, disapproval, condemnation of the situation, while coming off as positive judgments. For example, the CEO of EcoTech Innovations addressed questions about the company’s recent downturn in profits with a sarcastic remark: *“Well, in a shocking turn of events, it turns out that investing in sustainable technology isn’t just about planting trees and hoping for the best. Who would have thought?”* (Sathwara, 2023). This sarcastic comment serves multiple purposes. Firstly, it humorously acknowledges the challenges involved in the green technology sector, contrasting the naive optimism often associated with environmental initiatives

with the harsh realities of business. The sarcasm here plays a strategic role, simultaneously deflecting criticism and emphasizing the company's commitment to long-term environmental goals over short-term profits. The use of sarcasm in this context lightens the tone of the discussion and manipulates audience perception by framing the company's financial setbacks as an expected part of its journey in sustainable technology. This approach reassures investors and stakeholders of the company's resilience and forward-thinking strategy, persuading them to maintain their support. Moreover, the sarcastic remark highlights the speaker's wit and confidence, which enhances their credibility and appeal. By employing sarcasm to address potentially negative news, the executive cleverly shifts the narrative from disappointment to determination, thus showcasing the power of well-crafted humor to influence and reshape public opinion even in the face of adversity. The sarcastic humor in many cases, including this statement, performs the regulating function (the audience, while being aware of the gravity of the problem, still do not react to it as acutely and calm down after a chuckle) (Malyuga and Grishechko, 2021).

Oxymoron is another common technique and instrument behind humorous narratives. It involves placing seemingly non-contradictory words next to each other in a way that their combination brings to the surface a secondary, unexpected meaning in one of the elements: *"We're navigating through a thriving recession this year, a rare blend of downturn and opportunity"* (RTVI News, 2020). This oxymoron – "thriving recession" – juxtaposes the grim reality of economic decline with the notion of growth or prosperity, sparking both humor and reflection. By labeling the downturn as a paradoxical state of flourishing, the speaker softens the blow of the harsh economic forecast and manipulates the audience's perception, suggesting that within the apparent setback lies hidden potential for innovative adaptation and resilience. This humorous twist engages the audience with its witty incongruity and encourages a more optimistic and proactive outlook on economic challenges, which showcases humor's ability to transform perception and inspire a more dynamic engagement with the realities of economic fluctuations.

Table 1 below extrapolates the proportion of each humor device from the total of 299 instances.

Table 1. *Distribution and impact of key humorous devices in business media discourse*

Humor device	Number of instances in the sample	Percentage (%)	Key functions in business media discourse
Metaphor	70	23.4	Simplification, Engagement
Idiom	60	20.1	Accessibility, Relatability
Understatement	40	13.4	Tension Relief, Persuasion
Allusion	50	16.7	Engagement, Cultural Connectivity
Sarcasm	45	15.1	Infotainment
Oxymoron	34	11.4	Contradictory humor, Infotainment

The table delineates the distribution and functional impact of various humorous devices across a sample of 299 instances from business media discourse, illustrating the prevalence and strategic utilization of each device. Metaphors and idioms are the most employed techniques, which points out their effectiveness in simplifying complex ideas and boosting relatability to a broad audience. Understatement, allusion, sarcasm, and oxymoron also play significant roles, each contributing uniquely to the discourse by easing tension, ramping up engagement, and prompting reflection through contradictory humor. Humor constructed based on the above rhetorical devices can help enrich the discourse and engage viewers, which testifies to humor's integral role in effective communication. In the context of popular business media discourse, the entertaining function of humor is somewhat superimposed on the informative one, which leads to humor performing the infotainment function, which is connected to the narrow focus of business media discourse and orientation towards familiarizing a wide audience with special information.

Discussion

The study reveals that business media discourse distinguishes itself through its simplicity and accessibility as it caters to both experts and laypersons alike. This approachability is achieved through the thoughtful selection of specific yet commonly understood terms, alongside the use of metaphors,

colloquial language, and idiomatic expressions.

Humor in business media fulfills several key functions, aligned with the speaker's communicative goals, including establishing rapport (phatic), guiding behavior (regulating), and easing tension. The entertaining function of humor in business media discourse experiences the influence of the informative function of mass media, resulting in a new function of humor – infotainment. Humorous elements in discussions about business not only entertain but also sharpen focus, thus paving the way for the seamless absorption of subsequent information.

Such means as sarcasm, allusion, and understatement were found to be exceptionally frequent in business media discourse. Business figures craft their speech to resonate broadly and generally prioritize the establishment of rapport (phatic function) as a primary goal. This effort is marked by the use of humor, which is explicit, rich in emotiveness, abundant in vivid image-metaphors, and replete with colloquial and suggestive language. Furthermore, humor serves as a vehicle for these speakers to offer their personal viewpoints on current events, masked within the guise of jest. Their discourse is aimed at addressing pertinent issues and seeks to sustain a delicate balance: while it seeks to engage on a professional level, it eschews complex image-metaphors in favor of straightforward, “dead” metaphors, employing subtle humor to psychologically prime the audience. This ensures that the information is accessible and predisposes the audience towards a particular understanding or perception of the discussed topics.

The analysis of humor in business media discourse points to its evident manipulative capabilities. The study's findings reveal that effective leveraging of humor garners audience engagement and influences their perceptions and attitudes towards business issues discussed. This manipulative potential is primarily harnessed through the strategic employment of humor to simplify complex concepts, making them more accessible and palatable for the general audience. By integrating humor, speakers not only boost the appeal of their message but also guide the audience's focus, directing their understanding and interpretation of the information presented. This capacity of humor to engage and manipulate is especially crucial in the context of business media discourse, where the inherent complexity and dryness of the subject matter can easily alienate or overwhelm the audience.

The obtained results should be integrated as a “starter pack” in teaching humor in an LSP classroom. Below we discuss some of the most fitting methodologies that can be used to introduce LSP students to the functional-stylistic means creating humorous effect in business media discourse.

The communicative approach. The communicative approach addresses a fundamental challenge faced by all learners of foreign languages: “I understand, but I can't verbalize it”. Considering that the communicative approach is originally based on the conversational practice of the target language, it is very effective in overcoming the language barrier. In this case, introducing the “starter pack” in the LSP classroom will operate on several key principles: (1) achieving fluent and competent speech as a natural result of ongoing practice, providing intuitive language development; (2) making sure that students actively use the target language from the very first class; (3) application of authentic materials in the classroom, like the ones discussed above. The communicative approach will help students get rid of the habit of literally translating their thoughts from their native language into the target language (Farea & Singh, 2024). Using the communicative approach, students will practice the rules through repeated practical application, which will allow them to form an understanding of the communicative features of using lexical and stylistic means creating humorous effect in business media discourse.

The audiolingual approach. This approach is about developing the ability to comprehend foreign languages by listening. Its distinctive feature is that it uses analogies for memorizing new vocabulary (Pérez-Cabello and Quinn, 2024). Specifically, students learn language patterns and words often used in business media to create humor, which helps them to independently form sentences and engage in conversations. This method incorporates the memorization of various dialogues, starting with essential grammatical and lexical structures built around a core vocabulary. Over time, this vocabulary expands with new words. Notably, only a quarter of instructional time is dedicated to theoretical learning, with the remainder devoted to hands-on practice. Renowned globally and implemented in academic institutions from Oxford to language schools worldwide, the method has formed the basis of many original methodologies, including author-developed methodologies of Charles Freese, Robert Lado (USA), Pierré Rivin (France), Petar Guberin (Yugoslavia), and others (Dermendzhieva and Tsankov, 2022). Suitable for both novice and advanced learners, particularly those under tight time constraints, it offers flexibility for both group and individual settings.

Learning through play. The game-based approach allows to get wants and needs meet, while ensuring an easy and natural learning process. Utilizing games as educational breaks can help shift students' focus from one activity to another. The educational value of this approach is also that it serves a critical didactic function and enables students to discover new information, broaden their knowledge base, and practice English communication in a playful context. Games are versatile and can enrich various aspects of language learning – from phonetics, grammar, and vocabulary to reading comprehension and listening skills – at any lesson phase (Al Fajri and Oktavianti, 2024).

The choice of a fitting approach is a rather individual matter. However, some of the fundamental criteria to be taken into account in an LSP classroom are students' level of proficiency, study hours, and priorities of the study program.

Building on the methodological applications for teaching humor in an LSP classroom, it is essential to directly address the manipulative potential of humor in business media discourse. The study's observations on how humor can be used to influence audience perceptions and decisions point to the need for LSP students to not only understand humor's linguistic aspects but also its strategic applications in professional contexts. Incorporating modules that dissect humor's role in shaping business narratives and public opinion would enable students to critically analyze the intent behind humorous expressions in business media discourse. This could involve case studies of successful marketing campaigns or public speeches where humor was a key element in swaying public opinion or reinforcing a brand's message. By critically engaging with these examples, students can develop a better understanding of humor's power as a communicative strategy.

Additionally, training LSP students to create humor that carries a manipulative potential requires a delicate balance between creativity and ethical consideration. Educators should emphasize the ethical implications of using humor to manipulate audience perceptions, especially in sensitive business contexts. Workshops or projects that task students with developing humorous content for business communication should be critiqued not just for their linguistic and stylistic accuracy but also for their ethical implications. This would prepare students to use humor responsibly, ensuring that their efforts to engage and persuade do not mislead or harm the audience. Embedding discussions on the ethics of humor in business discourse within the curriculum would cultivate a generation of communicators who are not only effective but also conscientious in their use of humor.

To further connect the classroom discussion to the real-world manipulative potential of humor in business media discourse, incorporating experiential learning through internships or collaboration with industry professionals could be invaluable. This hands-on experience allows students to observe and participate in the creation of humorous content within a business context. Guest lectures from business communication experts who have successfully leveraged humor in their campaigns could offer students practical examples of humor's manipulative power in action.

Hence, the findings point to the importance of integrating humor into LSP curricula, not only as a linguistic tool but also as a long-term business communication technique. Educators could use the identified “starter pack” of humor to develop lesson plans that boost students' ability to craft and analyze humorous content within business contexts. For instance, lesson plans might incorporate case studies analyzing successful humor-driven campaigns in business media, practical exercises focused on creating business pitches, and in-depth evaluations of how humor improves the retention of messages. Incorporating these elements into LSP teaching would prepare students to use humor effectively in professional settings and appreciate its strategic value in leadership and global business communication.

While this study offers important observations regarding the manipulative potential of humor in business media discourse, it acknowledges its limitation in scope to Russian and English-language media. The cultural specificity of humor suggests that findings may not be universally applicable across different linguistic and cultural contexts. Further research could investigate the role of humor in business media discourse in other languages and cultural settings to offer a more global perspective on humor's manipulative power. Additionally, considering the impact of humor on specific audience demographics within the business community could yield more tailored recommendations for LSP teaching.

Conclusion

The study explored the manipulative potential of humor in business media discourse, with a particular focus on its application in language for specific purposes (LSP) teaching. Adopting a functional approach, the study examined the interconnection between humor and linguistic manipulation across Russian and English-language business media, specifying the distinct stylistic mechanisms catering for humor’s persuasive, focus-setting, and entertaining functions. The investigation exposed the critical role of humor in simplifying and rendering complex business concepts accessible to a broader audience, thereby enhancing engagement, and influencing audience perceptions and attitudes. By examining 299 utterances from business media, the study demonstrated the varied applications of humor, fulfilling its goal of outlining effective strategies for LSP students to recognize and apply humor’s manipulative power.

Key findings from the analysis emphasize the critical role of humor in business media discourse and demonstrate its capacity to bridge linguistic and cultural divides and to tailor business narratives in a manner that resonates with diverse audiences. Through the examination of 299 utterances from a variety of business media sources, the study has identified a “starter pack” of tools essential for developing LSP students’ abilities to recognize and wield humor’s manipulative power effectively. This toolkit equips students with the skills to discern the manipulative intent behind humorous statements and empowers them to craft their own humor in a professional context, mindful of its potential to persuade and influence.

Study findings will benefit LSP educators, students and professionals in the fields of business communication, marketing, and public relations. By integrating the identified humorous linguistic strategies into LSP curricula, educators can offer students a solid framework for understanding and leveraging humor in business discourse. This preparation is crucial for navigating global business communication, where the strategic use of humor can distinguish effective communicators and leaders.

Moreover, this study advocates for a conscientious approach to teaching the manipulative potential of humor, emphasizing the ethical considerations inherent in its use. As we prepare the next generation of business communicators, instilling an awareness of the power of humor to shape opinions and behaviors is paramount. It is essential to facilitate a critical understanding of humor’s dual capacity to enlighten and manipulate. This way, educators can equip students with a powerful communicative tool, as well as the discernment to use it wisely and ethically in the global marketplace.

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Conflict of interests

The author declares no conflict of interest.

Author Contributions

Elena N. Malyuga: conceptualization; methodology; formal analysis; writing—original draft preparation; writing—review and editing. The author has read and agreed to the published version of the manuscript.

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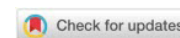
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Implicit Theories of Teachers About the Importance of Teaching Music

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Abstract: Contemporary pedagogical literature emphasizes holistic upbringing and education, with the goal of developing the overall personality of students. In this regard, the aim of this study is to explore and determine how teachers perceive the importance of teaching music. This research was conducted in the second semester of the 2022/2023 school year on with a sample of Republic of Srpska primary school teachers (N=10). Empirical data were collected through semi-structured interviews conducted both online and in person; a protocol with open-ended questions was developed. The data were analyzed using the method of qualitative thematic analysis. The research results show that teachers perceive music education positively and emphasize its importance for the comprehensive development of students. Additionally, teachers believe that certain changes are needed in the music curriculum, although they emphasize that they have freedom in choosing content in all teaching areas. There is a prevailing opinion among teachers which indicates the need for an increased focus of the educational system towards music education in the lower grades of primary school.

Keywords: *constructivism, implicit theories, music education, curriculum, teachers.*

Introduction

Constructivism and Implicit Theories

Constructivism, as an epistemological perspective, emphasizes the active role of the human mind in constructing knowledge and reality based on subjective experiences and interpretations. This perspective posits that our perception of the world involves a complex process of construction and interpretation, rather than merely passive reception of information. A fundamental premise of constructivism is that knowledge is not an absolute truth but rather a construct that emerges through the interaction between an individual and their environment. Consequently, each person develops their own subjective model of the world shaped by their unique experiences, beliefs, and the socio-cultural context. Thus, constructivism provides a valuable framework for understanding how individuals construct knowledge and interpret their surroundings, while also highlighting the importance of active engagement in the learning process.

Implicit theories refer to the intuitive explanations' individuals use to understand the causes and motives of behavior, both their own and others' (Sternberg, 1985). These theories are not necessarily consciously articulated or defined but often represent unspoken assumptions that influence our judgments and interpretations. Implicit theories are frequently employed by individuals to comprehend complex social and emotional behaviors, adapting them to specific situations and contexts. Understanding implicit theories bears significance in various domains, including education, group psychology, and interpersonal

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relationships. Being aware of how implicit theories shape our behavior can enhance our consciousness and accountability in our judgments and interactions with others. Implicit theories constitute implicit assumptions that significantly influence our understanding of behavior and motivation, whether our own or others'. Despite often operating at an unconscious level, these theories wield substantial influence over our perceptions and actions. Thus, gaining insight into implicit theories can promote greater awareness of our judgments and interactions with others.

The Significance of Music and Music Education

The universality of the language of musical art makes it a dominant means of communication with countless creative possibilities and expressions, thereby serving as a crucial pillar for the development of individual personalities and society as a whole. As an art form, music can influence the creation of self-perception and perceptions of others, as well as categorize individuals into specific groups based on responses to questions such as "What music do you listen to?"; which was a frequently asked question among children and young people in the latter half of the 20th century, but is regrettably rarely asked nowadays. Music which is thoughtfully selected and of high quality typically evokes pleasant emotions, develops taste and stimulates brain development. For instance, both hemispheres of the brain are active during music performance (Parson; cited in [Habermajer, 2001](#)) which facilitates learning processes. Also, [Habermajer \(2001\)](#) found that listening to music enhances the acquisition of subject matter, thereby promoting overall psychophysical development in children. Key factors which influence the development of musical abilities include: heritage, family, nurturing environments, individual activities and motivation ([Jeremić, 2015](#)). The significance of early musical stimulation and education, ideally through play, along with a wide range of teaching methods, contributes to the development of fine and gross motor skills, speech, and overall cultural and musical upbringing. Classroom music education in the Republic of Srpska, with its diverse range of program content in the first and second triads of the nine-year primary schooling system, is realized through musical activities across three interrelated teaching areas: music performance (singing, playing, movement, and introduction to the basics of music literacy), music listening, and children's music creativity (*Curriculum for Primary Education*, 2014 and 2021). A competent, motivated, and creative teacher epitomizes the most important figure in not only the fostering of a love for work and learning, but also the creation of an atmosphere in which music can be introduced to children in order that they acquire knowledge and values, make decisions, collaborate in teams, nurture individuality, and where music classes become a source of joy and satisfaction. In this way, conditions are created for achieving the goal of music education in primary school – to develop the students' love and interest in music, or to develop musical taste (*Curriculum for Primary Education*, 2014 and 2021). "From the set goal of music education, which relates to developing interest, creativity, and critical thinking, tasks emerge that cannot be clearly differentiated regarding their dominant role in the teaching process as educational, instructional or functional" ([Vukićević and Stanojević, 2014, 128](#)). These tasks collectively contribute in the creation of a musical education environment which is rich and inspiring, and aims to develop students' musical abilities as well as a broader set of skills and values that will benefit them in life.

Music education holds a particular importance in the preservation and nurturing of cultural identity, national values, and folk traditions, as well as in the fostering of multicultural awareness ([Đurđanović et al., 2018](#)). Through this domain, respect for national and world cultural-historical, folk, and artistic heritage is cultivated. "Musical folklore adapts and transfers to areas of work in music education where students learn about and adopt it" ([Čalić and Grkić, 2013, 292](#)). Highlighting the importance of song, [Stošić](#) emphasizes: "song carries within itself a multifunctional potential and, through its structure, generates multiple functions, among which there are strong causal links that contribute to the versatile development of students' personalities" ([Stošić, 2008, 72](#)). Musical pedagogues and researchers have written about the educational value of folk music tradition and its insufficient presence in music education ([Gajić, 1996](#); [Spasojević-Stojanović and Trakilović, 2016](#)), emphasizing the values of musical heritage. Furthermore, the work of music teachers and their collaboration with classroom teachers can result in the creation of various school and extracurricular activities that contribute to familiarizing students with folk music traditions and other musical genres. [Martinović Bogojević \(2010\)](#) suggests that special attention should be paid to the use of experiential listening to music in early schooling to foster an emotional connection to it. Through empathy, humor, and successful execution of music culture tasks, as well as through the

teacher's attitude towards their students, a teacher can deliver quality education even in the absence of a specialized classroom, especially if open to undertaking various forms of professional development. The organization and structure of the class, the relationship between teacher and students, mutual respect, as well as opportunities for intellectual, moral, aesthetic, physical, health, ecological, national, patriotic, intercultural, and multicultural education, together with the application of the advantages of contemporary technology or simply *integrated pedagogy of the 21st century*, altogether contribute to comprehensive education. Music education in early schooling, in conjunction with a cluster of (skills-based) artistic subjects, should be a corner stone, which facilitates the branching out into all other knowledge and skills in various natural and social sciences. Through literature analysis in the region (Martinović Bogojević, 2010), it has been determined that the subject of music in the reformed educational system of Montenegro has achieved a significant status, closely linked to other subjects. The presence of music content also contributes to a more engaging acquisition of content from other subject areas. Therefore, the importance of music education is also reflected in its integration: "A well-organized class does not know only one activity in the classroom. The class should be dynamic, with various activities for students alternating or intertwining, but whenever possible (with exceptions when it is difficult to implement), they should fall under the same umbrella of the set task. Therefore, through an integrative approach, experientially going through two and/or three music activities for students and corresponding music content within them, the same or similar problem should be solved" (Stojanović, 2010, 6). It is evident that an integrative approach in classroom teaching, as well as the intertwining of music activities, contributes to a more successful achievement of learning outcomes and class goals.

Research Objective and Research Questions

In our study, we aim to explore teachers' perceptions of music culture education and comprehend their fundamental interpretations of the significance and impact of this subject on students. Therefore, the aim of our research is to examine teachers' implicit understanding of music culture education in the lower grades of primary school. The research questions are: (1) How do teachers perceive the importance of music culture for the comprehensive development of students? (2) How do teachers perceive the Music Curriculum?

Materials and Methods

Procedure

The research was conducted in June 2023. Participants took part in the study on a voluntary basis. Data were collected online via the Zoom application and in person on school premises where teachers conduct classes. Interviews were recorded and transcribed; each interview averaging about 45 minutes.

Sample

In this study, the population consisted of school teachers (Grades 1 – 5) employed in primary schools in Bosnia and Herzegovina/the Republic of Srpska. All participants were female. The sample consisted of 10 teachers from the Republic of Srpska. The main criteria for participation in this research were that the teachers have more than 10 years of teaching experience, a willingness to participate and it was necessary that they had completed a bachelor's degree in teaching. Interviews were conducted by a psychologist and two music educators.

Instrument

Data were collected through semi-structured interviews. For the purposes of this research, a protocol with open-ended questions was developed. The questions in the protocol followed the thematic determinants of the research questions: How do teachers perceive the Music Curriculum?

Data Analysis

The data analysis method used was a qualitative thematic analysis. We investigated how teachers perceive music education. The first step was familiarization with the collected data, then we generated initial codes which were used as a basis to determined categories, and in the final step, we defined themes. In the selection of themes, we adhered to what is significant, that is “a set of criteria that help determine what is and what is not worth being a theme” (Viligi, 2016, 141). Although the instrument was wide-ranging, we analyzed responses to questions that were relevant to the research question.

Results and Discussion

The results are presented by means of seven thematic areas. The obtained responses are grouped into two thematic areas within the research question: What is the perception of teachers about the importance of music or students? The remaining five thematic areas explain the perception of teachers about the quality of the Music Curriculum for the lower grades of primary school.

Research Question 1: How do teachers perceive the importance of music for the comprehensive development of students?

Although the responses may seem generalized, they all relate specifically to the teaching contents of music. Therefore, they should be observed in that context. Within the category of student development, teachers identify aspects positively influenced by music education: 1) cognitive development, which is observed based on codes such as intelligence, creativity (imagination), critical thinking, attention, memory and knowledge (functional knowledge, general culture and awareness); 2) affective development defined by codes such as pleasant feelings (joy, relaxation, satisfaction and playfulness), sense of beauty, sense of musical taste and sadness (melancholy); 3) psychomotor development, where codes such as rhythm, motor skills, body posture, dance and singing are emphasized; 4) personality development, with codes such as self-confidence, patience and dedication; 5) speech development, evident through codes such as nursery rhymes and speech abilities; 6) student socialization, indicated by codes such as freedom of communication, community involvement, multiculturalism, collaboration and teamwork; and 7) representation of education. Table 1 shows the respondents’ responses regarding the mentioned codes.

Table 1. Importance of Classroom Music Education According to Teachers’ Perception

Theme	Categories	Codes
Comprehensive Development	Cognitive Development	Recognition (sound characteristics, types of music and musical instruments) Functional knowledge Understanding Musical memory in listening Musical memory in playing Intelligence Attention Creativity (imagination) Critical thinking
	Affective Development	Interest in singing Pleasant feelings (joy, relaxation, satisfaction, playfulness and enjoyment) Sense of beauty Sense of musical taste Sadness (melancholy)
	Psychomotor Development	Performance accuracy Performance skills in playing Coordination of movements Motor reactions in listening and reading sheet music Rhythm Body posture Dance Playing Singing

Theme	Categories	Codes
	Personality Development	Self-confidence Patience Dedication (in listening to and playing music)
	Speech Development	Nursery rhymes Speech abilities
	Student Socialization	Freedom of communication Community involvement (learning about tradition and culture) Multiculturalism Collaboration and teamwork
Representation of Education	Adequately Represented	Too many subjects Student overload
	Adequately Represented with Integration with Other Subjects	Correlation with other subjects Integration with other subjects
	Depends on Grade Level	Insufficient in the first triad Adequate in the second triad
	Insufficiently Represented	Increase the number of class hours Insufficient one class Eliminate one subject to increase the number of music culture class hours

The role of music as a positive stimulus is multifaceted, both in the prenatal period and in all stages of children's development. This topic has been investigated from the perspective of various scientific disciplines and in a multidisciplinary manner (Bašić, 1987; Matic and Mirkovic-Radoš, 1986), indicating that "favorable socio-economic conditions usually create a more musically stimulating environment" (Nešić et al., 2006, 128). School, as an adaptation space, can use music and play as factors in creating an educational environment crucial for the life and progress of students. Teachers in the Republic of Srpska are aware of the importance of music education for the comprehensive development of younger pupils' personalities. They observe this in the cognitive, affective and psychomotor domains of learning and development (Bjekić, Aleksić and Vučetić, 2012), which is beneficial, given that music education occurs in all of these learning domains.

"Affective development is linked to perceptual and cognitive development. The nature of such a complex human experience as music is both cognitive and affective at the same time. These two aspects are hardly separable in reality: all cognition has a certain affective character and vice versa" (Nešić et al., 2006, 128). Movement, as a natural human need, is most pronounced in preschool and early school age. Music, whether rule-based or free, with its playful character, stimulates the harmonious development of the child. Research shows how "aesthetic sensitivity can be developed through movement in children aged six to seven years. It was found that children's affective response to rhythm was most intense, followed by the quality of sound, and less so for color, melodic line and shape" (Nešić et al., 2006, 1289).

In the realm of affective development, our respondents provided the most responses relevant to music pedagogy (*This is very important to me, meaning, their emotions, how they will experience it; I mean more emotional than cognitive because, for that cognitive part, a lot of theory and knowledge are required. For the emotional part, well, I think it's necessary too, but somehow the teacher more easily masters that emotional part*). They talk about affective development as separate but also something that can interplay with the cognitive. For instance, in the teaching area of music listening, teachers state that the "emotional-cognitive approach is one of the strongest and highest quality" (*And, it is very important to connect the cognitive-emotional approach; When it comes to the intensity of the piece, then, whether its dynamic is piano or forte. For children, if some... melodies are such that they get scared, to calm them down, I don't know. Emotions certainly influence some parts. That's why it's necessary to connect*). Viewing music listening in this way epitomizes good practice, which complies with leading research findings (Vidulin et al., 2020). The significance of music education for cognitive development is also recognized, especially the analytical approach to music listening that aligns with age (*Listening to music must be meaningful; ...first, of course, we globally listen to a composition, then selectively. Depending on the*

composition, we follow tempo, dynamics, instruments, then if there are any repetitions, whether the same instrument repeats it, whether other instruments?), which we consider good, although the combination of emotional and cognitive should dominate in the realm of music listening (Vidulin et al., 2020). Additionally, music can be listened to with movement involving the psychomotor domain (Fryberger, 1916; Swanson, 1969; Matic and Mirković Radoš, 1986; Metz, 1989; Juntunen, 2004; Hallam, 2012; Đurđev and Lukač, 2013; Stolić, 2018), which teachers discuss less frequently. The importance of music education for the development of students in the psychomotor domain is observed through the performance of children's music games and similar activities. When it comes to this development, teachers combine the content and activities of music education and physical education. However, although learning through movement is less commonly practiced in our schools, this is one approach to learning that is gradually gaining more attention. "A lesson in which material is conveyed through movement is much more understandable and interesting for students. Students become active members of the classroom because movement stimulates their creativity, increases motivation for work and cooperation. Learning through movement enables and encourages the development of children in all areas" (Obrenović, 2021, 2). The importance of (creative) movement for the physical, social, emotional and overall holistic development of children has been written about by many researchers (Dennison, 2007; Hannaford, 2007; Bergstein Dow, 2010; Gazibara, 2016). It would be desirable for a subject like Dance to be taught in our schools, especially in primary education. "Allow daily dancing, music, drama and learning visual arts where movement plays a significant role, and you could achieve wonders" (Jensen, 2005, 107). According to the Curriculum for the nine-year primary schooling system in the Republic of Srpska, art (music in the first grade) and sports are combined within the subject area of 'rhythmics, sports and music' where appropriate implementation of the content can contribute to cognitive, affective and psychomotor development along with a sense of cultural identity. In this regard, traditional music, like – folk songs and dances are – unfortunately, insufficiently present in the primary school music curriculum which, both research (Gajić, 1996; Milovanović, 2009) and practice confirm. They should be a key educational aspect through the study of the content of the subject music culture from the second to the ninth grade of primary school.

When discussing the positive impact of music on personality development, this research has identified codes such as self-confidence, patience, and dedication. The presence of these components is evident in children's musical activities, which facilitate the expression of emotions. Public performances, while carrying responsibilities and excitement, can also enhance self-confidence. Engaging with music, whether in extracurricular activities or formally within primary music schools, demands dedication from students and fosters the development of work habits. Growing up in a stimulating family environment, children acquire the need for continuous effort towards achieving results in music education. Research findings confirm that "the most successful children also receive the highest level of parental support" (Davidson et al., 1996, cited in Bogunović, 2008, 169). Through daily deliberate practice of musical examples, in addition to learning methods, students become more conscientious, develop patience, a sense of responsibility and perseverance. Learning to play an instrument also cultivates general personal skills such as discipline, concentration, self-confidence, responsibility and self-esteem (Hallam, cited in Bogunović, 2008). Everything learned in music class can and should be applied by students in life and work.

Musical education, whether formal or informal, significantly influences the development of social skills: sociability, friendship, appropriate and patient behavior in groups, patriotism and a positive attitude towards national cultural heritage and the cultures of other nations. The variety of musical games, humor, and a positive emotional climate in music class encourage teamwork, communicativeness and understanding of the environment in which children grow up.

Key results of research on the impact of musical culture on various aspects of the development of younger students "indicate that respondents generally hold a positive opinion regarding various aspects of music education in the context of the socio-emotional development of their children. Parents whose

* The curriculum for elementary education and the educational program for the subject area Rhythmics, Sports, Music were downloaded on March 7, 2024, from the website https://www.rpz-rs.org/sajt/doc/file/web_portal/05/5.2/Nastavni_plan_za_osnovno%20obrazovanje/%D0%a1 and https://www.rpz-rs.org/sajt/doc/file/Novi_nastavni_programi/Redovna_nastava/2022/_ritmika_sport_muzika_nastavni_program_za_prvi_razred..pdf2021, respectively.

children participate in extracurricular music activities have a more positive opinion regarding the influence of music education content on the socio-emotional development of their children compared to parents whose children do not participate in extracurricular activities" (Stipančević and Milošević, 2020, 281).

Regarding speech development, nursery rhymes play a multifaceted role. Music-making in the first grade of primary school should naturally extend from children's free play. Developing creativity and freedom through movement, accompanied by nursery rhymes through clapping, tapping, and playing children's instruments, is important. In addition to developing rhythmic abilities, processing nursery rhymes promotes speech creativity and facilitates learning foreign languages. Although nursery rhymes, often filled with humor and originating from folklore, are unfortunately less prevalent among children today, they play an important role "in describing, shaping, articulating, and correctly pronouncing sounds" (Milijević, 2015, 50). Our respondents advocate the mentioned attitude about the importance of music education for the versatile development of personality, but they differ in opinions regarding the presence of music education in primary school classes. Some believe it is not sufficiently present, especially in the early grades, while others think it is, considering other obligations of the pupils. Some assess it in relation to the grade, and others believe it is sufficiently present but only if its content is integrated into many or all subjects at a younger age.

The research findings are consistent with the stated attitudes of teachers. Some argue that the number of music education hours in primary school is insufficient, especially in the early grades, which has negative outcomes on the development of musical abilities (Lazarević, 2001). Other findings note that reducing the number of music education hours, especially in the early grades, can be compensated by integrating content into regular classes. We concur with Perić (2016) that although there are challenges in schools, teachers should not neglect this subject and should enable students to continuously acquire knowledge and skills in the field of music.

Research Question 2: How do teachers perceive the Music Curriculum?

In formulating the themes, we relied on three teaching areas (1. Music performance: singing, playing instruments, movement and introduction to the basics of music literacy; 2. Music listening; 3. Children's music creativity) which intertwine in the primary school Music Curriculum in the Republic of Srpska (*Curriculum and Program for Primary Education and Upbringing*, 2014, p. 168; *New Curriculum/Regular Education/2021/Music Culture*), as well as on the analysis of respondents' answers.

Table 2 presents the results of the analysis providing answers within the research question related to the perception of the quality of the Curriculum and Program for primary school music, namely: Do you think certain changes to the program content of music teaching are necessary? And, if so, what would you change? Do you integrate program content of music teaching into the implementation of primary school teaching? Provide an example! Do you like the compositions you listen to in class (in accordance with the Curriculum)? What do you consider the most challenging aspect of music classes? How often do you "compose" with students in music class? What, in your opinion, is the most enjoyable aspect of music classes?

Table 2. Teachers' Perception of the Quality of the Primary School Music Education Curriculum in Primary School

Themes	Categories	Codes
Satisfaction with the Curriculum	Satisfaction	Appropriate content Adequate number of hours Sufficient freedom
	Dissatisfaction	Inappropriate content Insufficient number of hours Limited content choice
Music Performance	Singing	Frontal and group singing of children's and traditional songs

** Downloaded on March 7, 2024, from the website https://www.rpz-rs.org/sajt/doc/file/Novi_nastavni_programi/Redovna_nastava/2021/Muzicka_kultura_nastavni_program_za_cetvrti_razred.pdf; (https://www.rpz-rs.org/sajt/doc/file/Novi_nastavni_programi/Redovna_nastava/2021/Muzicka_kultura_nastavni_program_za_peti_razred.pdf)

Themes	Categories	Codes
	Playing	Instrument playing using Orff instruments
	Movement	Musical movement Traditional games Dance
	Introduction to Musical Literacy	Writing and reading notes (rhythmic reading and playing metallophones)
Music Listening	Global Listening	Cognitive-emotional listening to music
	Selective Listening	Analytical approach
Creativity	Musical Creativity	Musical additions
	Musical creativity with language	Nursery rhymes Songs
Intercorrelation and Correlation of Content	Correlation with Play	Hide and seek Social game wheel of fortune Quiz
	Intercorrelation of Content Areas	Correlation of content during music class Correlation of content with other subjects

The obtained responses indicate the existence of various opinions regarding the perception of the quality of the Curriculum for Classroom Music Education from the perspective of teachers. Although we did not focus on the degree of expressed satisfaction or dissatisfaction with the existing Curriculum, but rather on identifying qualitative categories of respondents' answers, it can still be observed that they are generally satisfied with it, although they recommend certain changes or additions. Responses from the participants can be categorized into three groups: 1) those who do not want changes in the program content of music education (*I am satisfied with these topics and contents that I can really combine and use as needed. So, I wouldn't change anything for now*), 2) those who want changes but recognize that cooperation with music educators and university professors is needed for changes in the Curriculum (*It is necessary, therefore, to make some changes and of course we (teachers, university professors, music educators), all need to sit down together, everyone, to agree, give our suggestions and comments, and to make it easier, uh, music education*), and 3) those who want changes in terms of content (e.g. songs) that are repeated in different grades in such a way that they would prefer no repetitions or fewer repetitions, as children like learning new songs (*There is always room for innovation, to introduce some new songs, to have a wide range of compositions, to have a larger selection*). They believe that songs in the upper grades of primary school should be longer in duration because children want to perform such songs on field trips, excursions, and the like. For example, it is sometimes difficult for them to work on a song in the third grade that they sang earlier. This is particularly evident among students of primary music schools who hear such content several times during their schooling, and although they enjoy it, it can facilitate boredom. Therefore, teachers suggest additions (changes) in the field of musical performance, singing and playing, stating: *Well, introducing as many of these traditional songs as possible. Well, maybe there should be simpler compositions developed for children's orchestras*. When it comes to the field of musical performance, playing, and introduction to the basics of musical literacy, most teachers stated that they like compositions that children perform on metallophones, as well as Orff instruments that they made themselves due to the lack of original ones. Unfortunately, a smaller number of respondents do not use Orff instruments because schools are not equipped with them. They express that the examples are adapted to children, that they would like to have easier compositions for performance in textbooks, and that they need new compositions. Teachers emphasize that the Curriculum gives them a lot of freedom and that they thus overcome the difficulties of choosing content for singing or playing (*Well, I think, of all the subjects, music culture is quite well organized, that everything is covered, now, I don't know, maybe, but I'm talking about the number of hours. Although we have a lot of freedom*). Through the analysis

of teachers' responses, we determined that they are satisfied with the provided content for listening to music, they like the compositions, but they also strive for additions or changes in this area (*Listening to compositions could perhaps be refreshed. Well, of course, I like them, but again, I say, there should be a reform, uh, of the music culture curriculum expressed in these plans and programs of music culture in which they would participate. Teachers should also participate in this reform because I simply feel that we are excluded from these reforms. And yet, we know best what is most important to students up to the fifth grade in music education*). Teachers perceive the area of listening to music as relaxing, but also very demanding for quality processing of the teaching unit, mostly thinking about an analytical and cognitive-emotional approach to listening to music, which also indicates insufficient competence within the didactics of music education or the number of hours of this subject in undergraduate studies. The necessary refreshments should be more aligned to 21st-century students, and in the field of singing and listening to music, we confirm the opinions of teachers with this argument: *It should be refreshed a bit, the program content of listening to music and singing songs, to be ... a bit more adapted to children.*

If we talk about the perception of program content by grading them by the difficulty of processing for teachers, the area of musical literacy (music theory and rhythm setting) is foremost in its difficulty. Respondents state that the content area of introduction to the basics of musical literacy is the most challenging for them, followed by the content area of music listening (analytical and cognitive-emotional approach). Also, they consider the content area of musical creativity as one of the most challenging in music education, followed by pupil-influenced factors such as a lack of motivation to learn, as well as instances when pupils are embarrassed by or receive insufficient parental attention. These issues certainly require further investigation in future research studies.

There is a feeling amongst the respondents that they feel insufficiently trained to implement the prescribed number of classes as required by the Curriculum in terms of musical creativity (*So, as much as it is prescribed by the Curriculum, it's not that much, but there are, you know. I don't know, whenever something comes to mind during class..., we've come to something, someone wanted something, a rhythm was heard, so let's create, someone wrote a song, let's do it. And how often is that? Maybe 20 percent*). It is evident that teachers combine linguistic and musical creativity by adding visual illustrations, which are most often used in listening to music activities. However, there can be observed a difference in teachers' perception of the number of class hours. The first group of respondents believe that music education is not prevalent enough among students in the lower grades of primary school. This deficiency is compensated for by the integration of subjects in classroom teaching (*According to the current Curriculum, the number of class hours for music education is not sufficient, in... lower grades, so there should simply be much, uh, greater number of class hours to allow students to develop themselves as much as possible, uh, and their potentials. Well, I said that, with almost all classes, even with math, I integrate it. I don't know, I don't know if something is important, for example, we always, always listen to the composition to the end*). The second group of respondents falls into the category that the prescribed number of class hours is sufficient and that students in the primary grades are sufficiently burdened with the program content of other subjects, so any additional class would represent an effort for them (*Well, maybe it would be good if there could be a little more, but, looking at this, well, the number of class hours, somewhere it might be a little difficult to fit in without overburdening the children with additional classes, but certainly, music education can be, well, correlated with other subjects so it should be used whenever possible in other classes, not just in music classes. So I think that's about enough, but, well, if there is a need somewhere, it can always be added because there's never enough music*).

In exploring the sphere of experiencing music education, we could not overlook the answers to the question: What, in your opinion, is the most beautiful thing about music education? In all responses, the creation of a positive emotional climate in music education classes dominates as a result of the shift of musical activities in the class, where musical performance, singing, playing and vocal-instrumental group playing (according to teachers' and students' preferences) dominate, followed by musical games, movement and dance. As the most beautiful aspect of music education, some teachers also mention listening to and recognizing musical examples and developing musical taste. Namely, music performance, the creativity of both teachers and students, a positive emotional and stimulating climate and the development of musical taste are elements that characterize music education and are perceived by teachers as dominant, which is in line with the goals and tasks of teaching this subject at a younger school age. It is important that teachers are mostly ready for the challenges and new knowledge brought

by the 21st century.

The correlation in music education in the lower grades of elementary school involves linking various educational content to create a comprehensive and rich educational environment. Many researchers have dealt with the correlation and integration of educational content (Barry, 2008; Šulentić-Begić, 2013; Čudina Obradović and Brajković, 2009; Ratković, 2018). Skupnjak (2009) purports that correlation is easier to achieve in classroom teaching because it is entrusted to one teacher who teaches multiple subjects. For example, learning basic musical concepts can be expanded through activities such as singing songs or playing instruments, allowing students to practically apply acquired knowledge. Also, by getting acquainted with traditional music from different cultures, students can explore geographical, historical, and cultural contexts, contributing to a broader understanding of the world around them. Correlation in music education in the lower grades of primary school encourages active student participation and enables them to develop various skills and abilities through music education.

Conclusions

Teachers perceive music education positively, focusing on its positive aspects. They consider student activities in all areas of music crucial for their comprehensive development, believing that music fosters personality development on many levels. Although they find music lessons relaxing for both students and themselves, they express the need for refreshing the Curriculum and Program. Specifically, they highlight the need for adding new songs, more examples of traditional folk music and film music, as well as creating arrangements adapted to children's instruments; although they are willing to devise them in collaboration with students. Their experiences and attitudes indicate an urgent need for additional professional development in the field of music pedagogy, especially in the context of primary school music education and evaluation in that context. This research confirms our previous findings regarding the need to improve music reproduction skills – playing on harmonic instruments, as well as in the field of creative musical expression. It should be noted that the sample of respondents did not include the male gender, which means that the results cannot be generalized to the entire population of teachers. In the future, we plan to share with the scientific community the findings of related research analyzed in schools in this region. This research serves as an introduction to a series of topics on the attitudes, experiences and motivation of teachers in regard to teaching music.

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Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, M.D.P., O.B.B. and M.Đ; methodology, M.D.P. and O.B.B; software, M.D.P. and O.B.B; formal analysis, M.D.P., O.B.B. and M.Đ; writing-original draft preparation, M.D.P., O.B.B. and M.Đ; writing-review and editing, M.D.P., O.B.B. and M.Đ. All authors have read and agreed to the published version of the manuscript.

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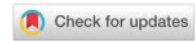
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Comparison of Compulsory Education of the Republic of Croatia and the Republic of Slovenia

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Abstract: Compulsory education is the basis of formal education, and in countries around the world, it has a different duration and characteristics and most often is related to elementary school. This current study compares compulsory education of the Republic of Croatia and the Republic of Slovenia. In addition to a review of the literature, current applicable laws and regulations, a comparative analysis of national curricula for compulsory education of the Republic of Croatia and the Republic of Slovenia have been made. The study showed that there is a difference in the number of subjects taught in elementary schools in Croatia and Slovenia, as well as in the number of teaching hours of individual subjects. Furthermore, an analysis of six subject areas of primary education that are taught in both countries was made, with respect to content determinants. An analysis of the existing content determinants shows that the same or similar content is taught in both countries, while in only one subject area, further analysis is required. This study provided new insights that can be used to further develop Croatian compulsory education.

Keywords: compulsory education, comparative analysis, national curricula, primary education.

Introduction

Compulsory education in most countries refers to elementary school and is considered to be the basis of formal education. Education systems are increasingly changing to keep up with the contemporary demands of society (Garrouste, C. 2010). At the heart of educational reforms are national curricula (Matijević, 2004; Previšić, 2005; Baranović, 2006; Matijević and Rajić, 2015). Therefore, it is not surprising that in the last few decades, curricula of all educational levels have become the subject of many researchers around the world (Baki and Gocek, 2005; Faas, 2011; Jóhannesson et al., 2011; Oda, Noborimoto and Horita, 2021; Swee Fong, 2004; Swee Fong, 2004; Tani, 2011, etc.).

Croatia and Slovenia had a not-so-common past; until 1991, they were an integral part of the Socialist Federal Republic of Yugoslavia, and with their dissolution, both countries became independent republics. So far, several studies have addressed the comparison of particular segments of education in the two countries (Apostolović, 2014; Baranović, 2006; Boras, 2010; Marinović Bobinac, 2007; Smilkov and Jovanova-Mitkovska, 2022; Vuk, Curić, and Jakovčić, 2008; Žnidarec Čučković, 2018) as well as comparison of education in Croatia and other neighboring countries (Duraković et al., 2018; Jovanović and Cvetković Crvenica, 2019; Runceva, 2018; Smilkov and Jovanova-Mitkovska, 2022; Vidulin, et al., 2015). However, none of the studies provided a complete picture of the compulsory education of the two countries.

Encouraged by all above, there is a need for further comparison of educational systems of compulsory education in Croatia and Slovenia. According to Milošević and Maksimović, (2020) the function of comparative research is reflected in determining the similarities and differences of education systems, but there is also a tendency to determine the internal dynamics of educational processes in a particular context. So the question arises as to whether there are similarities and differences between the education

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system in Slovenia, which underwent its major reform in 1995 and Croatia that has undergone the big curricular reform 2019. Therefore, the aim of this research is to determine differences in the organization and characteristics of compulsory education, with an emphasis on comparative curriculum analysis for compulsory education of the Republic of Croatia and the Republic of Slovenia.

Compulsory education in the Republic of Croatia and the Republic of Slovenia

In Croatia, compulsory education has been in existence for fifty years (Matijević, 2004). Although, there was a change in the curriculum after gaining independence in 1991, the duration of compulsory education remained the same (Matijević and Rajić, 2015) and still lasts only eight years (ISCED level 1 and 2). In Croatia elementary school is compulsory for all children from 6 to 15 years old. Unlike elementary school in Croatia, compulsory education in Slovenia, which also applies to elementary school, lasts nine years (ISCED level 1 and 2). The nine-year compulsory education in Slovenia is proposed with education reform starting in 1995, which extended compulsory education from eight to nine years (MIZS-Ministerstvo za šolstvo in šport, 1995). The school year in Croatia has 35 weeks of teaching, five days a week, while in Slovenia, there are 38 weeks of teaching. In Croatia, the daily duration of classes is determined by the schedule of classes, with compulsory subjects of up to 5 hours per day from first grade to fourth grade, and up to 6 hours per day from fifth grades to eighth grade (Zakon o odgoju i obrazovanju u osnovnoj i srednjoj školi, 2018). The elementary school in Slovenia is divided into three educational cycles, the so-called Scandinavian model. The first educational cycle refers to children from 6 to 8 years old, the second cycle from 9 to 11 years, and the third cycle to children from 12 to 14 years. The weekly workload of the students is different in all three educational cycles. In the first educational cycle, students can have a maximum of 24 school hours per week, in second cycle 26 school hours per week, and in the third cycle a maximum of 30 hours per week (MIZS, 1995; Zakon o osnovni šoli, 2005).

Organization of teaching in elementary school

In Croatia and Slovenia, teaching is divided into regular and elective classes. Regular teaching refers to all compulsory subjects taught in elementary school, which are established by the curriculum in Croatia and Slovenia. Elective classes refer to subjects defined in the curriculum, such as another foreign language, and they are conducted in a class or educational group (MIZS, 1995; Zakon o odgoju i obrazovanju u osnovnoj i srednjoj školi, 2018).

Classes in elementary schools in Slovenia and Croatia are taught by the subject. Bogonar and Matijević (2005) call this system: subject-class system and recognize Komensky as one of the founders of this form of education system.

Elementary school teaching materials

In Croatian elementary schools, textbooks, and supplementary teaching aids (workbook, task collection, atlas) are the most used of teaching materials (Pravilnik o obveznim udžbenicima i pripadajućim dopunskim nastavnim sredstvima, 2013). According to the *Rulebook on compulsory textbooks and associated supplementary teaching aids* (MZOS-Ministarstvo znanosti i obrazovanja, 2013), the selection of compulsory textbooks and related supplementary teaching aids is based on the national and subject curriculum, that is, the curriculum for each subject. According to the Slovenian *Rulebook on validation of textbooks* (Uradni list RS, 2013), a textbook is a teaching tool intended for students to master the curriculum. In addition to textbooks in elementary schools in Slovenia, atlases, manuals, worksheets, task collections, computer software, and other audiovisual materials are used, which supplement or form part of the textbook.

The importance of using textbooks in the education system is also emphasized by Matijević, Topolovčan, and Rajić (2013) which point out that the textbook alongside students and teachers is a key factor for primary and secondary school teaching and is an indispensable factor in the teaching process.

Evaluation and assessment in compulsory education

Evaluation is an indispensable part of the educational process. The concept of evaluation can be interpreted in different ways with regard to its role and purpose, and at which level of education it is

applied ([Rajić, 2017](#)).

In Croatian schools, according to the *Rulebook on Ways, Procedures, and Elements of Student Evaluation in Primary and Secondary Schools* ([MZOS, 2010](#)), there are three types of knowledge testing. Introductory or initial assessment (carried out at the beginning of the school year to see the level of student competencies achieved), oral examination (may be conducted for up to 10 minutes each hour) and written examination (short written examinations of up to 15 minutes maximum, and written checks which take more than 15 minutes). Student's knowledge in Croatia is evaluated by descriptive numerical grades: inadequate (1), sufficient (2), good (3), very good (4) and excellent (5), while student's behavior is assessed by descriptive grades: exemplary, good and bad ([MZOS, 2010](#); [Novak-Milić and Barbaroša-Šikić, 2008](#)).

In Slovenia, in the first and second grade of elementary school, students' knowledge is assessed with descriptive grades, and from third grade, the students are graded with descriptive numerical grades and like in Croatia, the five-point scale is used. In Slovenia, the assessment is carried out by oral and written examination, as well as by visual, technical, and practical examination and project work ([Pravilnik o preverjanju in ocenjevanju znanja ter napredovanju učencev v osnovni šoli, 2013](#)).

Elementary school teachers

The elementary school in Croatia can be divided into two levels (from first to fourth grade – ISCED level 1) and lower secondary education (from fifth to eighth grade – ISCED level 2). In the first four grades, only one teacher teaches all compulsory subjects except Informatics and Foreign language, while from the fifth grade, each subject is taught by a different professor or expert in a particular field. Teachers also perform all other tasks related to the educational work with students, as well as all activities and tasks in the school curriculum, and particular tasks related to the structure of the school work ([Pravilnik o tjednim radnim obvezama učitelja i stručnih suradnika u osnovnoj školi, 2014](#); [Zakon o odgoju i obrazovanju u osnovnoj i srednjoj školi, 2008](#)).

In the Slovenian elementary school, in the first grade, in addition to the teacher, there is another assistant teacher who is usually the preschool teacher. This mode of operation has existed since 1995 following the adoption of the new educational reform. By the end of the second educational cycle, that is, 6th grade, teacher of primary education can teach students, as is the case in primary education in Croatia (first to fourth grade). In the third educational cycle, classes are taught by subject teachers, professors ([Matijević, 2004](#); [MIZS, 1995](#); [Nacionalna strokovna skupina, 2011](#)). Every teacher has certain competencies, and according to [Simonović \(2021\)](#) teacher competencies are a set of specific knowledge, skills, and attitudes that teachers possess and use to affect the progress of the overall educational process.

Materials and Methods

Since the review of the literature has shown that there are differences in the organization of compulsory education of the Republic of Croatia and the Republic of Slovenia, it is essential to determine using content analysis ([Cohen et al. 2018](#); [Matijević, 2004](#); [Mejovšek, 2008](#)) whether there are differences in the national curriculum. According to [Krippendor \(2004\)](#) in the social sciences, content analysis is one of the most substantial research techniques.

Sample

The content analysis covers the basic educational documents of the Republic of Croatia and the Republic of Slovenia. The newly developed subject curricula of the Comprehensive Curricular Reform will be analyzed ([MZOS, 2019](#)) in Croatia and the Curriculum of the Republic of Slovenia ([Ministrstvo za šolstvo in šport, 2011](#)) for ISCED 1 level of education.

Results and Discussions

This section is divided into two parts. The first part focuses on analysis of the national curricula for compulsory education in which subject structure and the annual number of hours of compulsory

subjects are presented (ISCED level 1 and 2). The second part presents analysis of the primary education curriculum, with a focus on the comparison of common subjects, i.e., subject areas.

Analysis of the national curricula for compulsory education

Subject structure of national curricula for compulsory education

The subject structure of the national curricula for compulsory education of Croatia and Slovenia is shown in Table 1. Croatia has 15 compulsory subjects in elementary school, while Slovenia has 18 compulsory subjects. Croatia and Slovenia have eleven of the same subjects in elementary school. In the field of natural sciences in Croatia is taught *nature and society* and *nature*, while in Slovenia, *learning the environment*, *natural sciences*, and *natural sciences and techniques* are taught. *Informatics* (HR), *citizenship education* (SLO), *patriotic and civic culture and ethics* (SLO), *home economics* (SLO) are subjects that are not represented in the compulsory education of both countries.

Table 1. *Subject structure of national curricula for compulsory education in Croatia and Slovenia*

Subjects in Croatia	Subjects in Slovenia
native language	native language
mathematics	mathematics
nature and society nature	learning the environment natural sciences and techniques natural sciences
visual art	visual arts
music education	music arts
physical education	sports
foreign language	foreign language
biology	biology
chemistry	chemistry
physics	physics
history	history
geography	geography
technical education	technical education
informatics	-
-	patriotic and civic culture and ethics
-	citizenship education
-	home economics

The annual number of hours of compulsory subjects in elementary school

It is evident that students in Slovenia at the end of elementary school have higher workloads in native language, mathematics, science subjects, art education, music education, sports education, and foreign language than students from Croatia, considering the total number of hours at the end of elementary school (see Table 2).

The subjects taught in lower secondary education (biology, chemistry, physics, geography, and history) are represented in a larger number of hours in Croatia but with a very small difference.

Technical subjects have the same number of hours in Slovenia and Croatia, while the informatics is taught only in Croatian elementary schools (Ministrstvo za šolstvo in šport, 2011; MZOS, 2019).

Table 2. *The annual number of hours of compulsory subjects in elementary school*

	Grade								Subject		Grade									
	1.	2.	3.	4.	5.	6.	7.	8.			1.	2.	3.	4.	5.	6.	7.	8.	9.	
CROATIA	175	175	175	175	175	175	140	140	Croatian language	Slovenian language	210	245	245	175	175	175	140	122,5	144	SLOVENIA
	140	140	140	140	140	140	140	140	mathematics		140	140	175	175	140	140	140	140	128	
	70	70	70	70	-	-	-	-	nature and society	learning the environment	105	105	105	-	-	-	-	-	-	
	-	-	-	-	52,5	70	-	-	nature	natural sciences and techniques	-	-	-	105	105	-	-	-	-	
	-	-	-	-	-	-	-	-	natural sciences		-	-	-	-	-	70	105	-	-	
	35	35	35	35	35	35	35	35	visual art		70	70	70	70	70	35	35	35	32	
	35	35	35	35	35	35	35	35	music education		70	70	70	52,5	52,5	35	35	35	32	
	105	105	105	70	70	70	70	70	physical education/Sports		105	105	105	105	105	105	70	70	64	
	70	70	70	70	105	105	105	105	foreign language/ English language		-	70	70	70	105	140	140	105	105	
	-	-	-	-	-	-	-	-	citizenship education		-	-	-	70	105	-	-	-	-	
	-	-	-	-	-	-	70	70	biology		-	-	-	-	-	-	-	52	64	
	-	-	-	-	-	-	70	70	chemistry		-	-	-	-	-	-	-	70	64	
	-	-	-	-	-	-	70	70	physics		-	-	-	-	-	-	-	70	64	
	-	-	-	-	52,5	70	70	70	geography		-	-	-	-	-	35	70	52,5	64	
	-	-	-	-	70	70	70	70	history		-	-	-	-	-	35	70	70	64	
	70	70	70	70	70	70	70	70	informatics		-	-	-	-	-	-	-	-	-	
	-	-	-	-	35	35	35	35	technical education		-	-	-	-	-	70	35	35	-	
	-	-	-	-	-	-	-	-	home economics		-	-	-	-	35	52,5	-	-	-	

Analysis of the primary education curriculum

Subject structure of national curricula for primary education

Primary education in Croatia refers to the first four grades of elementary school (ISCED level 1), while in Slovenia, it refers to the first two educational cycles of compulsory education (ISCED level 1), from first to sixth grade. In the primary education of both countries, there are five same subjects, while the Croatian subject *nature and society*, in Slovenia is taught through three different subjects following one after the other, as students move toward the upper grades (see Table 2). *Geography*, *history*, and *technical education* in Croatia are taught in upper grades, while in Slovenia, these subjects are from the last grade of primary education (sixth grade). Subject *home economics* and *citizenship education* are only present in Slovenian elementary schools (Ministrstvo za šolstvo in šport, 2011; MZOS, 2019).

Table 3. *Subject Structure of National Curricula for Primary Education in Croatia (first to fourth grade) and Slovenia (first to sixth grade)*

Croatia	Slovenia
Croatian language	Slovenian language
Mathematics	mathematics
nature and society	learning the environment natural sciences and techniques natural sciences
visual art	visual art
music education	music art
physical education	sports
informatics	citizenship education
foreign language	home economics geography history technical education

Considering that primary education in Croatia and Slovenia does not have all the same subjects, the comparison was limited to common subjects, i.e., subject areas, and subject areas were analyzed concerning content determinants: mathematics field, native language, natural sciences, kinesiology, art field, and music field.

Determinants of teaching content for the mathematics field

Table 4. *Determinants of teaching content for the mathematical field*

Mathematical Area - Content Determinants	
CROATIA	Domains 1. Numbers 2. Algebra and functions 3. Shape and space 4. Measure 5. Data, statistics, and probability
SLOVENIA	1. Geometry and measurement 2. Arithmetic and algebra 3. Other content

According to the Croatian subject curriculum for the mathematics (MZOS, 2019) in addition to mathematical processes the following domains are described as content determinants: „Numbers“, „Algebra and functions“, „Shape and space“, „Measure and data“, „Statistics and probability“. In the Slovenian Curriculum (Ministrstvo za šolstvo in šport, 2011), the mathematical field is divided into three contents: „Geometry and measurement“, „Arithmetic and algebra“ and „Other content“ (see Table 4).

An analysis of the content determinants of the mathematical area of both countries revealed that there were overlaps in certain segments. The domains „Numbers and algebra“ existing in the Croatian curriculum can be identified with „Arithmetic and algebra“, which are part of the content of the mathematical field in Slovenia. Furthermore, the domains „Shape and space“ and „Measurement“ in content correspond to the „Geometry and measurement“ described in the Slovenian curriculum. Although the previously compared content domains and determinants have broad similarities and matches, this is not the situation with the third content determinant described in the Slovenian curriculum, „Other content“. This domain cannot correctly be compared with any domain in the Croatian curriculum, but according to the description, it can be said that it is represented in almost all domains of the Croatian mathematical field. According

to this analysis, which was limited to the analysis of content determinants and did not analyze the more profound components of each content, the domain “Data, statistics, and probability” does not find relevant content in the Slovenian curriculum that can be compared.

Determinants of teaching content for the native language

Table 5. *Determinants of teaching content for the native language*

Native language areas - content determinants	
CROATIA	1. Croatian language and communication 2. Literature and creativity 3. Culture and media
SLOVENIA	1. Language 2. Literature

As can be seen in Table 5 Croatian language is divided into three main subject areas: „Croatian language and communication“, „Literature and creativity“, and „Culture and media“, while the Slovenian language is divided into two main subject areas: „Language“ and „Literature“ (MZOS, 2019; Ministrstvo za šolstvo in šport, 2011). Although, according to the Croatian curriculum, there are three determinants of the content of the native language, and according to the Slovenian curriculum, there are two determinants of the content, but the contents they cover overlap. We can associate “Croatian language and communication” with “Language” existing in the Slovenian curriculum, while “Literature and creativity” and “Culture and media” correspond to “Literature”, which is described in the Slovenian curriculum.

Determinants of the teaching content of the natural sciences

Table 6. *Determinants of the teaching content of the natural sciences*

Natural sciences - Content Determinants	
CROATIA	1. The organization of the world around us 2. Changes and relationships 3. The individual and society 4. Energy
SLOVENIA	1. Clock 2. Space 3. Substances 4. Forces and motions 5. Phenomenons 6. Living beings 7. Human being 8. I 9. Community 10. Relations 11. Transport 12. Environment 13. Energy 14. Nature 15. Human impact on the environment

The content determinants for the field of natural science are given in Table 6. In Croatia the approach the subject is interdisciplinary and there are four determinants of content divided into the subject *nature and society*, while in Slovenia the content is divided into fifteen teaching topics taught through three teaching subjects (*learning the environment, natural sciences and techniques, natural sciences*) (Ministrstvo za šolstvo in šport, 2011; MZOS, 2019).

Although in Slovenia the natural sciences are not divided into subject areas, we can observe that the curriculum topics prescribed by the curriculum correspond somewhat to the subject areas existing in Croatia, that is, each of the fifteen teaching topics can be classified in at least one subject area, while some may be classified in multiple subject areas.

Determinants of the teaching content of the kinesiology area

Table 7. *Determinants of the teaching content of the kinesiology area*

Kinesiology Area - Content Determinants	
CROATIA	1. Kinesiological theoretical and motor knowledge 2. Morphological characteristics, motor, and functional abilities 3. Motor achievements 4. The health and educational effects of physical exercise
SLOVENIA	1. Operational objective 2. Practical and theoretical content 3. General theoretical content

The determinants of the teaching content of the kinesiology area are illustrated in Table 7. In the Croatian elementary school, the kinesiology area is divided into four subject areas: “Kinesiological theoretical and motor knowledge”, “Morphological characteristics, motor, and functional abilities”, “Motor achievements” and „Health and educational effects of physical exercise“ (MZOS, 2019). In Slovenia, the kinesiology area is divided into three content determinants: „Operational objective“, „Practical and theoretical content“, and „General theoretical content“ (Ministrstvo za šolstvo in šport, 2011). The comparison showed that the contents covered by the „General theoretical content“, were repeated in a similar or the same form in the Croatian content „Health and educational effects of exercise“. Furthermore, we can observe that the content of „Practical and theoretical content“, corresponds to some extent with the content of „Kinesiological theoretical and motor knowledge“ and „Motor achievements“.

Determinants of the teaching content of the art area

Table 8. *Determinants of the teaching content of the art area*

Art area - content determinants	
CROATIA	1. Creativity and productivity 2. Experience and critical attitude 3. Art in context
SLOVENIA	1. Surface design 2. Design in three-dimensional space

In the Croatian elementary school the art area is divided into three subject areas: “Creativity and productivity”, “Experience and critical attitude,” and “Art in context” (MZOS, 2019). According to the Slovenian curriculum, the art area is divided into “Design on the surface” and “Design in three-dimensional space” (Ministrstvo za šolstvo in šport, 2011) (see Table 8).

This analysis, which restricted itself to content determinants, did not find any similarities between the content taught in the two countries, and a more in-depth analysis of curriculum content must be made in order to compare the content of visual art.

Determinants of the teaching content of the music area

Table 9. *Determinants of the teaching content of the music area*

Music Area - Content Determinants	
CROATIA	Domains: 1. Listening and introduction of music 2. Expressing yourself through music and with music 3. Music in context
SLOVENIA	1. Listening 2. Performance 3. Creation

The music area in both countries is divided into three content determinants (see Table 9).

The first content determinant is “Listening and getting to know music” (in Croatia) and “Listening” (in Slovenia). The second determinant of content is “Expressing with music and with music” in Croatia, or “Performing” in Slovenia. Furthermore, the third determinant of content, or domain, in *music culture* in Croatia is “Music in context”, which builds on and complements the previous two domains. The last determinant of content in Slovenia is “Creation”, which refers to the creation of various musical contents using instruments and singing, as well as expression through dance and movement (MZOS, 2019; Ministrstvo za šolstvo in šport, 2011).

Comparing the content guidelines, it can be seen that “Listening and learning about music” in Croatia and “Listening” in Slovenia, as well as “Expressing with music and with music” and “Performing”, cover similar or the same topics. There is a difference in the third determinant of content “Music in context” in Croatia and “Creation” which by comparison have no common elements, but the two determinants are based on the previous two determinants of content and combine the entire content of the *music art* of each country.

Conclusion

In this paper the comparison of compulsory education of the Republic of Croatia and the Republic of Slovenia was made with an emphasis on curriculum analysis in both countries (ISCED level 1 and 2). The differences in the compulsory education of these two countries are already evident in the duration and organization of compulsory education. Although a new education reform was implemented in Croatia in 2019., the reform has not led to changes in the duration of compulsory education, as it is the case in many European countries (Fort, 2006; Garrouste, 2010).

The curriculum analysis of the primary education (ISCED level 1) which covered six subject areas in both countries that are thought by primary school teachers, showed that the area of the native language, the mathematics area, the music area as well as the kinesiology area, are divided into similar content which means that in these subjects, almost the same teaching content is taught. Although the field natural science is not divided into similar content determinants in Slovenia and Croatia, due to different scientific approach to the subject the description of existing guidelines can conclude that similar content is taught in both countries. As far as the art area is concerned, a deeper analysis of the curriculum should be made to examine the similarity of the content.

Limits of the study and future research

Given that this research has not been conducted so far at the level of overall comparison of compulsory education in Slovenia and Croatia, as well as primary education (ISCED level 1), this study has provided useful information and knowledge that can be further implemented in the development and improvement of Croatian compulsory education.

It is important to emphasize that this research was limited to the analysis of the content determinants

of the subject areas of primary education, and continuations of this research in the future are possible. Some of the possible further research may include the analysis of educational goals of learning and teaching, as well as the analysis of educational outcomes. It is also possible to extend the analysis to other European countries for the purpose of improving the Croatian education system.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization A.K. and V.R.; methodology V.R. and A.K.; content analysis A.K.; waiting original draught version A.K.; waiting review V.R. All authors have read and agreed to the published version of the manuscript.

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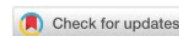
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The Influence of Organizational Factors on the School's Achievements

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Abstract: The purpose of this paper is to examine the influence of the most significant organizational factors on primary school achievements, with a note that the achievement of the school is expressed through the quality of outcome knowledge. The research was conducted on a sample of 460 employees, from 21 primary schools, of which 439 are professionals and 21 are principals in the South Bačka County, Republic of Serbia. The collected data were processed using the Gretl software and AMOS for modelling structural equations. More precisely, the research is based on the application of exploratory and confirmatory factor analysis. A neural network based on a standard multilayer perceptron model was used in the paper to test the validity of the obtained results of the AMOS model. The results of the research show that school management is the most important factor in school achievement and that this influence is most pronounced through teaching staff and school infrastructure. The results, also show that teachers' competencies have the strongest direct influence on the quality of outcome knowledge. The results obtained indicate that decision-makers and creators of social policies must pay special attention to the selection of school principals as well as their professional education, while school principals to the selection of teachers. Future researchers are recommended to use the Sobel test to precisely determine the indirect influences of school management on school achievement.

Keywords: organizational factors, school's achievements, primary education, outcome knowledge.

Introduction

Primary school is considered a complex system, because it consists of many functionally connected elements. Elements that comprise the primary school system are teachers, the teaching process and students who are expected to adapt to change, as well as an interactive approach to achieve the expected goal. School is a so-called learning space both for teachers and professional associates as well as for educators and students. It represents a team effort in which all actors exchange experiences and acquired knowledge, which they expand daily, creating new ones. The school nurtures the principles of good practice, following current events, it encourages independence in the acquisition of knowledge, supports creativity and freedom of expression, advocates permanent employee training, monitors innovations in information and communication technologies, and strives to implement effective approaches characterized by flexibility. Hence, the quality of work of a school assessed according to the potential and readiness for the application of new knowledge, and the recognition and daily acquisition of new knowledge (Pribudhiana, Bin Don and Bin Yusof, 2021), that is, through its achievements, which are reflected in the degree of quality of learning outcomes. Namely, as the quality of educational work is a key factor in achieving the entire existence of the school, it seems logical that the achievements of the school should be expressed through a category such as the achieved results of educational learning outcomes including skills, knowledge, attitudes of students and competencies acquired through formal school education. This is more, because a quality education also implies a stimulating atmosphere which enables students to develop individually, daily. Outcomes allow students to see to what extent they have achieved the planned

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programs, which will serve as a basis for their enrollment into the next educational level. The choice of work methods, as well as materials of different content, are harmonized with the planned outcomes so that they can expect, and verify with certainty, what the student will be capable of doing, and what he will know, after the adoption of teaching content. What the teacher strives to teach students represents the learning goal, and what the student has adopted at the end of learning represents the outcome. One of the indirect ways of checking the quality of work, through the achieved outcomes of students completing their primary school education, can be the results achieved at the primary school exit exam which, together with school grades, give a result based on which students have the opportunity to enroll into high school (Baketa, Dedic and Jokic, 2020).

Factors that greatly affect the quality of schoolwork and educational outcomes are school management, teaching processes, infrastructural conditions, motivation, curriculum, pre-knowledge. (Wargocki and Wyon, 2017; Park and Weng, 2020; Tang, 2020; Gupta et al., 2023). Also, teaching staff is, to a significant degree, a mediator in the educational processes which, with its knowledge and skills, adapts the content to the characteristics of the students. Teaching staff also monitors students' aspirations and abilities, as well as the technical possibilities of the institution, adapting them to the abovementioned characteristics of the students. When implementing the curriculum, the creativity of teachers and a combination of work methods is important, so that teaching content is adopted at a higher level and as such persists longer in the minds of students. Successful management of an institution implies versatility and leadership qualities of the principal, who will be able to recognize, enable, motivate, successfully communicate, perceive and improve the existing qualities (Dou, Devos and Valcke, 2017).

Namely, from the above it can be easily concluded that organizational factors have a crucial role in learning outcomes, i.e., the outcome knowledge. The question that arises is which of the organizational factors has the strongest influence. Identifying the factors with the greatest influence and their ranking according to the intensity of influence is significant both for the creators of educational policies and for the management of schools. When they have knowledge about the importance of factors on learning outcomes and the school's, they will make more effective decisions regarding the allocation of, as a rule, limited resources. They will invest in those factors that have a greater impact. Therefore, identifying the factors with the greatest influence enables the desired goal to be achieved efficiently. In this context, the goal of this work is to determine the effects of the most significant limiting factors on school achievement in the South Bačka County, Republic of Serbia.

Materials and Methods

Most authors (Harden, 2002; Hussey and Smith, 2002; Levenberg, 2016; Barak and Levenberg, 2016) who deal with the topic of education believe that it is a pedagogical process in the function of enriching human knowledge. International law has defined education as one of the basic human rights and a general social good. Barak and Levenberg (2016) believe that educational changes are very fast with contemporary work models inevitably following the rapid development of technology, hence the work is directed towards encouraging initiatives, creativity, curiosity, risk acceptance and flexibility. Improving the professionalism of staff, and encouraging team spirit, tolerance and humane principles supports the development of each individual and is in line with the highest principles of preparation for life skills. However, in such circumstances, it is important to understand how organizational factors contribute to the achievement of this function of education. In other words, it is important to understand how key organizational factors influence learning outcomes, which represent what has been achieved and evaluated, at the end of the learning process, and not simply what the aspirations or the intentions were (Harden, 2002), and which when set appropriately can be used in curriculum planning, teaching and learning, which facilitates the management process (Hussey and Smith, 2002). This is especially important when you have to the last years, there has been a significant focus on school's accountability for learning outcomes. Policymakers have emphasized the need for educational institutions to transparently demonstrate student learning, while accrediting associations have set higher standards for institutions.

Blömeke et al., (2022) point out that teacher competence is a key factor for learning outcomes. They emphasize that recognizing the significance of human resources is crucial in developing teaching quality, and the quality of the entire educational process, the most important thinks for education achievement. They emphasize the importance of three main sets of educator/teacher competencies: knowledge of

information technology, working with people and working in a team and for a team. According to [Ho et al., \(2023\)](#), the preferred forms of teacher psychological competency that are within the function of methodical competency are social and emotional intelligence, cognitive autonomy, openness to new experiences, visualization of methodical situations and solutions, realistic judgment, objectivity and critical thinking, cognitive receptivity to innovation, creative and divergent thinking, stability of the value system, maturity of attitudes, wealth and stability of interest, self-perception (self-image), etc. Research conducted in Spain ([Aragon-Sanchez, Barba-Aragón and Sanz-Valle, 2003](#)) points to the significance of human resources training, with always current innovations and their direct impact on the quality of work outcomes. [Fuadi, Nasution and Wijaya \(2023\)](#) emphasize the importance of management of teacher professionalism development and suggest that the efforts of management must be known as efforts to develop teacher professionalism in the form of increasing expertise, and skills, broadening horizons, coaching carried out on the initiative and in collaboration with the regional government. A similar view is expressed by [Rusyn et al. \(2021\)](#). Especially important are the competencies of the teachers, which encourage student's motivation. While certain students demonstrate a willingness to resolve the challenges they encounter during lessons or at school, others tend to avoid seeking solutions for the problems they face. Among the various factors that influence students' behaviours within the same school, motivation emerges as a primary determinant. Motivation plays a crucial role in the effectiveness of the learning-teaching process as it empowers students to actively engage in their educational journey ([Brooker et al., 2018](#); [Yu, Gao and Wang, 2021](#); [Karakose et al., 2023](#)), which is presented through the expectancy-value theory of motivation in learning ([Lo et al., 2022](#)). At the same time, learning outcomes affect student motivation. Namely, according to the theory of expectations, a positive learning outcome leads to improved expectations, increases the value of the reward and clearly connects the learning effort with the achievement of the goal and the reward. This cycle leads to the strengthening of student motivation. The teacher's expectation plays a special role in this ([Gentrup et al., 2020](#); [Johnston, Wildy and Shand, 2023](#)). On the contrary, amotivation represents an internal state in which students exhibit reluctance towards participating in classroom activities and become disengaged from the lesson ([Leroy and Bressoux, 2016](#)). In the case of amotivation, students lack any driving reasons to take action, and more significantly, it can lead to feelings of disappointment, ultimately negatively impacting productivity and overall well-being. For this reason, the competencies of teachers are important, which encourage and motivate students. The importance of motivation for school employees is particularly emphasized by [Anselmus et al., \(2022\)](#), [Ahmadi et al., \(2023\)](#), [Robinson \(2022\)](#) etc. These studies particularly emphasize the importance of teachers' motivational beliefs which direct and sustain their efforts to engage in relationship-building behaviours and, thus, lead to positive relationships with their students.

The infrastructure of the school is closely related to the previous one. It is not only important for student motivation, but also for teachers, especially contributing to the improvement of self-efficacy, which is considered a key concept in Bandura's Social Learning Theory. Studies on self-efficacy have emphasized its cognitive nature and their results showed that students' perceived self-efficacy was positively associated with learning outcomes such as task choice, task persistence, effective student activities, and academic achievement ([Girelli et al., 2018](#); [Gutiérrez and Tomás, 2019](#); [Hayat et al., 2020](#)). [Brinson \(2015\)](#) points to the importance of technology in facilitating the learning process and evaluating outcomes. Therefore, the results of learning outcomes are also used as a starting point for the further development of more advanced programs, and thus the development of information systems adapted to programs adjusted to the adoption of new curricula. Research shows that school conditions and equipment affect the organizational aspects of the school and thus have an impact on the education and learning process ([Doyer and Bean, 2023](#)). However, budget is often imposed as a limiting factor ([Dadmand and Pooya, 2023](#)).

[Bouslama et al. \(2003\)](#) propose a new academic model, based on the availability of laptops and IT classrooms, that will respond to the challenges of contemporary society and demonstrate how technology is used to facilitate the learning process, as well as being able to assess its impact on the success of learning outcomes. [Brinson \(2015\)](#) illustrates that learning success in virtual classrooms is the same, or greater, than that in traditional classrooms, according to all categories of learning outcomes (knowledge and understanding, research skills, practical skills, perception, analytical skills and social and scientific communication). It has been observed that learning theories need to be more heavily considered when developing virtual applications to make them more relevant to learning outcomes, which will increase the

accuracy of simulation (Radianti et al., 2020). Similar views were expressed by other authors (Alfoudari, Durugbo and Aldmour, 2023; García-Tudela, Prendes-Espinosa and Solano-Fernández, 2023; Dimitriadou and Lanitis, 2023; Dai et al., 2023; Dadmand and Pooya, 2023; Doyer and Bean, 2023; Uyen and Thu, 2023).

Therefore, technological changes affect the shaping of both the education process and the learning outcomes and goals (Young, Klemz and Murphy, 2003). In this respect, education management, as well as the teaching and learning process, needs to be redesigned according to the needs of the individual and the sustainable development of the knowledge economy. The challenge is to effectively utilize these technologies in a way that serves the interests of students. Young, Klemz and Murphy (2003) believe that it is precisely through the use of ICT that we can influence the actualization of values that substantially support the paradigm according to which education is a student-centered process. It may be concluded that organizational learning is at the core of this process and that ICT are the optimal means for this transformation.

School management also plays an important role in this process. Analysis of data from scientific literature indicates that school management directly affects the scope and breadth of infrastructure and ICT implementation, the development of teacher competencies and learning outcomes. School management encourages and facilitates development planning and the development of the school (West-Burnham, 1997) and provides support in the management of the teaching process. Research in the United States indicated what we often find in our country as well, a lack of functional knowledge and basic skills in those who become able to work, over time (Nonaka, 1994). This is reflected through the harmonization of theoretical knowledge with the ability of its implementation while following the development of new technologies that enable greater functionality.

However, management, in an educational system, is achieved by an established state and educational policy. Hence, Harris and Hopkins (2008) state that the theory of school leadership must be non-individualistic. Understanding school leadership must go beyond thinking about principal-hero. Leadership in the school environment can be manifested at different levels. Fullan (2011) points out the importance of the context within which school leadership is interpreted and considers it important to state the causes and ways of interpreting context in relation to the desired outcomes.

Conceptualization of previously performed analysis of the empirical studies on the impact of organizational factors on the school's achievements graphically can be displayed by the following research model, with a note that the achievement of the school is expressed through learning outcomes *i.e.*, the quality of outcome knowledge, which is expressed through the results achieved at the primary school exit exam. More precisely, the students' achievements were measured through the success of the final matriculation exam, which at the time of examination consisted of 3 tests: a test in mathematics, a test in the Serbian language and a combined test. The combined test includes material from biology, physics, chemistry, history and geography.

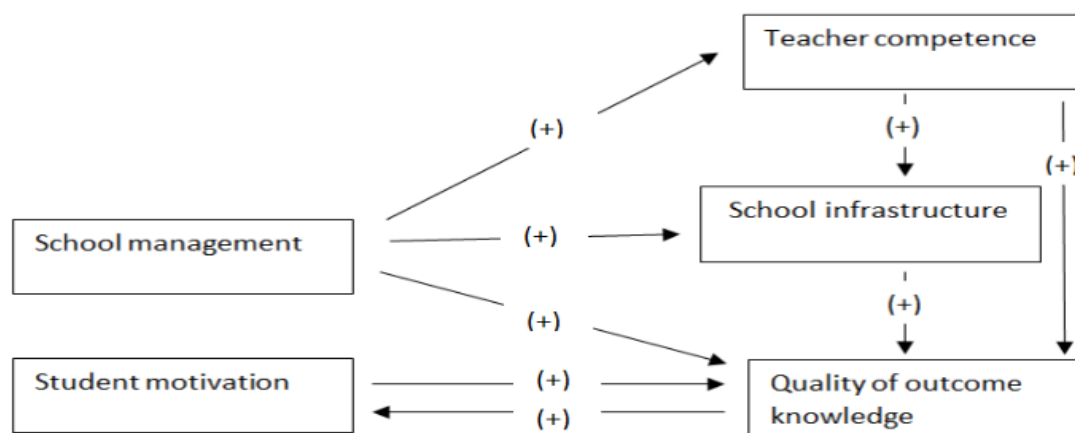


Figure 1. Conceptual model

The model assumes the role of management is crucial, so it is assumed that school management primarily affects the competency of teachers, and school infrastructure but also, directly, the quality of outcome knowledge. The effect of management on the quality of outcome knowledge is also indirect so that by selecting a quality teaching staff and investing in school infrastructure, it influences a higher quality of outcome knowledge. In addition, a quality teaching staff will influence an investment in school infrastructure, which also has a positive effect on the quality of outcome knowledge. In other words, teachers directly affect the quality of knowledge, by requiring management to invest in school infrastructure, while classroom equipment enables the modernization of the teaching process, thus raising the quality of outcome knowledge. On the other hand, it was assumed that the second most important factor influencing the quality of outcome knowledge was student motivation and it was assumed that this connection is twofold; higher student motivation leads to a higher quality of knowledge, which in turn empowers students and further increases their motivation.

Based on the presented model, it is possible to define the main hypothesis: *The better management of organizational factors in primary education will lead to better the school's achievements*, as well as and six auxiliary hypotheses were derived from the main hypothesis:

- H_1 : School management has a positive impact on the quality of primary education learning outcomes;
- H_2 : School management has a positive impact on teacher competency.
- H_3 : School management has a positive impact on the infrastructural conditions at the school.
- H_4 : Teacher competency has a positive effect on the quality of primary education learning outcomes;
- H_5 : Infrastructural conditions at the school have a positive effect on increasing the quality of primary education learning outcomes;
- H_6 : The quality of learning outcomes has a positive effect on student motivation;
- H_7 : Student motivation positively affects learning outcome quality, i.e., the quality of outcome knowledge.
- H_8 : Teacher competency has a positive impact on the infrastructural conditions at the school.

The data were collected based on a structured questionnaire, which was compiled based on relevant statements proposed in the scientific literature. The validity of the questionnaire was tested by applying principal component analysis (PCA), since a high Cronbach's alpha value does not indicate a high reliability as it can simply be the result of a large number of items included in the analysis. The research was conducted during 2022. The respondents assessed the statements from the questionnaire using the five-point Likert scale, with ratings from (1), "completely disagree", to (5), "completely agree". The heterogeneous sample included employees holding different positions within an educational institution, i.e., primary school (teachers, professional associates and principals). The schools included in the research are from the territory of the South Bačka County (Novi Sad School Administration), selected according to the random sampling method. The schools included in the research were selected according to the random sampling method. The number of participants in this research numbered 460 employees, from 21 primary schools, of which 439 are professionals and 21 are principals. Of the professionals, 114 are male (26%) and 325 are female (74%).

The sample adequacy is tested using the KMO test adequacy test (test value = 0.873). The results of the questionnaire validity test were shown in Table A1 in the Appendix, with the note that promax rotation was used. The results of the PCA indicate that items are grouped according to expectations, ie, so that the questionnaire can be used reliably in further analysis. The collected data were processed using the Gretl software and AMOS for modeling structural equations.

Although principals and teachers may have different views on the factors that are the subject of study in this paper, for example on the issue of the quality of school management work, the ANOVA analysis shows that there are no significant differences between these two groups of respondents. The stated view is confirmed by the ANOVA analysis results shown in Table A2 in the Appendix, from which it can be seen that in the case of all four factors, the critical values of the test are greater than the value of the F test for a confidence level of 0.05.

Results

Before the AMOS model parameters were assessed, a correlation analysis of the indicators was conducted. A crucial requirement for the accurate utilization of factor and structural analysis is that indicators be highly correlated and mutually replaceable. Table 2 shows the correlation matrix of indicators

(variables that are measured in the model), the average variance extracted (AVE) and Cronbach's alpha for estimating the reliability of the multi-item sections and the goodness-of-fit indices for the SEM model.

Table 1. Correlation Matrix (squared correlation), AVE (average variance extracted)

	SM	TC	SIC	StM	QOK
SM	1				
TC	0.569	1			
SIC	0.548	0.563	1		
StM	0.602	0.419	0.594	1	
QOK	0.512	0.534	0.502	0.521	1
AVE	0.611	0.569	0.691	0.672	0.641
Reliability	0.713	0.778	0.722	0.781	0.726
RMSEA (root mean square error of approximation) 0.046					
RMSR (root mean square residual) 0.051					
NNFI (non-normed fit index) 0.978					
AGFI (adjusted GFI) 0.902					

Note: SM – School management, TC - Teachers' competences, SIC - School infrastructural condition, StM - Student motivation, QOK - Quality of outcome knowledge.

All squared correlations are significant at 1% level of confidence

The correlation matrix analysis indicates that the variables are highly correlated with each other. The AVE for each construct was greater than the square of the correlation coefficient for the corresponding inter-constructs, which confirms discriminant validity, while the results of convergent validity of measures also contribute to convergent validity. Values of Cronbach's alpha in all cases are above 0.7, indicating an acceptable level of reliability for each construct. According to the goodness-of-fit indices, the proposed structural model was found to fit the data well.

Table 2. Results of hypothesis testing

Variables	Coeff.	Stand. error	Critical value	P value	Results
QOK←SM	0.208	0.067	3.097	< 0.01	H ₁ accept
TC←SM	0.909	0.039	23.343	< 0.01	H ₂ accept
SIC ←SM	0.470	0.052	9.117	< 0.01	H ₃ accept
QOK←TC	0.673	0.062	10.926	< 0.01	H ₄ accept
QOK←SIC	0.462	0.060	7.650	< 0.01	H ₅ accept
SM←QOK	0.621	0.029	21.755	< 0.01	H ₆ accept
QOK←StM	-0.475	0.096	-4.930	< 0.01	H ₇ reject
SIC←TC	0.322	0.042	7.624	< 0.01	H ₈ accept

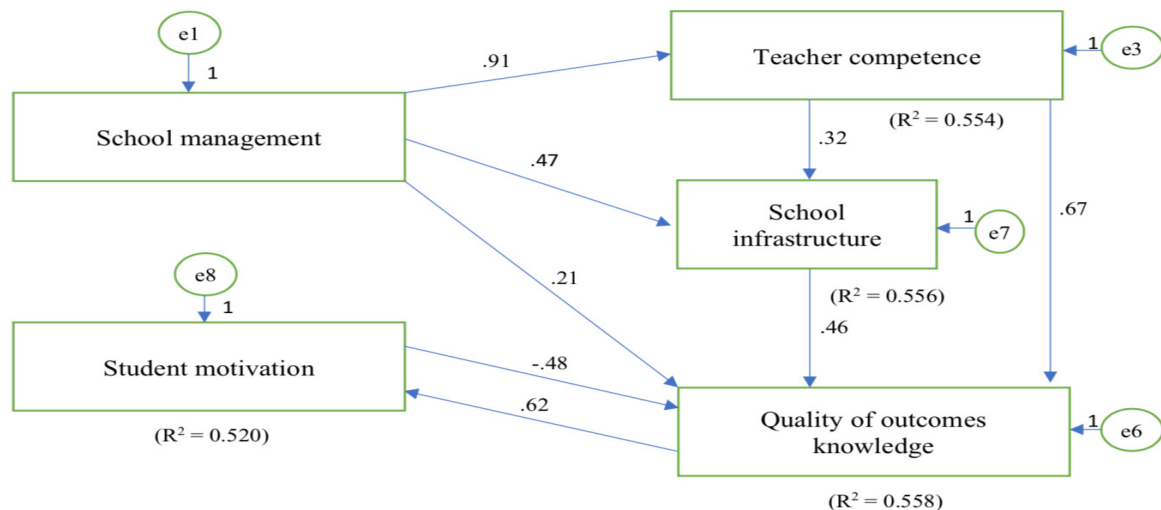


Figure 2. Tested structural model

The results of the confirmatory factor analysis are shown in Table 2 and Figure 2. Namely, Table 2 shows the values of the regression coefficient estimates together with the statistical significance tests. All examined connections are statistically significant. The strongest connection was made between school management and teacher competency: $\beta=0.909$, $t=23.343$, $p<0.01$, which indicates the importance of management in the management of teaching staff, as well as the impact that this relationship has on the quality of schooling outcomes. Management has an impact on the quality of outcome knowledge through competent staff - the link between teacher competency and the quality of outcome training being also positive and significant: $\beta=0.673$, $t=10.926$, $p<0.01$, but also with the teaching staff influencing the maintenance and improvement of the institution's infrastructure: $\beta=0.322$, $t=7.624$, $p<0.01$. In other words, good management influences the school having a quality teaching staff, which directly affects the quality of outcome knowledge, as does a good school infrastructure that provides students with better teaching and thus, consequently, better outcome knowledge ($\beta=0.462$, $t=7.650$, $p<0.01$). The direct influence of management on the quality of outcome knowledge is not so pronounced, but it is still statistically significant: $\beta=0.208$, $t=3.097$, $p<0.01$. In other words, the influence of management is most pronounced through teaching staff and school infrastructure: $\beta=0.470$, $t=9.177$, $p<0.01$, which is the ultimate goal of their function. When it comes to student motivation, it has a negative impact on the quality of outcome knowledge, which is very likely a consequence of the existence of an opposite connection between the quality of outcome knowledge and student motivation. However, the connection has been left in the model because it significantly affects the suitability and validity of the model. The negative impact of motivation on the quality of outcome knowledge could mean that when students are less motivated, teachers work harder and thus achieve a higher quality of outcome knowledge (Tella, 2007). On the other hand, achieving better outcomes has a positive effect on students' motivation - positive outcomes additionally motivate students (Johnson et al., 1981).

Figure 2 shows the coefficients of determination. As can be seen, the quality of outcome knowledge is explained with 55.8% of the predictor variance, i.e., the infrastructure, teacher competency, student motivation and school management share about 56% of the variance with the quality of outcome knowledge. Teacher competency was explained with 55.4% variance, school infrastructure with 55.4%, and student motivation was explained with 52% variance to the quality of outcome knowledge. This model has a significant percentage of explained variance.

Based on structural model testing, which is in accordance with the data, all initial hypotheses can be accepted with certainty, except H_7 . H_7 hypothesis, which refers to the influence of students' motivation, has also been rejected because a connection was recorded in the opposite direction from the one that was assumed.

Thus, the structural model was tested by analyzing structural equations. With their testing, it can be concluded with certainty that school management is key to the quality of students' outcome knowledge. The action of management is threefold. The influence of competent teaching staff is most pronounced, followed by the influence of a quality infrastructure, with direct influence being of the least influence. In

other words, school management is the most responsible and can achieve the greatest action. It does so by maintaining and influencing the quality of teaching staff, as well as by providing students and teachers with a quality infrastructure within which the teaching process can be performed at a high level and at that level can influence the most favourable learning outcomes. The greatest direct impact on learning outcomes is the teacher's competence.

The results obtained by the AMOS model were subjected to validation using a neural network, which was developed in the paper. The paper uses a standard multilayer perceptron (MLP) model. The network was used to confirm the importance of organizational factors that were the subject of research in this paper. The structure of the network is shown in Figure 3, while information about Neural Network Hyperparameters is shown in Table A3 in the Appendix.

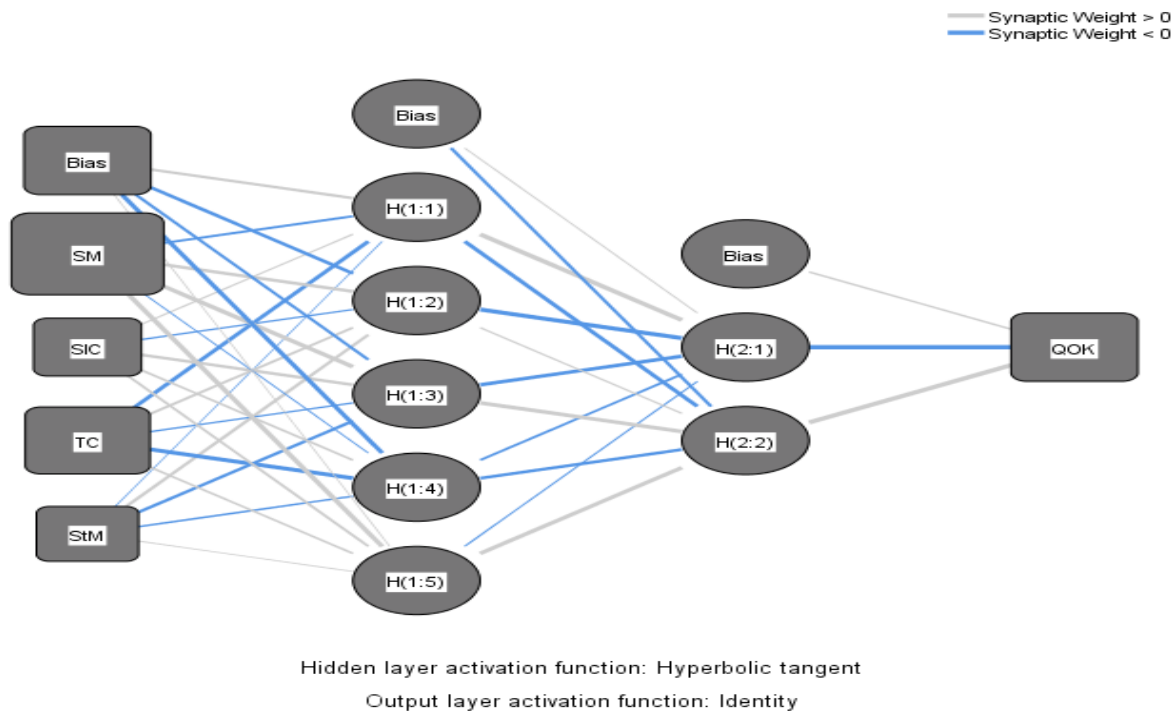


Figure 3. Neural network for testing AMOS model

For network testing, about 70% and about 30% for prediction testing. A summary of the neural network is shown in Table 3. The relatively low values of the relative errors during training and testing of the network indicate its high validity, which implies that it can be used to validate the obtained results regarding the importance of the influence of organizational factors that are the subject of analysis in the paper.

Table 3. Summary of neural network quality

Training	Sum of Squares Error	0.360
	Relative Error	0.002
	Stopping Rule Used	1 consecutive step(s) with no decrease in error ^a
	Training Time	0:00:00.02
Testing	Sum of Squares Error	0.122
	Relative Error	0.002

Note: ^aError computations are based on the testing sample.

As can be seen based on the analysis of the importance of factors (Table 4 and Figure 4), the most significant influence on school achievements is school management, followed by teacher competence, then school infrastructure and finally student motivation. These findings are consistent with the findings of the AMOS model, which implies that the obtained results can be reliably interpreted.

Table 4. Independent Variable Importance

	Importance	Normalized Importance
School management	0.631	100.0%
School infrastructural condition	0.076	12.0%
Teachers' competences	0.288	45.6%
Student motivation	0.005	0.8%

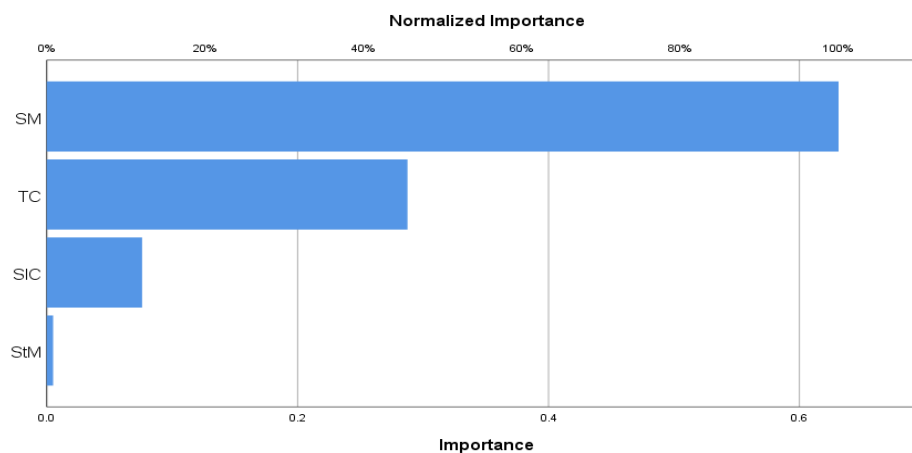


Figure 4. Independent variable importance

Discussions

By analyzing structural equations, we were primarily interested in testing a theoretical-conceptual model developed based on seven auxiliary hypotheses, which were set up to answer the main hypothesis. Results show that the influence of school management is key to the quality of students' outcome knowledge and that its performance is threefold. Through teaching staff, this impact is most pronounced, followed by a quality infrastructure of the institution, while direct impact is the least pronounced. Such a finding is logical and clear if the impact of school management on learning outcomes is looked at through the following chain: management shapes policies affecting the selection and support of teachers. Through quality infrastructure, teachers can perform better, thus directly influencing learning outcomes. The direct impact of management on student learning outcomes is less pronounced, as it is achieved indirectly through supporting teachers and creating optimal learning conditions.

The positive impact of school management on teachers' competencies can be explained through the support, resources, and atmosphere provided by the school. Effective management can establish clear goals, provide regular professional development, and offer mentorship, directly contributing to the development of teachers' competencies. Good management can also ensure a fair distribution of resources, including materials, training, and technological tools, supporting teachers in implementing innovative teaching methods. Dedication to creating a positive work environment can motivate teachers to continuously enhance their skills and contribute to the quality of instruction. Ultimately, well-led schools create an environment that fosters the professional development of teachers, enabling them to effectively impart knowledge to students.

The positive impact of school management on school infrastructure can be explained through the following arguments: Efficient Resource Allocation - effective school management contributes to the proper

allocation of resources. Through careful budget planning and management, the management can ensure sufficient funds for maintaining and improving the school's infrastructure; Strategic Planning - school management implementing long-term and strategic planning can identify priorities in infrastructure. For instance, setting clear goals and strategies can lead to improvements, such as renovating classrooms, acquiring modern equipment, or maintaining the premises; Effective Maintenance - management plays a crucial role in ensuring regular maintenance of school facilities. Continuous monitoring of infrastructure conditions and timely problem-solving can extend the lifespan of buildings and enhance their functionality; Enhanced Communication with the Local Community - well-managed schools establish effective communication with the local community. Through open communication, the management can attract additional funds, donations, or volunteer work that directly contributes to improving infrastructure; Focus on Student Needs - Management that prioritizes student needs recognizes that quality infrastructure directly impacts the learning experience. This may involve creating a stimulating environment that supports learning and development; Efficient Partnerships with External Resources - management that forms partnerships with organizations outside the school, local government, or the private sector can secure additional resources and support for infrastructure projects. These points highlight the role of management in guiding the school towards optimal resource utilization and improving infrastructure, directly contributing to the overall educational environment.

The finding that teacher competencies have the strongest direct positive influence on the quality of primary education learning outcomes can be explained by the fact that teachers with strong competencies create a stimulating environment, tailor instruction to various learning styles, and provide support for individual student needs. Namely, The ability to tailor instruction to different students and learning styles enables a personalized approach, directly supporting learning. Secondly, teachers' expertise in effectively delivering content, motivating students, and managing classroom dynamics is crucial for creating a stimulating environment. Teachers with strong competencies can recognize individual student needs and provide appropriate support. Additionally, teachers' competencies in employing diverse teaching methods and integrating technology contribute to dynamic instruction, often encouraging student engagement and deeper understanding of the material. This expertise directly contributes to enhancing the quality of teaching, leading to improved learning outcomes. this finding indicates that more attention must be paid to the training of teachers, but also to the selection of personnel during employment in education. These findings are in line with the results of research by Hattie (2003; 2012), which proved the influence and importance of teachers on student achievement. Hattie (2003; 2012) clearly show that the role of the teacher has a significant impact on student achievement. Studies show that the quality of teaching directly affects student success, which confirms the importance of professional development of teachers and their engagement in the classroom.

The finding that quality infrastructure has a positive effect on the quality of primary education learning outcomes can be explained by the fact that quality infrastructure provides an optimal environment for education. Well-equipped classrooms, laboratories, and access to technology facilitate a more effective learning process because support diverse teaching methods and create an inspiring atmosphere, all contributing to the improvement of students' academic achievements.

The finding that learning outcomes can positively impact student motivation has significant implications for school managers and education policymakers. School managers should recognize the importance of achieving measurable and positive learning outcomes as it can enhance student motivation, contributing to a better school environment in the long run. Managing resources, supporting teachers, and promoting innovative teaching methods can further facilitate the attainment of successful learning outcomes. Education policymakers should consider implementing strategies that encourage diverse teaching methods and provide support for teachers. Additionally, they need to support policies promoting measurable standards and the evaluations of learning outcomes. On the other side, the finding that motivation has a negative impact is surprising. The negative impact of motivation on learning outcomes can stem from various factors. For instance, insufficient or inadequate motivation may lead to a lack of student engagement and reduced attention during lessons, affecting the absorption of material. Additionally, a lack of motivation can result in inadequate effort in learning and completing school tasks, directly impacting the achievement of successful outcomes. However, the finding is a signal to school managers and education policymakers that they must recognize the need for approaches that encourage and sustain student motivation, while also considering factors that may contribute to its absence. Proper support for teachers,

including teaching methods, and the development of programs focusing on motivation can help overcome these challenges.

Conclusions

Based on the above, we can conclude that school management is key to the school's achievements, which is expressed in this paper through the quality of students' outcome knowledge since we are talking about schools as non-profit institutions whose basis and purpose is education. The action of management is threefold, it is most pronounced through teaching staff, followed by the influence of the quality of the institution's infrastructure, with the weakest being direct influence. In this manner, we see that school management is extremely important and that the greatest action can be achieved by maintaining and influencing the quality of teaching staff, as well as by providing students and teachers with a quality infrastructure so that the teaching process is realized at a high level and so that it can, in turn, influence better learning outcomes. Quality teaching staff affects the quality of learning outcomes directly, which is important, especially for those schools that do not have enough financial resources to invest in either the modernization of teaching or the institution itself.

The results obtained in this manner allow decision-makers to influence, in the future, those organizational factors which are ranked as the most important, about the goal which they want to achieve, and which will make the greatest contribution under the given conditions. School management influences the selection, and the building of teachers' competencies, while the given competence can indirectly affect the overall success of students through the establishment of an adequate school infrastructure, which affects the quality of outcome knowledge and therefore the overall success of students.

It remains for future researchers to examine whether and to what extent the differences in the socio-demographic characteristics of teachers and students by region affect the intensity of the influence of organizational factors on the school's achievement, expressed in the category of quality of outcomes knowledge.

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Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, R. N. and P. V.; methodology, O. S.; software, R. N.; formal analysis, G. R. N. and P. V.; writing—original draft preparation, R. N and O. S. All authors have read and agreed to the published version of the manuscript.

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Appendix

Table A1. Results of Principal factor analysis (factor loading)

Variable	Item	Factor loading			
		SM	SIC	TC	SM
SCHOOL MANAGEMENT (SM)	The school principal develops fair relations with the school staff	0.755			
	The school principal respects suggestions from the pedagogical and psychological school service	0.788			
	The school principal respects parent suggestions	0.891			
	The school principal respects suggestions made by the student parliament	0.774			
	The school principal provides continuous training for school employees	0.752			
	The school principal provides good conditions for teaching at school	0.872			
	The school principal provides pleasant conditions for staying at the school	0.783			
SCHOOL INFRASTRUCTURAL CONDI- TION (SIC)	The classrooms are pleasant for school teaching		0.775		
	The gym and other fields are a good place for students' physical activities		0.714		
	Computer cabinets are equipped with modern equipment		0.696		
	The safety of students at school is accompanied by the presence of persons professionally trained for this activity		0.783		
	Hallways, restrooms and other school areas are modernly equipped		0.709		
	The school yard is landscaped and safe for children		0.716		
	The students' achievements have been prominently displayed within the school		0.752		
TEACHERS' COMPETENCES (TC)	Teachers are adequately educated to teach			0.827	
	Teachers have developed communication skills			0.901	
	Teachers adequately transfer knowledge to students			0.772	
	Teachers use an interactive approach in teaching			0.763	
	Teachers continuously monitor achievements in their profession and apply them to teaching			0.754	
	Teachers' competencies affect the quality of knowledge with which students will be able to enroll in their desired school at the end of their schooling			0.811	
	Teachers only profess to agree with the introduction of innovations while in practice they do not advocate their implementation due to the uncertainties that they carry with them			0.729	
STUDENT MOTIVATION (SM)	Students strive to achieve the desired result throughout the year				0.729
	Students perceive innovations in work as a challenge				0.744
	Each teacher can motivate students				0.801
	Clear, understandable explication, explanation and presentation motivates a student for a quality of outcome knowledge				0.762
	The diversity of didactic-methodological possibilities, on the basis of which an appropriate choice can be made (depending on the specific situation), affects motivation				0.713
	Encouraging students to notice the value of what they are learning, i.e., make them want to learn and use the abilities they have, is the principle according to which teachers stimulate motivation				0.717
	Teachers' interest, participation and enthusiasm for what they are teaching motivates students				0.738

Table A2. *The results of ANOVA*

Groups	Count	Between Groups		
Principal	21	F	P-value	F crit
Teacher	439			
Schoool mangament		2.939	0.087	3.862
Teachers' competences		0.989	0.321	3.862
School infrastructural condition		0.258	0.612	3.862
Student Motivation		3.114	0.078	3.862

Table A3. *Information about Neural Network Hyperparameters*

Learning Algorithm	Back-propagation
Optimizer	Adam
Learning Rate	0.1
Loss	Sum Squared Error
Epochs	500
Hidden Layer(s) Activation Function	Hyperbolic tangent
Output Layer Activation Function	Identity

Application of Multirepresentation-Based Creative Problem-Solving Learning Models to Improve Critical and Creative Thinking Skills for Students

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Abstract: The 21st-century competencies students need to have include creative thinking skills, critical thinking skills, literacy, and numeracy. These competencies can be developed in the learning process in class explicitly. This research aims to analyze the effectiveness of the Multirepresentation Based Creative Problem-Solving (MBCPS) learning model in improving students' critical and creative thinking skills. The MBCPS Model Syntax consists of four stages: 1) problem identification, 2) finding ideas, 3) evaluating ideas with multiple representations (verbal, visual, and mathematical), and 4) validating solutions. The MBCPS model was applied to the experimental group and the Problem-Solving (PS) learning model in the comparison group on four study programs, natural science education, culinary education, public health science, and nutrition science with material on the science of nutrition. The difference between before and after learning was tested by Mann-Whitney, and N-gain tested the effectiveness. The results showed that before learning, there was no difference in critical and creative thinking skills, with a p-value > 0.05 between the experimental group and the comparison group. After learning, there was a very significant difference ($p < 0.05$). Learning the MBCPS model can improve critical thinking skills with an N-gain of 0.72 (high category) and creative thinking skills with an N-gain of 0.67 (medium category). The MBCPS learning model can be implemented on a broader scale according to the characteristics of complex course material to develop models in the field of education.

Keywords: creative problem-solving; multirepresentation; critical thinking, creative thinking; nutrition.

Introduction

Indicators of student quality include nutritional status in the form of malnutrition, namely, underweight, overweight, and obese. status of students in various countries, such as in Madrid is underweight 5%, overweight 16%, and obese 4% (Castelao-Naval et al., 2019), Cameroon medical students are underweight 4.9%, overweight 21.6%, and obesity 3.0%) (Bede et al., 2020). In Indonesia, the 2018 data is not much different; the percentage of young women aged 12-18 years who are stunted is 35.5%, consisting of very short 7.9% and short 27.6% (Kementerian Kesehatan RI, 2018). The findings on students. of the UNNES Faculty of Engineering underweight and overweight were 23.5% and 9.2% respectively (Fathonah, 2018).

In the following two years, malnutrition was 21.9%, and excess nutrition and obesity were 22.0% (Fathonah et al., 2020). The cause of malnutrition is poor diet (Lai et al., 2021; Smith, Disler, and Watson, 2020). Habits that many students from various studies related to eating patterns include not having breakfast (Bede et al., 2020; Chen et al., 2014; Mameli et al., 2014; Ministry of Health Indonesia, 2014; Mullan, 2014), fatty sausages/meat, industrial cakes, lean meat, and fish are consumed excessively (Castelao-Naval et al., 2019), low consumption of fruit, vegetables, and milk, high consumption of sweets, fried foods, and alcohol (Bede et al., 2020), consumes a lot of food fast food (Smith, Disler, and Watson, 2020), fluctuating eating patterns (Smith, Disler, and Watson, 2020), eating out habits (Lee et al., 2020), not under the body's nutritional needs (Castelao-Naval et al., 2019; Hashimoto, Inoue, and Kuwano, 2020; Partida et al., 2018), and poor nutritional quality (Schroder, Fito, and Covas, 2007). Most students

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from the faculties of medicine and nutrition in Mediterranean countries need to improve their knowledge about healthy eating habits (Antonopoulou et al., 2020).

Poor dietary conditions, poor literacy, and health literacy will have a negative impact on health, so awareness is needed and must be corrected (Henrique et al., 2019; Kalkan, 2019; Parekh et al., 2018). The Food and Agriculture Organization (FAO) wants everyone to have access to a diet that is adequate, diverse, healthy and safe (WHO, 2018). Various studies have been conducted to determine the importance of nutrition education. The active and healthy nutrition group scored higher on academic achievement test scores with reading, math, and science standards (Asigbee, Whitney, and Peterson, 2018). The highest average score for nutritional knowledge was obtained by respondents with a standard body mass index (BMI) (Całyniuk et al., 2019). Nutrition education is needed to support future doctors in the 21st century (Crowley, Ball, Hiddink, 2019). Nutrition improvement programs reduce the frequency and likelihood of illness and improve students' health status (Liang et al., 2022).

Based on several studies, the substance of nutrition is reported to constantly be developing (Sizer et al., 2020), both vertically and horizontally into the future (Hardinsyah, 2017). The nutritional problem is complex and characterized by many components, interrelationships, feedback, and dynamics (Schneider et al., 2011). In this study, the nutritional material is limited to balanced nutrition. Balanced nutrition is a nutritional guideline in Indonesia to maintain average body weight and prevent nutritional problems (Ministry of Health Indonesia, 2014). One that influences nutrition education is the learning process following the characteristics of nutritional problems and alternative solutions in learning nutrition and health with the Creative Problem-solving (CPS) learning model. According to Nazzal, the CPS learning model has four stages: problem identification, generating ideas, evaluating ideas, and validating solutions. Creative Problem-solving is a collective creative effort used by groups to solve problems (Kim, Choe, and Kaufman, 2019) and seek more original and more solutions (Hooijdonk et al., 2020). Well-executed Creative Problem-solving will encourage the development of higher-order thinking (Skeriene et al., 2020). For the learning process to be more meaningful, to have a deeper understanding of concepts, and to improve students' creative and critical thinking skills, an expansion of answers was carried out in evaluating ideas. The answers are not only verbal but added non-verbally, namely visually and mathematically. Answers with multiple representations are multi-representations (Angell, Guttersrud, and Henriksen, 2007). The combination of CPS learning with multi-representation is called the Multirepresentation-Based Creative Problem-solving (MBCPS) learning model (Fathonah et al., 2022). The MBCPS model that has been tested is expected to add to the innovative teaching model in the education sector, especially in the fields of nutrition. Improving the quality of learning can be done by implementing innovative learning models (Novkovic Cvetkovic and Stanojevic, 2017).

The results of the literature study show that nutrition and its problems are related to various fields of natural science or science nutrition, brain development, and cognitive function involving chemical reactions and human biological systems. Proper nutrition is essential for normal brain and neurocognitive development. Failure to optimize neurodevelopment early on can have profound long-term implications for mental health and quality of life (Kadosh et al., 2021). For normal neurocognitive development and to prevent its decline, adequate nutrition is needed throughout life (García et al., 2018; Kadosh et al., 2021), and reasonable stimulus efforts are needed (Muin et al., 2020). Nutrients are related to various chemical reactions in the field of food processing and their impact on health, including fats that are easily oxidized in various ways, such as thermal oxidation and air oxidation (Barden and Decker, 2016). Oxidized fats decrease the nutrition, taste, texture, and appearance of food, reduce food quality, shorten shelf life, and cause enormous economic losses (Barden and Decker, 2016). Consumption of fried foods is higher in people with coronary heart disease and acute myocardial infarction (Jin, G. U. O. et al., 2013). The research objectives were to analyze the effectiveness of Multirepresentation-Based Creative Problem-Solving Learning Balanced Nutrition to improve critical and creative thinking skills.

Materials and Methods

Research using research and development (R & D) methods are carried out to develop or validate educational and learning products (Stigler et al., 2020). The product developed is a multi-representation-based CPS learning model that includes RPS, Student Worksheets (SW), and data collection instruments equipped with Nutrition and Health textbooks. The research used the instructional design of the Analyze,

Design, Develop, Implement, and Evaluate (ADDIE) (Branch, 2009).

The program implementation phase is applied to the nutrition learning process with the experimental group (MBCPS) and the control. The learning model in the control group is the Problem-solving (PS) learning model. The learning activities observed are in line with the CPS syntax as reported by Nazzal and Kaufman (2020) which includes (1) problem identification, (2) idea generation, (3) idea evaluation, and (4) solution validation. In the evaluation stage, ideas are expressed in three representations of answers. The three representations of the answer are verbally, visually, and mathematically. Table 1 lists the syntax modifications of the MBCPS learning model previously reported by Nazzal and Kaufman (2020). The activities of students and lecturers as data sources at each stage of syntax are displayed. The experimental activity began with the lecturer's explanation of the objectives of MBCPS research and learning. The activities carried out by students in each pillar of balanced nutrition are 1) studying the material of each pillar of balanced nutrition, 2) studying problems according to the pillars, 3) working on MBCPS questions in groups with stages of problem identification, idea generation, idea evaluation with multirepresentation, and 4) solution validation, 5) listening to material explanations, 6) presenting the results of problems in class, 7) problem solving class discussions with MBCPS, and 8) the establishment of problem solutions. The activities carried out by lecturers are 1) explain each pillar with videos created with the Zoom app, with various examples of solving problems with the MBCPS model, 2) accompanying and guiding students both working individually and in groups, 3) observing discussion and presentation activities and 4) evaluating the results of solving problems with MBCPS and providing feedback. The support system for the application of the balanced nutrition MBCPS learning model is 1) learning tools in the form of Semester Learning Plans and Student Activity Sheets, and 2) learning media in the form of 5 learning videos, for the first video in the form of a learning model, and containing 4 videos containing 4 pillars of balanced nutrition; 3) MBCPS model balanced nutrition textbook entitled "Literasi Gizi Seimbang dalam Pembelajaran Sains" with ISBN 978-623-02-3790-4 (Fathonah et al., 2022), 4) Research instruments include creative thinking skills and critical thinking skills, and 5) Other learning resources related to balanced nutrition material in the form of e-books, textbooks, and national and international journals. One example of the problem of CPSBM balanced nutrition on food diversity, presented in Appendix 1.

Table 1. *Multirepresentation Based Creative Problem Solving Learning Syntax on Four Learning Phases*

Four phases model CPSBM	Learning Activity Indicators
Problem identification	1) Looking at the concept of balanced nutrition that is difficult to understand, 2) Read carefully the problematic concept of balanced nutrition
Idea generation	1) Discovery of various kinds of ideas / alternative solutions according to theory, 2) Find a variety of appropriate balanced nutrition problem-solving techniques;
Idea evaluation	1) Determine the design of a specific and best <u>solution</u> 2) Present solutions with multirepresentation (verbal, visual, and mathematical) correctly
Solution validation	1) Implement the design of the best solution, 2) Compare solution design against standard values or sources (if present in the literature) 3) Re-examine the best solutions based on the right concepts

Sources: Nazzal and Kaufman (2020)

The research was conducted in four study programs, natural science education, culinary education, public health science and nutrition science, with 114 students as the experimental group and 113 students as the control group. Activities are divided into independent, structured, and face-to-face activities on campus. Independent activities are carried out at home for 120 minutes, structured activities in groups for 120 minutes, and face-to-face activities on campus for 100 minutes. Independent activities in MBCPS or PS are activities to work on student worksheets (SW) individually. Activities consist of studying the material

for each pillar, compiling problems, and solving problems according to the MBCPS and PS stages.

The results of independent activities are individual SW on each pillar of balanced nutrition. The individual student activity sheets are discussed in groups as a structured activity. The result of this activity is an SW, which will be discussed in class.

Face-to-face activities on campus are carried out jointly between students and lecturers offline. Student activities include listening to lecturers' explanations, presenting tasks of solving problems with MBCPS and discussing and improving according to input from other students and lecturers. Lecturer activities present material, observe presentation and discussion activities, evaluate and provide feedback.

Critical Thinking Skills is measured using a multiple-choice test instrument with reasons for the concept of balanced nutrition, according to the stages of the thinking process to solve problems correctly. The components of critical thinking studied include the skills to argue, the skills to make inferences (think deduction and induction), and the skills to evaluate, and make the best solution (Sani, 2018). Scoring is based on critical thinking steps using a scale of 1 - 4. Each component is composed of 5 questions, so that the maximum score for each component is equal to 20.

Creative thinking skills are measured by the Torrance Test of Creative Thinking (Kashani-Vahid et al., 2017). There are four indicators of TTCT, namely fluency, originality, flexibility, and elaboration, with four criteria. The indicator is associated with the MBCPS syntax. Each indicator is assessed with a score between 1 - 4. The creative thinking skills are assessed from the Student Worksheet instrument (4 problems), which is worked on individually and continued in groups and classes. Three assessors carried out the assessment.

The instruments used in the research have been subjected to content validation, construct validation, and reliability. Instruments that have been standardized are not tested for validity and reliability. Content validity was tested by Aiken's V (Aiken, 1985). The results of the content validity test showed that the AikensV value was above the acceptance limit > 0.80 , which meant that the instrument was declared valid and feasible to use. Instrument reliability test with two odd and even questions tested for correlation with person correlation. The results of the instrument reliable test and correlations obtained are very high. Construct validity was tested by testing the personal correlation between each component and the variables (Bonamente, 2017). The test results show that the r value is above 0.5 and the p value > 0.05 , meaning that all components are valid. Data analysis techniques to determine the effectiveness of MBCPS learning use N-gain ($<g>$) (Fadaei, 2019). The data normality test obtained abnormal results, so the analysis used was Mann-Whitney (Kirch, 2008).

Results

Students have the skills to think critically at the same level in the PS and MBCPS groups at the beginning of learning and are not significantly different ($p > 0.05$). Table 2 shows that MBCPS and PS learning can improve all indicators of critical thinking skills, as shown by the scores achieved. The increase in the average score in the MBCPS group was 15 points, while the PS group increased by 6.7. The Mann-Whitney yields $p = 0.000$, which is very significantly different. The results are the same as those on all indicators of critical thinking skills.

Table 2. Results of Assessment and Test of Differences in Critical Thinking Skills

Critical thinking skills Indicator	Before learning		<i>p</i>	After learning		<i>p</i>
	PS groups	MBCPS groups		PS groups	MBCPS groups	
Analytical skills	16.4	16.5	0.399*	18.3	19.6	0.000**
Inference skills	14.8	15.1	0.109*	16.3	19.0	0.000**
Evaluation skills	14.2	14.3	0.115*	15.7	18.4	0.000**
Decision making skills	13.4	13.4	0.974*	15.1	17.3	0.000**
Critical thinking skills	58.7	59.2	0.082*	65.4	74.2	0.000**

Note: * there was no difference between the PS group and the MBCPS group

** there was a difference between the PS group and the MBCPS group

The increase in students' critical thinking skills occurred in both the PS group and the MBCPS group. However, the increase was higher in the MBCPS group. This is shown from the N-gain value of critical thinking skills in the MBCPS group 0.72 (high category) and the PS group 0.31 (medium category), presented in Figure 1. The research results obtained showed that critical thinking skills increased significantly and were strongly supported by the implementation of MBCPS with stages that were carried out effectively. Students experience a more manageable way when using multiple representation forms in understanding the concept of balanced nutrition. The decision-making procedure is preceded by critical and creative thinking, followed by an assessment thinking step by considering the best method and/or criteria and determining the decision taken by the student. In the two PS and MBCPS groups, the increase in decision-making skills was the lowest with the low and medium N-gain category.

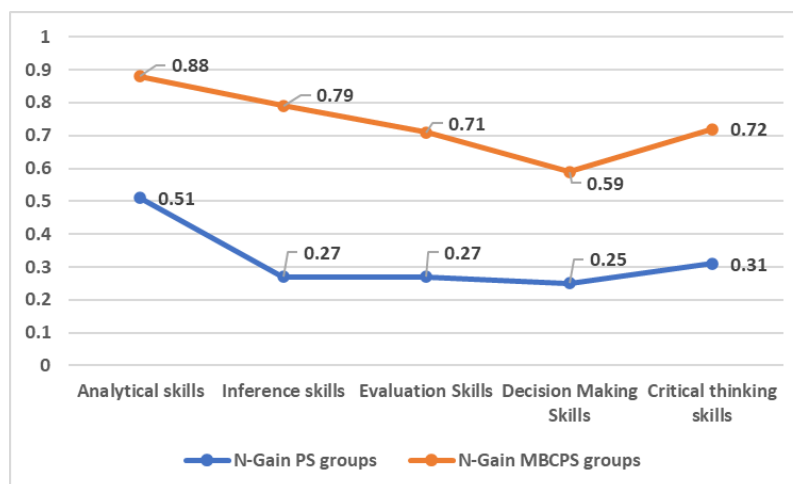


Figure 1. Effectiveness Test of Critical Thinking Skills in PS and MBCPS Groups

A different test was carried out on students' creative thinking abilities at the beginning, before, and after learning to find out the effectiveness of learning. For all indicators of creative thinking skills, the mean was obtained between the PS group with a score of 11.3 - 14.6 and the MBCPS group, slightly higher with a score between 11.6 -14.1, in full, as seen in Table 3. The results of the different tests showed no difference in all indicators with a *p*-value > 0.05, both in the PS and MBCPS groups. In contrast, after learning, the results showed a significant difference between the PS and MBCPS groups with a *p* < 0.000. These results show that MBCPS learning can effectively be used as a balanced nutrition learning model. The difference was that balanced nutrition problems were self-made individually, and the control group was given a problem-solving learning model.

Table 3. Results of the Assessment and Test of Differences in Creative Thinking Skill

Creative thinking skill Indicator	Before learning		p	After learning		p
	PS Group	MBCPS group		PS group	MBCPS group	
Fluency	14.6	14.1	0.099*	24.5	30.1	0.000**
Originality	12.3	12.2	0.170*	20.7	27.6	0.000**
Flexibility	11.3	11.6	0.759*	17.9	24.4	0.000**
Elaboration	11.7	12.0	0.249*	15.4	20.2	0.000**
Creative thinking skill	50.0	50.0	0.618*	78.5	102.3	0.000**

Note: * there was no difference between the PS group and the MBCPS group

** there was a difference between the PS group and the MBCPS group

The creative thinking skills, including all the indicators for the PS and MBCPS groups, did not differ before the learning model treatment but significantly differed afterward. This shows that the two groups experienced increased creative thinking skills. However, its effectiveness in the MBCPS group was higher than in the PS group. Overall, N-gain after MBCPS learning can increase creative thinking abilities in the medium category (0.67). The N-gain indicators of fluency and originality in the high category are 0.90 and 0.78 respectively (Figure 2). Meanwhile, N-gain in the flexibility and elaboration indicators is in the medium category. Effectiveness with PS learning is lower than MBCPS, with indicators of fluency, originality, and flexibility in the medium category, with N-gain between 0.31 - 0.56, and even elaboration in the low category.

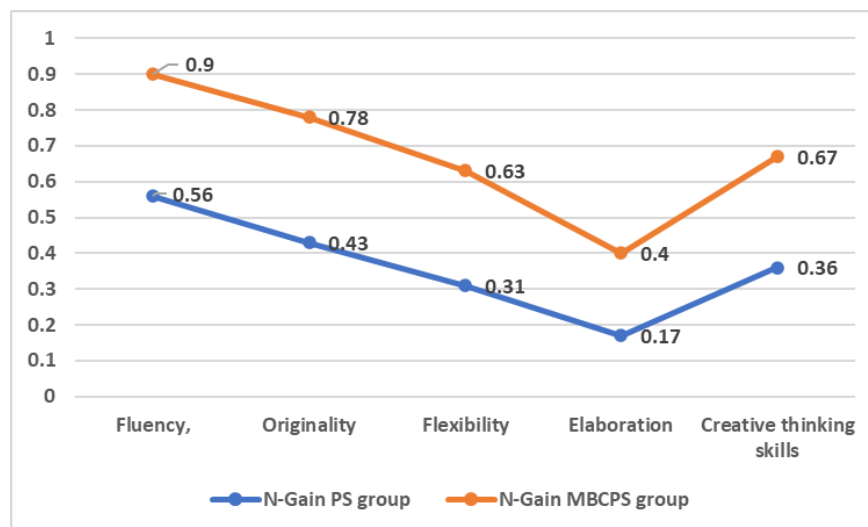


Figure 2. Effectiveness Test of the Creative Thinking Skill of the PS and MBCPS Groups

Discussions

The creative thinking skills, including all the indicators for the PS and MBCPS groups, did not differ before the learning model treatment but significantly differed afterward. This shows that the two groups experienced increased critical thinking skills (Table 2) and creative thinking skills (Table 3). However, its effectiveness in the MBCPS group was higher than in the PS group. The N-gain value was more significant in the MBCPS group. The MBCPS group was trained to look for different alternative answers (at least three answers), so they had to read a lot and understand various learning resources. It trains fluency in generating lots of ideas and originality in finding solutions to problems that are relevant and original. Students make inferences by developing ideas relevant to the problem and evaluate by assessing solid arguments and evidence in determining solutions. However, to get an alternative answer takes time. The

time spent searching for additional information, the amount of information viewed, and the extent of the information search mediated the relationship between problem construction engagement and creativity across categories. Furthermore, the relationship between information search efficiency and creativity depends on the involvement of problem constructs. For people involved in problem construction, the more efficient the search for information, the more creative the solutions (Harms, Reiter-Palmon, and Derrick, 2020). The increase in N-gain for the two indicators received the most significant value, with the high category. There were only two alternatives in the PS group at the solution planning stage, so the fluency and originality skills needed to be higher. Searching for a lot and variety of information trains students' inference and literacy skills to be increasingly honed. In addition, the activities of the lecturers in the learning process support this achievement. These activities include mentoring and mentoring students working individually and in groups in working on SW, evaluating the results of problem-solving, and providing feedback and input, especially in determining alternative solutions and visualizing verbal answers in pictures. This makes the skills to think continue to grow to be more perfect.

Three indicators of critical thinking skills (Figure 1), namely analytical skills, inference skills, and evaluation skills, are in the high category (N-gain > 0.70). These results show that the MBCPS model is more effective in improving students' critical thinking skills than the PS model. Students can analyze, inference, and evaluate nutritional problems well in the high category. Various previous studies have shown the same results, namely that the application of learning models can improve critical thinking skills, among other things Android-based media in Androwebic and E-Bokartumban (Isnaeni, Sujatmiko, and Pujiasih, 2021), reflective inquiry learning (Verawati et al., 2021), Problem-based interactive physics e-modules (Sujanem and Suwindra 2023), Learning Strategy "Students as Researchers" (Daryanes et al., 2023). Flipped classroom learning based on disaster map visualization (Astawa et al., 2022) and flipped Classroom-Based Project Assessment (Rapi et al., 2022) influence critical thinking skills.

Developing critical thinking skills is based on Piaget's cognitive theory when students individually explore or look for solutions to answer assigned problems. In Piaget's theory, exploring and building knowledge means understanding and internalizing knowledge within themselves. When students work in groups, which is based on Vygotsky's theory, they present individual ideas. During discussions, they are able to produce interference of ideas so that the correct theoretical formula and the best solution can be obtained (Nazzal et al., 2020). Thinking students focus on the core of the problem and think deeply so that they do not produce biased thought products or deviate from correct concepts and theories in determining solutions to problems. Apart from that, students can also think sharply about problems, and students can find solutions that are narrow enough so that they get the right solution (Kim et al., 2019).

Multirepresentation-based CPS learning has advantages in the ability to analyze and generate ideas based on the problem being studied (at the problem identification and idea generation stage). They convey the selected and best ideas as problem-launching designs based on collaborative activities and helping each other in active learning activities (Laughlin et al., 2006). The development of critical thinking is shown in determining the most appropriate solution plan and effective procedural strategy in solving problems, namely choosing the formula for the theory of balanced nutrition with the appearance of the material in a multi-representational manner (visual/pictures, mathematics, graphics) which is applied following the theory of balanced nutrition by students (solution assessment).

Students apply the principle of sharing knowledge and experience (Mayseless, Hawthorne, and Reiss, 2019; Sophonhiranraka, Suwannatthachoteb, and Ngudgratokec, 2015), and discuss developing students' thinking to be logical and reasoned (Al-Tabany, 2015). Students' critical thinking skills have been developed through solving balanced nutrition problems using convergent thinking patterns. Students' ability to make conclusions and solve problems is necessary and supports the mastery of concepts (Sani, 2019).

Students process data and information from various points of view to make the most appropriate nutritional decisions. Students also use nutritional standards from applicable national and international regulations to answer problems by complying with scientific principles (solution validation). The critical thinking skills students had developed during MBCPS learning in the experimental group were not facilitated in learning for the control group with conventional problem-solving learning. MBCPS learning involves students exchanging skills and experiences between individuals in one group (O'Neil, Chuang and Baker, 2009).

The research results obtained showed that critical thinking skills increased significantly (Table 2)

and were strongly supported by the implementation of MBCPS with stages that were carried out effectively. Students experience a more manageable way when using multiple representation forms in understanding the concept of balanced nutrition. The decision-making procedure is preceded by critical and creative thinking, followed by an assessment thinking step by considering the best method and/or criteria and determining the decision taken by the student. In the two PS and MBCPS groups, the increase in decision-making skills was the lowest with the low N-gain category. This happens because decision-making is a complex and challenging process that requires training (Ahmady and Shahbazi, 2020), emotional stability, and caution (Hough, 2020). The challenge in decision-making is determining priority criteria and using appropriate decision-making strategies. The cognitive knowledge required is scientific knowledge and scientific epistemological beliefs (Fang, Hsu, and Lin, 2019). Judgmental thinking uses arguments with information claims and/or scientific evidence. Making decisions is high-level thinking at the top level. Therefore, it requires complex, focused, deep thinking (Butterworth et al., 2013).

Several previous studies support the results of this study. Well-executed Creative Problem-solving will encourage the development of higher-order thinking (Skeriene et al., 2020). High-order thinking includes creative thinking and critical thinking skills (Sani et al., 2019; Tawil and Liliyasi, 2013), problem-solving, and decision-making (Tawil and Liliyasi 2013), and Multiple Skill Laboratory Activity Module (Malik and Ubaidillah, 2020). Besides that, the instructional design used by ADDIE supports learning effectiveness. The same research results show that training with ADDIE can improve creative skills (Shahat, Gaber, and Aldawsari, 2023). In the MBCPS and PS learning models, practice is carried out in expressing various ideas or information (convergent thinking) and deciding the best solution (divergent thinking). Divergent and convergent thinking that is carried out together during various phases of problem-solving can produce better solutions (Shettar, Vijaylakshmi, and Tewari, 2020).

The average N-gain obtained on all indicators of critical thinking skills in the MBCPS group was higher than the PS group. This shows that MBCPS learning is efficacious in improving critical thinking skills. Overall, the effectiveness of creative thinking skills in MBCPS learning increases in the high category, with an N-gain of 0.72, presented in Figure 2. In the early stages of learning, students are trained to create and solve problems on each pillar individually. Arranging problems means students create conflicts that must be resolved. This can encourage curiosity and high voluntary interest (Merrotsy, 2017). Practice making problems and solving them individually requires good initial knowledge of the concepts of balanced nutrition. Students carry out activities by reading and understanding the textbooks given. Through “deliberate practice” at each level (Deslauriers, Schelew, and Wieman, 2011), students can acquire the necessary knowledge and skills to become better problem solvers (Mahalingam and Fasella, 2017).

Making MBCPS and PM problems is done individually and continued as a group. In groups of five to seven, members can share ideas. The goals in group learning include: 1) students have positive interactions with the thoughts and feelings of their peers (Kim et al., 2019). 2) emphasizing cooperative activities and mutual assistance in learning activities (Gerace et al., 2005; Laughlin et al., 2006), 3) applying the principle of sharing knowledge and experience (Mayseless et al., 2019; Sophonhiranraka et al., 2015), 4) discussions that will help students thinking become logical (Al-Tabany, 2015), and 5) involve exchanging abilities and experiences between individuals in a group (O’Neil, et al., 2014), developing critical thinking skills (Chou, Wu, and Tsai, 2019; Kim et al., 2019; Nazzal et al., 2020).

The creative thinking skills, including all the indicators for the PS and MBCPS groups, did not differ before the learning model treatment but significantly differed afterward. This shows that the two groups experienced increased creative and critical thinking skills. However, its effectiveness in the MBCPS group was higher than in the PS group. The N-gain value was more significant in the MBCPS group. The MBCPS group was trained to look for different alternative answers (at least three answers), so they had to read a lot and understand various learning resources. It trains fluency in generating lots of ideas and originality in finding solutions to problems that are relevant and original. Students make inferences by developing ideas relevant to the problem and evaluate by assessing solid arguments and evidence in determining solutions. However, to get an alternative answer takes time. The time spent searching for additional information, the amount of information viewed, and the extent of the information search mediated the relationship between problem construction engagement and creativity across categories. Furthermore, the relationship between information search efficiency and creativity depends on the involvement of problem

constructs. For people involved in problem construction, the more efficient the search for information, the more creative the solutions (Harms, Reiter-Palmon, and Derrick, 2020). The increase in N-gain for the two indicators received the most significant value, with the high category. There were only two alternatives in the PS group at the solution planning stage, so the fluency and originality skills needed to be higher. Searching for a lot and variety of information trains students' inference and literacy skills to be increasingly honed. In addition, the activities of the lecturers in the learning process support this achievement. These activities include mentoring and mentoring students working individually and in groups in working on SW, evaluating the results of problem-solving, and providing feedback and input, especially in determining alternative solutions and visualizing verbal answers in pictures. This makes the skills to think continue to grow to be more perfect.

Related to the idea evaluation stage, students must choose and decide on the best alternative solutions with various logical considerations and correct arguments. This activity will increase student flexibility and detail. The effectiveness of the evaluation skills of students in the MBCPS group was higher because, at this stage, it was carried out in a multi-representational manner. In contrast, in the PS group, it was not. Answers are multi-represented visually (images) (Table 1) as linkages to alternative solutions that require high intellect and creativity. According to Ainsworth, Prain, and Tytler (2011), drawing activities can increase engagement to communicate, explore, and justify understanding of science. Drawing precision provides an opportunity to exchange and clarify ideas. People prefer image stimuli to written words (Sweet, 2021). Various studies related to multirepresentation have been used in various materials. Multirepresentation effectively increases understanding of scientific concepts (Carolan, Prain, and Waldrup, 2008) and solves scientific problems (Zuhri et al., 2023). Various scientific concepts, such as electric fields, chemical concepts (Ferreira and Lawrie, 2019; Olaleye, 2012); work-energy concepts (Suhandi and Wibowo, 2012), solving Newton's law problems (Rizky, Tomo, Haratua, 2014), physics cognitive skills (Widianingtyas, Siswoyo, and Bakri, 2015).

Visual answers could have been more optimal for students, with low N-gain in the PM group and moderate in the MBCPS group. This happens because drawing requires understanding and connecting material or scientific concepts (Waldrup, Prain, and Carolan, 2006), requires skill in drawing, and requires time to search for information by surfing the internet.

Studies with various learning models integrated with multi-representation can improve creative thinking skills, critical thinking skills, and learning achievement. Problem-based learning with a multi-representational approach increases learning achievement in the medium category with a gain of 0.44 (Sari et al., 2015), development of problem-based multirepresentation worksheets increases problem-solving skills reaching 85% (Maharani, Prihandono, Lesmono, 2015), inquiry learning guided by multirepresentation increases the mastery of scientific concepts (Rizal, 2014). Multi-representation-based modules improve representational abilities with an N-gain value of 0.75 in the high category (Setyandaru, Wahyuni, and Putra, 2017). Multi-representation-based Directed Activities Related to Texts (DARTS) worksheets can improve the critical thinking skills of prospective chemistry teachers (Imaduddin and Haryana, 2019). Multi-representational learning approaches and students' motivation towards physics learning outcomes (Doyan, Taufik, and Anjani, 2021).

The effectiveness of the learning model in CPCBM and PS on creative thinking skills is in the medium category, with an N-gain value between 0.4 – 0.8. This is almost the same as other studies that apply learning models. Teaching science using the Ethno-SETSaR approach scores higher scores for the creative thinking skills teachers (Winarto et al., 2022), with project-based learning (Khoiri, Ristanto and Kurniawan, 2023) and STEM-based scientific learning (Astawan et al., 2023).

Multirepresentation-based modules can improve multirepresentational abilities at high criteria with an N-gain value of 0.75 (Setyandaru et al., 2017). Several applications of the learning model did not show any difference between the experimental group and the control group. Learning with simulations and written case studies (Blakeslee, 2020), explicit textual reading between high and low levels critical thinking students (Heidari, 2020). The reasons for the N-gain that have not been maximized include 1) the time to apply the learning model is not long, 2) the implementation of research that coincides with the lecture period while students have to attend lectures and work on assignments from the courses taken, 3) The material discussed is something that new to students, so it takes time to learn and understand.

Conclusions

The Multirepresentation Based of Creative Problem-Solving learning model in balanced nutrition is creative learning carried out in groups to solve problems and find more and original solutions verbally, visually and mathematically. The implementation of the MBCPS Learning model in balanced nutrition can effectively improve creative thinking skills and critical thinking skills with N-gains of 0.67 (medium category) and 0.72 (high category). The CPSBM learning model differs significantly ($p = 0.000$) from the Problem-Solving learning model (comparison group). The implication of this research is that the CPSBM learning model is a model that can activate students and lecturers in learning, can be applied to improve higher-order thinking skills. To increase the effectiveness of learning, it is recommended to 1) increase the duration of time and frequency of CPSBM learning, by conducting group discussions outside class meeting hours, presentations are carried out effectively and efficiently, 2) expand the nutritional material taught (nutritional components, nutritional problems, nutrient metabolism) and other scientific fields that have the same characteristics.

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Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Literature review, data collection, statistical analysis, manuscript drafting, SF; Analysis of results and manuscript editing, language editing, EC, RSI, and SH. All authors read and approved the final manuscript.

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Appendix 1.

Examples of CPSBM problems in balanced nutrition on food diversity

Problem: Consumption of vegetables and fruits

Andi is a student who doesn't like to eat vegetables and fruits as his main food, so Andi has difficulty defecating. How many servings of vegetables and fruits are consumed daily? What is the function of vegetables and fruits in metabolism and how to increase the consumption of vegetables and fruits to be liked?

Identify the problem

Andi does not eat vegetables and often has difficulty defecating.

1. How many servings of vegetables and fruits should be consumed every day
2. What is the function of vegetables and fruits in the process of metabolism?
3. How to increase the consumption of vegetables and fruits to be liked?

Ide generation

Portions of vegetables and fruits consumed every day

- 1) Based on the contents of my plate, the portion of vegetables at each meal is 1/3 part vegetable, and 1/6 part fruit. If 3 main meals a day means 1 plate of vegetables and 1/2 plate of fruit / day (Ministry of Health of the Republic of Indonesia, 2014).
- 2) Consumption of vegetables and fruits for a healthy life amounts to 400 g per person per day, consisting of 250 g of vegetables and 150 g of fruit. A 250 g vegetable is equivalent to 2 1/2 servings or 2 1/2 cups of vegetables after cooking and draining. 150 g fruit is equivalent to 3 medium ambonese bananas or 1 1/2 pieces of medium papaya or 3 medium oranges) (Ministry of Health of the Republic of Indonesia, 2014).
- 3) Vegetable consumption 2 1/2 cup/day, with details: a) Dark green vegetables (broccoli, spinach, kale, mustard, watercress) 1 1/2 cup/week, red and orange vegetables (carrots, tomatoes, yellow pumpkin) 5 1/2 cups/week, c) legumes (peanuts, green beans, soybeans, lentils) 1 1/2 cup/week, d) starchy vegetables (corn, potatoes) 0 5 cups/week, other vegetables (bean sprouts, bamboo shoots, beets, asparagus, eggplant, cucumbers, letus, mushrooms, okra) 4 cups/week. Fruit consumed 2 cups/day (Sizer and Whitney, 2020)

The functions of vegetables and fruits in metabolic processes include:

- 1) Contains vitamins, minerals that act as antioxidants or antidotes to bad compounds in the body;
- 2) Contains high fiber so as to reduce the risk of difficult bowel movements (defecation / constipation) and obesity;
- 3) Maintain normal blood pressure, sugar levels and blood cholesterol.

Various ways to increase the consumption of vegetables and fruits to be liked by children

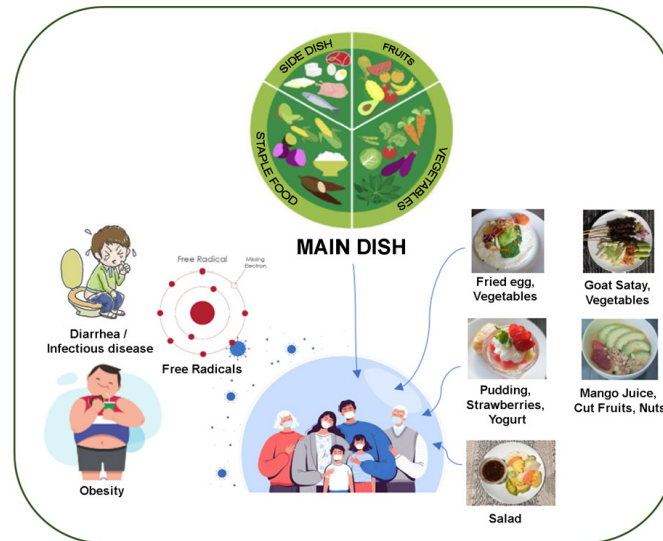
- 1) Include all types of vegetables in meals and snacks; Good fresh, frozen, and canned vegetables (choose low-fat and low-sodium types).
- 2) Store cut raw vegetables in the refrigerator, such as carrots, cucumbers, celery sticks for snacks.
- 3) Make or buy ready-to-eat salads. Choose vegetables that are dark green (broccoli, spinach), red or orange (tomatoes, pumpkin, carrots).
- 4) Try a new vegetable once every month. Read some cookbooks to get ideas.
- 5) Choosing whole or cut fruit more often than fruit juice.
- 6) Store a variety of fresh, frozen, canned low-sugar, and dried fruit to choose from as a snack or to use in cereals, yogurt, salads, or desserts.
- 7) Add toppings to snacks with various pieces of fruit (strawberries, berries, oranges).
- 8) Mix a smoothie from bananas with fruit juice or yogurt.
- 9) Add fruit juice with canned fruit.

Idea Evaluation

1) Verbal:

The portion of vegetables at each main meal is 1/3 part vegetable and 1/6 part fruit. Vegetables and fruits function as free radical protectors and prevent difficult bowel movements and obesity. How to increase vegetable consumption by including all types of vegetables in meals and snacks/snacks and making cut vegetables and fruits as snacks.

2) Visual



Source : private collection and freepik.com

Solution Validation

- 1) The contents of my plate are slogans that regulate the balanced nutrition diet of the Indonesian Ministry of Health, which is easy to understand and apply in everyday life. One-third of vegetables and one-third of fruits at each meal can meet nutritional needs, especially vitamins, minerals and fiber.
- 2) High vitamin and mineral content in vegetables and fruits can function as antioxidants. Anti-oxidants are compounds that protect other compounds from damaging reactions involving oxygen by itself reacting with oxygen (anti means “against”; oxy means “oxygen”). Oxidation is a potentially damaging effect on normal cell chemistry involving oxygen. By consuming anti-oxidants means protected from normal cell damage, increasing blood flow through the brain so as to help mental health sharper (Sizer and Whitney, 2020).
- 3) Water-insoluble fiber helps provide a feeling of fullness and helps encourage healthy bowel movements thus aiding weight loss and lowering the risk of diverticulosis, hemorrhoids, and appendicitis. Water-soluble fiber is able to bind bile and reduce the absorption of fat and cholesterol so as to promote normal blood cholesterol concentrations and reduce the risk of heart and artery disease, modulate blood glucose concentrations (reduce the risk of diabetes), bind and remove carcinogens so as to prevent colon cancer, rectal cancer and maintenance of healthy bowel function (reduce the risk of bowel disease) (Fathonah et al., 2020; Sizer and Whitney, 2020)
- 4) Mixing vegetables and fruits into meals and snacks or using vegetables and fruits as snacks will reduce or disguise the less desirable flavors and flavors and give new flavors and flavors.

Original scientific paper

UDC:

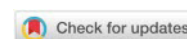
796.077.5:159.947.5(470)

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Basic Needs Satisfaction and Conscious Motives for Sports Activities of Juniors

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Abstract: Athletic motivation is actively studied in the sports psychology. The study of the juniors' motivation is crucial for exploring the reasons to quit the sport, the factors that reduce an athlete's productivity, the principles of building support programs for young athletes. The purpose of the study was to study the basic needs satisfaction and the hierarchy of young athlete conscious motives. The study involved juniors, in the amount of 133 people aged 13-16 years ($M=15.1$; $SD=1.6$; 59.4% men). The following methods were used: the essay "Why I came into sports", "Method of paired comparisons" by V.V. Skvortsov (modified by I.A. Akindinova), as well as statistical methods (descriptive statistics, W - Kendall, Chi-squared test, Kruskal-Wallis H - test). Personal, professional and status conscious motives were found out to form a complex motivation for sports activities. Conscious motives for sports activities differ among juniors in various sports. The least satisfied needs are those for acceptance needs and self-expression. The type of sport does not determine the satisfaction of the junior needs. The prospect of the study is to create a model of motivation for a young athlete. The results can be used in the activities of sports institutions.

Keywords: need, motivation, motive, conscious motives, sport, junior.

Introduction

The motivational sphere occupies a special place in sports psychology. The term motivation in sports can also be defined in a broad and narrow sense. In a broad sense, it means factors and processes that encourage people to act or non-act in various situations. In a narrower sense, the motives study involves a detailed analysis of the reasons that explain why people prefer one type of activity to another (Dautov, 2020; Kozhukhar et.al., 2020; Uvarova et.al., 2016). Leidl D. (2009) described the traditional and modern motivational constructs of sports trainers.

Djurovic D. et.al. (2020) they point out that motivation is the most important psychological factor for achieving success in sports. The authors conducted a systematic analysis of motivational theories and identified the most significant ones from the point of view of sports psychology (Djurovic D. et.al., 2020): theory of goal achievement, theory of attribution, theory of self-efficacy, theory of self-determination, theory of the value of the expected result. In this article, we will not stop at a detailed description of motivational theories, but will move on to research on the motivation of young athletes.

Motivation in sports activities is considered as an adaptation factor. At the same time, motivation is distinguished between personality and activity. Gaudreau P. and Braaten A. (2016) investigating the relationship between sports results and goals of the approach to mastery and the approach to performance, showed the relationship of these goals with the goal intended achievement. Beckman J. (2020) describes the place of the classical theory of achievement motivation in sports psychology.

Matej T. (2007) and co-authors describe a social-cognitive perspective in the motivation model of

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young athletes. [Monacis L. and co-authors \(2014\)](#) presented a trajectory model of an athlete's development using self-determined motivation as a mediating variable and sports orientation as remote determinants.

There are many classifications of sports activity motivation ([Guedes, Netto, 2013](#)). Researchers name different motives, for example, physiological, personal and social motives, training and competitive motives, direct and indirect motives, all classifications include the division into internal and external motivation of sports activity. Athletes' achievement motivation is of great importance ([Beckmann, 2020](#); [Ong, 2019](#)). In the process of playing sports, an athlete has a shift in the activity motives.

Therefore, it is legitimate to ask about the peculiarities of the athlete motivation over the stages of their sports career. Conditionally, it is possible to distinguish the stages of a professional sports career. At the stage of specialized basic training, work will be carried out to form a sustainable interest of the future athlete in professional sports. At the stage of maximum realization of one's capabilities, achievement motivation will play the most significant part, directly aimed at achieving a sports result. At the stage of maintaining achievements, achievement motivation will also be relevant, but its emphasis will be shifted towards the development and improvement of the athlete's skill level. The most relevant motivation becomes at the specialization stage as there arises a strong interest not only to going in for sport but also to its specific type, cognitive interest in technique and tactics in this sport, the desire for achievements in this type ([Dyatlova, 2013](#)). Mizuno M. and the co-authors point out that career intervention for professional athletes should be performed before the turning point of the career (transition to a career), and it is also important to monitor the processes when professional athletes independently open their careers ([Mizuno et.al., 2012](#)). [Martynova V.A. et.al. \(2022\)](#) write that the problem of motivation in sports activities is far from being resolved, and it is necessary to study motivation at specific stages of preparation. [Schmid M.J. et.al. \(2021\)](#) indicated that in order to provide psychological assistance to a young athlete, it is necessary to study the dynamics within the motivational subsystem and its predictive value. This fact determines the problem of our research, what conscious motives and basic needs young athletes have before the turning point of their careers (given by [Mizuno M., 2012](#)), whether the chosen sport determines the motivation of a young athlete, what conscious motives and basic needs modern young athletes have. The study of the above-mentioned tasks will expand the possibilities of psychological support for modern young athletes.

The relevance of the study of the junior motivation is determined by the need to understand the reasons to quit the sport, the factors that reduce the athlete productivity, the principles of building support programs for young athletes. These practical tasks determined the vector of our research interest aimed at studying the conscious motives of young athletes and the basic need satisfaction.

Materials and Methods

The survey sample consisted of students from the Rostov Regional School (College) of the Olympic Reserve. A total of 133 athletes enrolled in the 1st and 2nd courses took part in the study ($M=15.1$, $SD=1.6$; men 59.4%).

The sample includes athletes from various sports. Sports represented in the sample only by men: boxing, judo, gymnastics, shooting, football. Types of sports represented in the sample only by women: handball, rhythmic gymnastics, synchronized swimming, triathlon. Sports represented in the sample by both men and women: rowing (men 62.86%, woman 37.14%), athletics (men 37.5%, woman 62.5%), wrestling (men 83.3%, woman 16.7%), swimming (men 77.7%, woman 22.2%), cycling (men 60%, woman 40%), fencing (men 25%, woman 75%), pentathlon (men 66.6%, woman 33.3%), sailing (men 50%, woman 50%).

In the empirical study, the following methods were used: a survey, the method of paired comparisons, content analysis, scientific assessment, statistical analysis (descriptive statistics, W - Kendall, Chi-squared test to compare two empirical distributions, Chi-squared test to compare empirical and theoretical distributions, Kruskal-Wallis H - test). Computer data processing was carried out using the statistical package SPSS 20.0 (trial version). The following methodological tools were used in the study: 1) the study of conscious motives for sports activities - the essay "Why I came into sports"; 2) a study of the basic needs satisfaction - "Method of paired comparisons" by V.V. Skvortsov (modified by I.A. Akindinova).

In the essay "Why I came into sports," the respondents were given the following instruction: "Tell me what motivates you to play sports." Next, a content analysis procedure was carried out, the category "motivation (reason) for sports activity" was singled out in the texts, we take this category as the conscious

motivation of athletes. The resulting array of semantic units of content analysis (n = 376) underwent an expert evaluation procedure. 2 experts were involved. The task for the experts was to evaluate the semantic units of content analysis by status, professional and personal motives groups. The assessment was carried out on the Likert scale. Further, the expert opinion agreement degree (W - Kendall) was revealed, which showed a high degree of expert opinion agreement by status groups (W=0.199; Chi-squared test =53.564, p=0.001), professional (W=0.203; Chi-squared test =53.972, p=0.000), personal motives (W=0.219; Chi-squared test =54.672, p=0.000). The resulting semantic units of content analysis, understood by us as conscious motives for the sports activities of the respondents, were divided into three groups of status, personal and professional motives.

The following assumptions were tested: 1) the conscious motives of juniors are equally divided into categories of personal, professional and status motives, and form a complex motivation for sports activities; 2) conscious motives (personal, professional, status) can be distributed unevenly among athletes of different sports groups; 3) the junior motives, aimed at satisfying basic needs, can be distributed unequally; 4) the junior motives, aimed at meeting the basic needs, may differ among athletes of different sports groups.

Results

Conscious motives of junior sports activity

An empirical study of the conscious motives for going in for sports was carried out with the help of an essay on the topic "Why I came into sports". The content analysis of the essays made it possible to identify various conscious motives for going in for sports among the respondents. The following groups of motives (semantic units of content analysis) were identified: I want to gain high sports achievements (52.15%), I like to play sports (44.38%), I want to become an Olympic champion (36.78%), I want to have good health, a trained body (25.09%), build a sports career (21.86%), I want to become a member of the Russian national team, to defend the honor of the city / country (20.02%), I want to become a champion (15.29%), I want to meet the expectations of a coach and parents (13.58%), my family members are athletes (12%), I want to bring people pleasure, a beautiful sport (10.46%), to become a coach (6.23%), I want to be a professional athlete (6.16%), I want to play in elite sports (6.07%), I want to play in a famous team (5.63%), I want to get a gold medal (4.39%), I want to play in other countries (3.31%).

After the procedure of expert evaluation of semantic units of content analysis, the conscious motives of athletes were divided into 3 groups of personal, professional and status motives (Table 1).

Table 1. *Personal, professional and status conscious athlete motives*

Group of conscious motives	Semantic units	Frequency (in%)
Personal motives	I like to play sports, good health, a trained body, meet the expectations of parents and a coach, family members are athletes, bring people pleasure, a beautiful sport	38.1
Professional motives	achieve high sports achievements, sports career, become a coach, to be a professional athlete, to play in other countries,	30.1
Status motives	to become an Olympic champion, to become a member of a national team to become a champion, to play in an elite sport, to play in a famous team, to get a gold medal	31.8

To test assumption (1), Chi-squared test was chosen to compare empirical and theoretical distributions. It was found that the empirical and theoretical distribution of personality, professional and status motives were found not to differ (Chi-squared test =6.557; df=2; p = 0.741), that is, the frequency of occurrence of these groups of conscious motives in juniors is equiprobable.

Bearing in mind the results described above, it seems important to us to consider the correlation of the three identified groups of conscious motives in the motivational sphere of young athletes from different sports groups. To test assumption (2), Chi-squared test was chosen to compare several empirical distributions. It was found that the personal, professional and status motives of athletes from various

sports groups are different (Chi-squared test =25.787; df =15; p = 0.013) (in %): Rowing (33.78, 42.56, 23.66), Football (36.72, 27.58, 35.70), Athletics (35.29,35.29,29.41), Wrestling (39.37, 36.02, 24.61), Artistic Gymnastics (37.95,49.40,12.65), Swimming (44.14, 26.44, 29.42), Handball (36.47,36.47, 27.07), Cycling (35.29, 35.29, 29.41), Fencing (35.97, 23.98, 40.05), Judo (43.86, 43.86, 12.28), Pentathlon (39.06, 39.06, 21.88), Sailing (53.59, 10.72, 35.69), Artistic swimming (62.11, 20.70, 17.18), Shooting (66.67, 33.33, 0.00), Triathlon (0.00, 54.55, 45.45).

Junior motives aimed at meeting basic needs

To test assumption (3), Chi-squared test was chosen to compare empirical and theoretical distributions. The results of the statistical analysis showed that the junior motives, aimed at meeting basic needs, are distributed unevenly (Chi-squared test =5.087; df =3; p =0.002).

The leading motives are self-expression needs, material needs and social (interpersonal) needs are the least expressed (Table 2).

Table 2. Juniors' motives aimed at satisfying basic needs

Sports group	Material needs (average rank)	Security needs (average rank)	Social (interpersonal) needs (average rank)	Acceptance needs (average rank)	Needs for self- expression (average rank)
The whole sample	15.4	16.2	15.1	22.5	29.3
Kruskal-Wallis H - test	25.687	31.840	31.384	28.43	18.159
df	2	2	2	2	2
p	0.581	0.243	0.413	0.069	0.073

To test assumption (4), the Kruskal-Wallis H - test was used, since the methodology procedure involves ranking needs. It was found that the motives aimed at meeting the athlete basic needs from different sports groups do not differ. The above trends are fully consistent with the results in each individual sport group. The hierarchy of needs is structured as follows: 1 – needs for self-realization, 2 – needs for recognition, 3 - needs for safety, 4 – material needs, 5 – social needs.

Discussions

The conducted study of basic needs satisfaction and conscious motives of junior sports activities allows us to determine the features of the young athlete motivational sphere.

The ranking list of conscious motives for juniors' going in for sports shows that the leading component of the conscious motivation for going in for sports is meaningful, aimed at results in sports achievements, emotional and satisfaction, reflecting the highest level of reward for these achievements.

In the conscious motives expressed at the average level, there is a mixture of personal motives (health, a beautiful body; to meet the expectations of parents and a coach; family members – athletes; the desire to bring people pleasure, a beautiful sport), professional (sports career,) and status (membership in the national team, to become a champion). In general, at this level, personal motives for going in for sports dominate, while it can be distinguished as a positive motivation: health, a beautiful body, the desire to bring people pleasure; and motivational trends, which in the future can provoke certain problematic situations in the development of the young athlete personality. For example, the conscious motive "I came to play sports because my family members are athletes" can only be an external motivation, not expressing the personal choice of an athlete. The motive "to meet the expectations of the parents and the coach" is also ambiguous. In general, such motivation may long encourage a teenager to play sports with great effort. This motive is external, and, in the absence of stimulation from the coach / parents, the absence of internal motives for sports, can neutralize all previous sports achievements of a teenager.

Discussing the personal motives "health" and "beautiful body", it is interesting to study Homan K.J. and co-authors, who consider the relationship between the motivation for going in for sports and the risk of eating disorders among female athletes (Homan et.al., 2019). The authors showed that the risk of eating

disorders is not associated with a specific sport, but with the external motivation of athletes to engage in sports, with high physical/ cardiovascular stress and requirements for leanness (Homan et.al., 2019).

The ratio of status and professional conscious motives in this category shows a clear dominance of the former. Kovacs K. and Kovacs K. E. (2021) showed that a higher social status of boys and girls contributes to the internal motivation for sports, and a lower socioeconomic status contributes to external motivation and absence of motivation for sports.

Zernova T.I. (2017) points out that the formation of sports skills is more influenced by internal motivation than external. The author calls the destructive components of responsibility in the formation of sports skills passivity in the realization of responsibility, personally significant motivation, personally significant result, applying responsibility for the result to others (Zernova, 2017). Znamenskaya E.V. notes the advantages for the sports development of sports and business motives over personal and prestigious ones (Ilyinsky, 2013). Pronounced personal prestige motivation leads to inadequate self-esteem and emotional instability in competition conditions (Ilyinsky, 2013).

Caglar E. and Asci F.H. (2010) indicate that juniors with high and moderate sports motivation are focused on sports competence, physical condition and positive physical self-esteem.

Comparison of the junior conscious motives of various sport groups allows us to conclude that personal motives prevail among athletes in the groups of shooting, artistic swimming, sailing, swimming, wrestling and football. For these groups, the most crucial orientation is towards a significant adult (to meet the expectations of a coach and parents, family members are athletes), the emotional component of sports (I love sports, bring people pleasure, a beautiful sport), the physical component (health, a trained body). Gucciardi D. F. (2010), exploring the motivational sphere of junior football players, notes that a group with high mental stability prefers both skill goals and achievements, as well as external motivational trends.

Professional motives are dominated by juniors in the triathlon, artistic gymnastics and rowing groups. In these groups, the motivation to go in for sports is most associated with the professional sphere: direct professional motives (professional sports achievements, sports career, becoming a professional athlete) and indirect (becoming a coach, playing in other countries) motivation for sports activities is the most productive and will contribute to the active development of the chosen type of sports.

It is especially necessary to highlight the groups of juniors, in which personal and professional motives are equally expressed. Applicants of judo, pentathlon, handball, athletics, cycling, boxing groups. In these groups, productive professional motivation is expressed, supported by personal motives, which expresses the presence of external and internal motivation of future athletes, doubling its motivating force.

Status motives prevail among athletes in the fencing group, which shows the greatest fixation on the qualification assessment of achievements, which can be designated as the predominance of external motivation. Status motives are fully absent in the shooting group.

Features of the motivational sphere of athletes from different sports groups are actively considered by researchers (Liao, 2013; Martinent et.al., 2014; Jung et.al., 2021).

Motives aimed at satisfying basic needs are not determined by the sport. Needs for self-realization are leading in the group. This means a positive trend in the future sports career, as it indicates the need for achievements, in this case, sports, which will encourage the athlete to improve in the chosen sport. Similar results were obtained by Nurgalieva A.G. (2018).

Material and social needs are the most satisfied ones. Partial satisfaction of these need groups is explained both by the change in the social situation of the adolescent development studying in a sport's educational institution, and by the age characteristics of the respondents.

Kuzmin M.A. et.al. (2016) in the study of motivation of sports activity indicates that in cyclic sports, motivation for results, motivation of duty and awareness of the purpose of sports are most formed. In game sports, motivation for communication in sports is more pronounced, and motivation for financial reward is equally expressed in all groups.

Partially satisfied are the security needs. That is, for athletes, the need for protection from outside physical and psychological dangers and the confidence that physiological needs will be satisfied in the future are relevant.

Babushkin E. G. and Antipin V. B. (2006), in a study of the motivation of boxer athletes, describe the dynamics of actual needs: physiological needs are actualized as athletic achievements grow, and safety needs lose their relevance in the process of professional skill growth. The need for social connections,

respect and self-actualization remain significant at different stages of a professional career. These results are consistent with this study conducted in a sample of different sports groups. Babushkin E. G. and Antipin V. B. (2006) It is noted that satisfaction of the actual needs of athletes contributes to an increase in the level of sports motivation and the preservation of the contingent at the stage of initial sports specialization.

Acceptance needs are located closest to the dissatisfaction zone. In general, this is consistent with the dissatisfaction of the needs for self-realization. The development of a sports career at a professional level ensures the satisfaction of this need group, due to past sports achievements. In general, dissatisfaction with the needs for acceptance and self-realization corresponds to conscious motives. Thus, the leading conscious motives were the Olympic championship, belonging to the national team, a gold medal, which describes the juniors' ideas about the goals of sports activities and corresponds to a low level of satisfaction of the group's needs for acceptance and self-realization.

In connection with the above, the study of Sari I., who studied sports images, self-efficacy and sports motivation, is of interest (Sari, 2015). The author points out that there are no differences in these variables depending on gender and the presence of a medal. However, images of general skill and cognitive images are associated with the internal motivation of athletes (Sari, 2015).

Conclusions

The study results of basic need satisfaction and conscious motives of junior sports activities allow us to draw a number of conclusions.

1. Conscious motives of junior sports activities are equally distributed by categories: personal, professional, status, and form a complex motivation for sports activities.

2. Conscious motives differ among juniors in various sports, namely: personal motives prevail in the groups of shooting, artistic swimming, sailing, swimming, wrestling, football; professional motives prevail in the triathlon, artistic gymnastics, rowing groups; status motives prevail in the fencing group; mixed groups, where personal and professional motives are equally expressed athletes of the judo, pentathlon, handball, athletics, cycling and boxing groups are observed.

3. The motives of juniors, aimed at meeting the basic needs, are unevenly distributed, the groups of needs for acceptance and self-expression are predominant. The sports group does not determine the satisfaction of motives aimed at satisfying basic needs.

The prospects for further development of this topic are the creation of a model for the motivational profile of a young athlete, mathematical and statistical verification of this model. The study results can be used in the practical part of sports educational institutions to adjust motivational programs.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, B.A., G.S., T.Yu.; methodology, B.A., G.S., T.Yu.; formal analysis, T.Yu.; writing—original draft preparation, B.A., G.S., T.Yu.; writing—review and editing, B.A., G.S., T.Yu. All authors have read and agreed to the published version of the manuscript.

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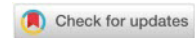
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Legal Basis of Educational Processes of Artificial Intelligence Algorithms in E-tourism

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Abstract: E-tourism has become a key component in the tourism industry and allows travelers to easily access information about destinations and services via the Internet, facilitating their travel planning process. Through e-tourism, travelers can research destinations, plan trips, book accommodations, purchase transportation tickets, and explore tourist attractions through online resources. Also, this area helps tourism businesses to effectively promote their services, communicate with clients and manage reservations. E-tourism represents the integration of information and communication technologies in the tourism sector. This concept encompasses the application of digital technologies such as the Internet, mobile applications, online reservation systems, web platforms and social media to improve aspects of travel and tourism. The legal foundation of educational procedures utilizing artificial intelligence algorithms in e-tourism holds significant importance because of the multitude of potential legal complexities and obstacles that could emerge. The Republic of Serbia, like many other countries, is working on improving its regulations in order to enable the development of e-tourism and at the same time ensure the protection of the interests and safety of travelers.

Keywords: e-tourism, internet, legal regulations, artificial intelligence, user safety.

Introduction

Tourism has a long history dating back to ancient Greece and Rome, where people traveled for a variety of reasons. During the Middle Ages, tourism was limited to pilgrimages and trade caravans. During the Renaissance, travel writers wrote travelogues that inspired travelers. The Industrial Revolution accelerated the development of tourism, enabling mass transportation. The 20th century saw the further development of tourism with the development of aviation and the automobile. Today, tourism is a global industry worth trillions of dollars and includes various forms of travel. The Internet and social media have changed the way travel is planned. Tourism continues to develop and plays a key role in the economies of many countries.

By analyzing the available literature, it can be concluded that tourism has a direct and indirect impact on the country's economy, primarily on the gross domestic product (GDP) and national income of that country.

The direct influence is reflected through the support of certain sectors of material production that serve the tourism industry, while the indirect influence implies the spillover of income from other countries into the domestic economy. Also, tourism can have a positive effect on the development of tourist activities, increasing employment and raising the standard of living of the population. The direct impacts of tourism include the impact on investment activities and the structure of investments, as well as on the accelerated development of less developed regions in the country (Trifunović, et al., 2023). Tourism is an area of the economy where technology plays a key role by helping businesses in their day-to-day operations, while improving the user experience or making the destination more desirable for potential visitors (Giotis and Papadionysiou, 2022).

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E-tourism refers to the use of modern technologies for various tourism activities, including online reservations for hotels, airline tickets and other services, as well as providing informational resources to travelers through web portals of tourist destinations. The main difference between e-tourism and traditional tourism lies in the ability of e-tourism to bring significant savings in traditional activities, such as telephone centers and information points. In other words, e-tourism enables information and reservation services to be provided to a large number of consumers at relatively low costs, resulting in more efficient processes and better access to information for travelers (Mavri and Angelis, 2009; Frechtling, 2001).

Information and communication technologies in tourism, also known as the concept of e-tourism, have started a new era in modern tourism and catering (Kirtil and Ashkun, 2021). E-tourism is defined as the use of information and communication technologies within tourism. This practice includes the widespread use of the Internet, mobile applications, social media and other digital technologies to improve the service and experience of travelers, facilitate travel planning and increase efficiency in the tourism industry.

Social networks have significantly transformed the way tourism products and services are promoted and consumed. They are one of the popular data sources used by both tourists and tourism companies to communicate, find or provide relevant information (Rahmadian, et al., 2021; Lv, et al., 2021). In the modern digital age, social networks play a key role in the field of e-tourism, which represents the integration of the Internet and electronic commerce in tourist activities.

Facebook, the pioneering social network, was the initial platform to surpass one billion registered user accounts. Presently, it boasts over 2.9 billion monthly active users. Meta Platforms, the parent company, possesses the four most prominent social media platforms, each boasting more than one billion monthly active users: Facebook (the core platform), WhatsApp, Facebook Messenger, and Instagram. In the second quarter of 2023, Facebook reported that it had over 3.8 billion monthly active users (Statista, 2023a). Figure 1 shows the most popular social networks.

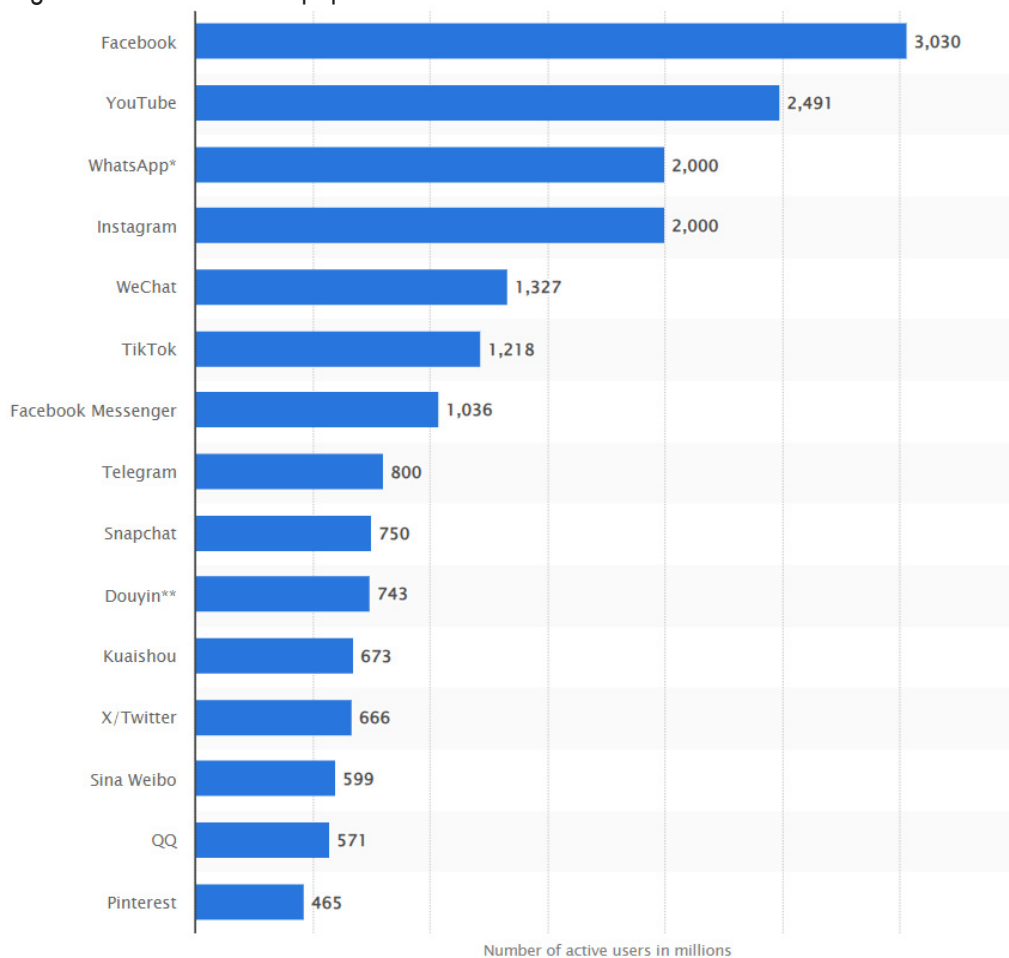


Figure 1. The most popular social networks around the world according to the number of monthly active users (expressed in millions), as of October 2023 (Statista, 2023a).

Considering everything that has been said above, the key role of legal regulation for artificial intelligence (AI) in e-tourism is reflected in providing a framework that protects the rights and interests of all participants in e-tourism, including tourists, organizations and employees. In addition, responsible behavior, ethical approach, and sustainable development in this dynamic industry are promoted through legal regulations.

E-tourism and legal regulations in the Republic of Serbia

The legal considerations surrounding educational practices incorporating AI algorithms within e-tourism are multifaceted and contingent upon the specific laws and regulations of each jurisdiction. Variations exist from one country to another, underscoring the importance for institutions and organizations integrating AI algorithms to vigilantly observe local legislation. This ongoing monitoring is crucial to guarantee legal adherence and safeguard the interests of all stakeholders involved.

E-tourism and legal regulations in the Republic of Serbia are related to the laws and regulations governing online tourism activities and the protection of consumer rights.

In this paper, we will emphasize several key points related to this topic, namely:

Protection of personal data: In alignment with the General Data Protection Regulation (GDPR) of the European Union (EU), the Republic of Serbia has implemented the Personal Data Protection Act. This act governs the collection, processing, and storage of personal data, particularly pertinent in the context of e-tourism where booking details and traveler profiles are frequently amassed. The GDPR, a cornerstone of data protection legislation, upholds the right to privacy as enshrined in the European Convention on Human Rights of 1950, affirming that “Everyone has the right to respect for his private and family life, his home and his correspondence.” This recognition of the right to privacy underscores the importance of safeguarding personal data within e-tourism practices. To modernize and uphold the right to privacy in the digital era, the EU implemented its first data protection directive in 1995. However, with the evolution of the internet, the General Data Protection Regulation (GDPR) was introduced in 2016, becoming enforceable as of May 25, 2018. This regulation establishes rigorous standards for privacy and data security, extending its reach to organizations worldwide that handle the data of EU citizens. Its implications extend to online tourism in the Republic of Serbia, encompassing the protection of travelers’ personal data. Consequently, travel agencies and online platforms are required to adhere to data protection regulations and ensure the secure processing of personal information. The GDPR stands as the most stringent privacy and data security legislation globally. Despite being formulated and adopted by the EU, it imposes obligations on organizations worldwide, provided they interact with or collect data concerning individuals within the EU. The GDPR will impose severe penalties on those who violate its privacy and security standards, with fines reaching tens of millions of euros ([The General Data Protection Regulation \(GDPR\)](#)).

Electronic business: The Republic of Serbia has legislation that regulates electronic business and electronic transactions, namely the Law on Electronic Commerce ([Law on Electronic Commerce](#)) and the Law on Electronic Invoicing of the Republic of Serbia ([Law on Electronic Invoicing](#)), which enable secure online transactions and electronic exchange of documents between tourism companies and travelers. The Law on Electronic Commerce regulates the conditions and manner of providing information society services, obligations to inform service users, commercial messages, rules regarding the conclusion of contracts in electronic form, responsibility of information society service providers, supervision and violations.

Online Payments: The Payment Services Act ([Payment Services Act](#)) covers online payments, including the security of online payments. This is crucial for e-tourism as travelers often make online payments for booking accommodation, tickets and other services.

Marketing activities: The Consumer Protection Act, also known as the Consumer Protection Act, outlines fundamental rights of consumers that underpin contemporary society, fostering protection, safety, and an enhanced quality of life for all citizens. These rights guarantee consumers access to essential necessities, safe products, comprehensive information, freedom of choice, legal recourse, education, and a sustainable environment. By upholding these rights, the Consumer Protection Act aims to empower consumers and promote fair and ethical practices in the marketplace. In the context of e-tourism, this law regulates the marketing activities of tourism companies, which ensures that marketing campaigns are truthful and do not mislead potential tourists.

Based on the above, we can say that legal regulations in the Republic of Serbia are being developed in order to adequately deal with the challenges of e-tourism. This includes privacy protection, security of online transactions and protection of passenger rights. The Republic of Serbia follows international standards in order to improve e-tourism and ensure that the tourism industry is competitive on the global market.

The impact of artificial intelligence on e-tourism

In today's world full of advanced technologies, AI stands out as one of the most innovative discoveries that have dramatically changed various industries around the world. In tourism, AI is increasingly being used for a variety of purposes, including customizing travel experiences, personalizing travel recommendations, and providing faster responses, thereby improving service interactions. By exploiting the possibilities of AI, businesses can provide personalized services, optimize operations and contribute to sustainable practices (García-Madurga and Grilló-Méndez 2023; Doborjeh et al., 2022). AI integration has become common in the business environment, where it is used for assistance and communication with users, which significantly increases the quality of engagement. A key factor for the success of AI is the abundance of data, especially rich data. The more diverse information algorithms have at their disposal, the more effectively they learn and improve their predictive abilities. This data is integrated into a global data processing network infrastructure, focused on the Internet, which serves as a platform for communication, data access and provision of various services to citizens. Algorithms, often powered by AI, play a key role in mediating citizens' access to information and services, tracking their actions (Putera et al., 2022). It is estimated that there are over 30 billion devices today, including computers, smartphones, and industrial equipment, that generate massive amounts of electronic data, as illustrated in Figure 2. In the figure, we can see statistics showing the annual size of actual data in the global datasphere from 2010 to in 2025. Real data constitutes a significant part of the global datasphere. Between 2018 and 2025, the size of actual data in the global datasphere is expected to increase tenfold, from five zettabytes to 51 zettabytes.

AI is developing rapidly and has the potential to change our lives in many ways. It can improve health care through more accurate diagnoses and better disease prevention. Furthermore, AI can bolster agricultural efficiency, aid in climate change mitigation and adaptation, and enhance production systems' efficiency via predictive maintenance. Additionally, its potential extends to enhancing the security of European citizens in ways that are yet to be fully realized. However, AI also carries with it a number of potential risks, including lack of transparency in decision-making processes, possible gender or other type of discrimination, invasion of our privacy and the possibility of misuse for criminal purposes (European Commission, 2020).

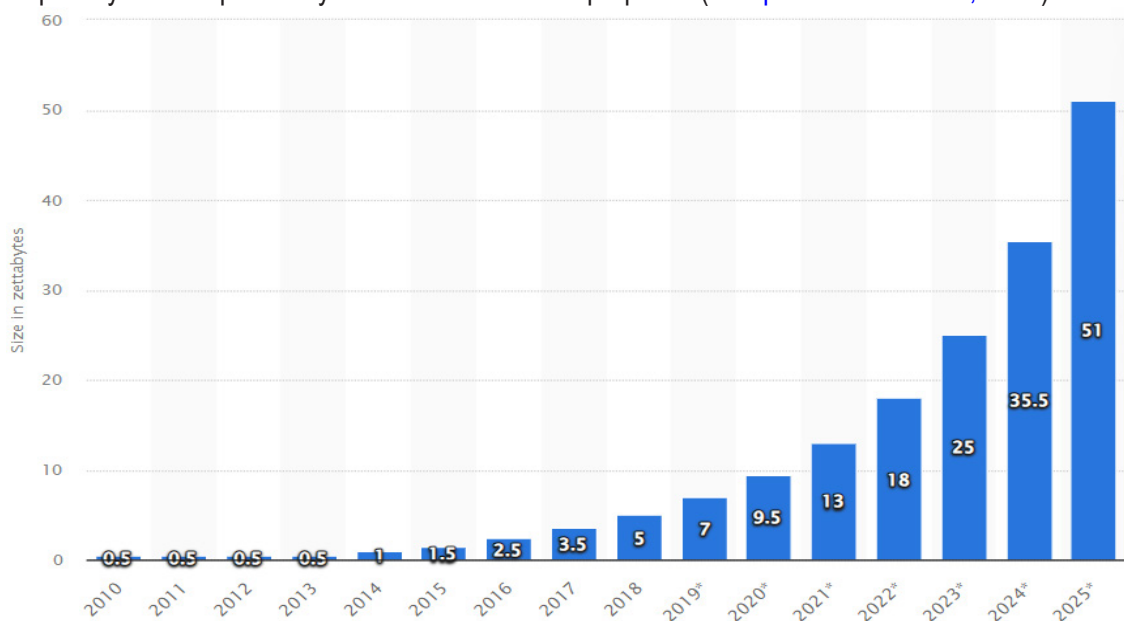


Figure 2. Annual size of real data in the global datasphere from 2010 to 2025 (expressed in zettabytes) (Statista 2023b).

In practical terms, AI finds extensive applications within the tourism and service industries. However, within academic circles, the predominant focus of existing research lies in information science, examining the AI technology itself and the associated ethical considerations. There exists a notable dearth of research that adopts an interdisciplinary and macro perspective. Primarily, scientists have delved into exploring the repercussions of AI technology on employment, as well as the individual anxiety, apprehension, and other adverse emotional responses stemming from the substitution of AI for human labor. Additionally, there are studies examining the impact of AI on various facets of tourism and services, including marketing, strategy, and retail. Nevertheless, many of these investigations tend to be speculative in nature, lacking sufficient empirical evidence. These above issues can be summarized in three key aspects:

1. Previous research has overlooked analyzing the essential characteristics of how AI technology impacts the tourism industry, failing to consider its distinctiveness.
2. Research on the mechanism of AI's influence on the tourism industry is scarce due to the evolving nature of AI, thereby complicating the comprehension of its internal mechanisms on this sector.
3. Limited research exists on the potential negative impacts of AI on the tourism industry, posing challenges in the development of pertinent policies, corporate governance, and public management strategies to address these specific challenges (Yanzheng, et al., 2021).

Skilton and Hovsepian (2018) assert that intelligent systems are increasingly becoming ingrained in every facet of our lives, suggesting that this fourth industrial revolution will precipitate cultural and social transformations of unparalleled magnitude. These technologies are challenging the values, consumer experiences and business propositions that have been the foundation of nearly every business and organization in existence. By redefining and embracing new value structures with the help of new intelligent technologies, new innovative models are created and brought to the market. Understanding the potential and impact of these changes will be a fundamental requirement for leadership in the coming years. Considering the inseparable relationship between the rise of AI technology and the swift advancement of computer technology, Skilton and Hovsepian define AI from the standpoint of computer science as “the scientific examination of computer principles underlying intelligence and intelligent behavior.”

Kelly et al. (2023) examine the interplay between AI and human intelligence, categorizing AIs into three distinct types:

1. Narrow AI, capable of substituting humans in specific tasks or domains.
2. General AI, possessing advanced perception of the external environment and the capability of autonomous learning.
3. Super AI, characterized by intelligence that surpasses human capabilities to a significant degree.

AI algorithms are having an increasing impact in e-tourism, providing numerous benefits and improving the traveler experience. Some of the areas where algorithms are used in e-tourism are: (Bulchand-Gidumal, 2020)

Accommodation search and reservation: Algorithms can analyze large amounts of data on accommodation facilities (prices, locations, guest ratings, etc.) to provide personalized recommendations to travelers. Also, they can be used to find the best offers and adjust search results to travelers' preferences.

Recommending destinations and activities: Based on travelers' profiles, algorithms can recommend destinations, attractions, restaurants, and activities that match their interests. These algorithms are often used on travel booking platforms to help travelers discover new destinations and plan their itineraries.

Personalized advertising: By analyzing data about previous trips and interests, algorithms can display targeted advertising to travelers. In this way, relevant content is provided that is related to their needs and interests.

Trend forecasting: AI algorithms can analyze large amounts of travel data to identify trends and forecast future traveler needs and preferences. This information can be useful for travel agencies and organizations to adjust their offers and services.

Sentiment Analysis: Algorithms can analyze travelers' comments and feedback to determine their satisfaction, preferences, and attitudes about specific destinations, accommodations, or activities. This sentiment analysis helps tourism organizations better understand the needs of their travelers and improve the experience they provide.

Chatbots and virtual assistants: AI algorithms can be used to develop chatbots and virtual assistants

that can answer travelers' questions, provide information about reservations, recommend activities, and more. This type of 24/7 assistance improves the user experience and reduces the need for human intervention in communicating with passengers.

Weather monitoring and forecasting: Algorithms can analyze weather data to predict weather conditions in different destinations.

AI algorithms offer numerous advantages in the realm of e-tourism. From a consumer standpoint, AI facilitates the discovery of more accurate and pertinent information, enhances mobility options, refines decision-making processes, and ultimately enriches the overall tourism experience (Gretzel, 2011; Tussyadiah and Miller, 2019).

One example is definitely the travel website "Qyer" which has developed a travel planning tool called "Itinerary Assistant". Namely, in the pre-trip preparation phase, tourists face certain challenges in making decisions. First, information about tourist destinations includes a large amount of data of various types. The decision-making process itself requires significant engagement and a high degree of analytical ability. Second, the travel planning process is dynamic, so finding optimal solutions for time, distance and price can be challenging. In order to overcome these challenges, the travel planning tool "Itinerary Assistant" can be used, where tourists enter their requirements and use this tool to intelligently optimize the trip with a simple push of a button, in order to get the most rational plan. This approach allows tourists to feel more excited and have higher expectations towards their destinations" (Yanzheng, et al., 2021). From all this, it is not difficult to see that "smart tourism" is a new field that is developing through the growing use of information communications and AI.

Globalization and intense competition force organizations to be flexible and adaptable to constant changes in the market (Chen et al., 2022). According to some research, it is estimated that around 70% of companies will implement at least one type of technology with AI by 2030, while a little less than half will have the entire spectrum of such technologies, and that the global GDP will increase by around 1.2% per year. In addition to numerous advantages, primarily in increasing the economic potential, the development of AI also brings with it certain challenges. Mainly, the focal points encompass safeguarding personal data, mitigating biases and inherited discriminatory factors, the emergence of novel occupations potentially altering existing job demands, the educational system's challenge in equipping students for future job roles, and ensuring transparency alongside addressing various ethical concerns (Strategy 2020-2025).

Ethical guidelines for the development, application and use of reliable and responsible AI aim to enable progress in the field of AI, but not at the expense of people, their rights and well-being, animals and the environment. AI has become a key component of the fourth industrial revolution and has wide applications in various fields, including healthcare, finance, education, energy and many others.

The development of AI is directed towards the creation of solutions that meet high standards throughout the entire life cycle, which means that they are reliable and responsible. This implies technical security, compliance with laws and respect for ethical principles and values.

The key goal of these guidelines is to prevent the endangerment of human rights and freedoms, as well as not to neglect the role of man in all processes that concern him. Also, the guidelines promote the creation of an ecosystem where AI contributes to improving people's productivity, more efficient use of resources and improving the quality of life. In essence, these guidelines set a framework for the development of AI to ensure that it serves people and society as a whole, while preserving fundamental values and rights (Conclusion on the adoption of ethical guidelines for the development, application and use of reliable and responsible artificial intelligence).

The ethical guidelines for the development, application and use of reliable and responsible AI are aligned with the AI development strategy in the Republic of Serbia for the period 2020-2025. One of the main goals of this strategy is to promote the ethical and safe application of AI, and they represent a step towards achieving that goal. The key purpose of the guidelines is to ensure the responsible development and use of AI, while respecting the highest ethical and security standards.

UNESCO has also played a role in promoting the ethics of AI and adopted Recommendations on the ethics of AI systems in November 2021. These principles are included in these guidelines, indicating a global trend and consensus on the need for an ethical approach to the development and use of AI.

The Republic of Serbia has committed itself to the gradual harmonization of its laws with the acquis of the EU. In this context, the European Commission presented the Proposal for a Regulation on AI to create a common legal framework for the development and use of AI in the EU. This will facilitate

investment and innovation in the field of AI and provide a standardized approach. Also, the Commissioner for Human Rights at the Council of Europe has issued Recommendations on AI and human rights that build on existing guidelines and regulations in this area. These guidelines apply to a wide range of actors in the AI ecosystem, including those who develop and deploy these systems, organizations, institutions, and the general public. The goal is to provide a horizontal approach to the application of ethical and security rules in this area.

Establishing ethical guidelines for the development, application, and utilization of trustworthy and conscientious AI constructs a legal framework aligning AI development and usage with ethical and security norms. This initiative aims to ensure that the Republic of Serbia adheres to international trends and standards in this domain, fostering responsible AI practices in accordance with global expectations.

Conclusions

In the conclusion of this paper, the key aspects highlighted in connection with e-tourism, legal regulation in the Republic of Serbia and the impact of artificial intelligence on this area are emphasized.

E-tourism has become a key component of the global travel industry, allowing travelers to more easily plan and book trips online. In the Republic of Serbia, legal regulations are continuously developing in order to follow the comprehensive changes in digital tourism and to ensure the protection of both the interests of travelers and providers of tourism services. These regulations cover a wide range of issues, including the protection of personal data, electronic commerce, online payments and marketing activities.

Artificial intelligence is increasingly influencing e-tourism, providing personalized experiences for travelers, faster responses to inquiries and optimization of travel. Artificial intelligence algorithms play an increasingly important role in the development and improvement of e-tourism. They enable the automation of processes, the analysis of huge amounts of data and the provision of personalized services to tourists. However, while artificial intelligence brings many benefits, its implementation also brings challenges, including ethical and security aspects that must be carefully considered.

Advances in the field of artificial intelligence carry potential risks, such as the protection of personal data, possible discrimination and the impact on the labor market. Therefore, it is important to establish clear ethical and security frameworks to ensure the responsible use of artificial intelligence.

E-tourism and artificial intelligence are key factors in the transformation of the tourism industry. The legal basis of educational processes of artificial intelligence algorithms in e-tourism is complex and requires careful compliance with legal regulations.

Legal regulation is actively developing to keep up with these changes and ensure the protection of the interests of all actors in the industry. The Republic of Serbia recognizes the need for harmonization with international standards and ethical principles in the application of artificial intelligence in order to preserve the integrity and competitiveness of e-tourism in the modern world.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization: Ž.S. and S.M., Formal Analysis: B.M., Investigation: Ž.S. and S.M., Methodology: Ž.S., S.M. and B.M., Writing – original draft: Ž.S. and S.M., Writing – review & editing B.M.. All authors have read and agreed to the published version of the manuscript.

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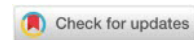
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Digital Literacy in the Service of Science and Scientific Knowledge

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Abstract: The subject of this paper is the interdependence of communication and digital literacy, as original entities, and especially digital communication and science and scientific knowledge. In the present day, digital literacy is a necessary ability for scientific professionals. The concept of digital literacy is increasingly prevalent in the 21st century. Scientific research requires the capacity to efficiently use digital tools, platforms, and databases as technology continues to improve at an unparalleled rate. The capacity to get and assess data from a variety of online sources is a crucial component of digital literacy for scientific professionals. In order to encourage cooperation and creativity across scientific groups, digital literacy is vital. Moreover, scientific professionals that possess digital literacy are better equipped to disseminate their research findings to a larger audience. The essence is that the higher the level of digital literacy, the easier it is to find suitable and therefore the best forms of communication.

Keywords: *digital literacy, scientific research, digitalization.*

Introduction

The purpose and goal of digital literacy are recognized in every aspect of our lives. Whether one is a student, a scholar, employed, or entering retirement, it is now essential to possess certain technological skills for communication with the external world and for performing administrative, creative, and educational tasks. «Digital» is no longer a separate realm entered occasionally and reserved for specific individuals. It has become fully integrated into the mass population through various means of personal device proliferation, such as smartphones, various digital devices, and tablet computers. News of the unilateral declaration of independence by the British colonies in the New World in 1776 (USA) took a month to reach Europe. The most significant news in the 19th century, the assassination of U.S. President Abraham Lincoln in April 1865, took 12 days to «travel» to Europe. «In November 1963, the U.S. President was assassinated in Dallas, Texas. He died at 1:00 PM. At that moment, 68% of Americans already knew about the news; by 2:00 PM, it was 92%, and by 6:00 PM, 98.8%. Today, thanks to the internet, media, and digital literacy in some ways, news is transmitted in «real-time.»

Paul Gilster (1997) popularized the term «digital literacy» in his book of the same name. It is the capacity to comprehend and use knowledge that is delivered through computers in a variety of formats and from a broad range of sources. Gilster first defined digital literacy as the «ability to understand and use information in multiple formats from a wide range of sources when presented through computers.» This enlarged meaning of «digital literacy» in English. Since reading with meaning and understanding is the foundational act of knowledge, the idea of literacy encompasses more than just learning how to read. Digital literacy extends the boundaries of this concept as it involves the awareness of what is seen on the computer screen using online media. Here, demands are placed that have always been present, though less visible in analog media such as newspapers and TV. Literacy is more than merely learning to read, as reading with comprehension and meaning is the fundamental act of knowledge. The idea of digital literacy

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is expanded upon as it encompasses the understanding of what is viewed on a computer screen when utilizing online media. Demands that have always existed but are less apparent in analog media like TV and newspapers are made here.

Pure diversity means that digital literacy can be considered a «framework for integrating various other literacies and skill sets» without the need for a comprehensive overarching literacy or serving as «one literacy to rule them all» (Martin, 2006; Dašić et al., 2023b). The idea and concept of «digital literacy» must be explained in terms of its relationship to various other «information literacies,» a topic explored in many works (Bawden, 2001; Bawden and Robinson, 2002; Secker, 2007; Venkatesan, 2023). Their notion is that digital literacy not only needs to find its place among information literacy, computer literacy, ICT literacy, e-literacy, network literacy, and media literacy, but it must also be paired with terms that avoid the idea of «literacy,» such as informativeness and fluidity. „It is observed that in some cases, mentioning information or anything similar is avoided, and terms like «basic skills,» «smart internet,» or «smart work» are used instead“ (Robinson et al., 2005).

The digital age has brought about significant disruptive changes in many facets of life, including how people connect to one another and learn. As such, scientists and practitioners need to be able to handle this dynamic change. (Yustika, Iswati, 2020). Competencies in operation, reasoning, teamwork, and awareness are essential for scientific professionals who are digitally literate. Operation skills are the technical know-how needed to operate technology effectively. Scientific personnel need to exhibit thinking abilities, particularly a high degree of analytical thinking, in addition to operating skills. Scientific personnel that possess critical thinking abilities are able to comprehend technology and have a favorable outlook on it. To develop work that benefits both the general public and themselves, they must also exercise creative thought. Furthermore, because digital technology makes it easier for people to collaborate and interact, scientists need to be aware of cooperation and awareness techniques. Since we are now responsible for gathering, sharing, and preserving information resources and for taking advantage of the opportunities that arise from digitising these resources, the position of an information expert has evolved to encompass the development of digital material. One study (Kaeophanuek, et al., 2018) asserts that the development of an information specialist's digital literacy requires the practice of three skills: the creation of new material, the use of digital technologies, and information management. The development of cognitive abilities, which must be included at each stage of the developmental process, is the foundation for the three skills.

Theoretical framework

In the highly technical age we live in today, digital literacy is essential for scientific professionals. It gives students the tools necessary to successfully explain their study findings in addition, giving them the ability to locate and assess trustworthy information. Furthermore, by facilitating smooth communication and utilizing cutting-edge technology, digital literacy promotes cooperation and creativity within scientific communities. In order to be at the forefront of scientific innovation, scientific personnel must constantly develop their digital literacy abilities as technology continues to evolve.

According to one study (Asrizal, et al., 2018), digital literacy must be included in teaching materials in order to enhance school literacy programs. Digital literacy encompasses basic, scientific, economic, technological, visual, informational, and intercultural literacy (Bain, Siddique., 2017; Vuković, et al. 2023). Digital literacy consists of functional, visual, scientific, technological, information cultural, and global literacy (Shafeeq, 2013). Students must employ a range of multimodal interpretation strategies in their digital literacy instruction, including foundational, scientific, technical, visual, gestural, spatial, informational, intercultural, and global awareness skills (Jing, 2016). It is thought that using integrated science resources is crucial to the educational process. Researchers were drawn to create integrated scientific teaching materials with digital literacy because of this.

Science nowadays is being shaped in large part by digital literacy. The scientific environment has changed dramatically as a result of the capacity to acquire and analyze enormous quantities of data, work with academics from around the world, and use sophisticated software and simulations. The Internet and other technologies have significantly changed many domains, including the political, social, cultural, and economic ones, as well as the ensuing behavioral patterns in today's "information and communication society." (Méndez Domínguez, 2020). Technology advancements in information and communication have altered the way literacy is taught. Lack of time, direction, and training has made the quicker shift to

practical usage of digital media difficult. Because it requires new knowledge and abilities to be utilized effectively for the intended purpose and to provide benefits, digital literacy has emerged as a cutting-edge method for gaining access to, obtaining, and managing the information that is all around us (Reddy et al., 2022b). The act of increasing awareness and providing people with specific information and abilities to enable them to grasp ICT is known as “digital literacy”.

Because digital literacy’s primary goal is to improve everyone’s quality of life, regardless of position, gender, ethnicity, religion, or origin, Bawden and Robinson (2002) claim that it is a factor in social inclusion. It suggests that one may perform “the necessary activities to ensure that information and communication technologies are accessible to and used by all individuals and communities, including the most disadvantaged.” Digital literacy is essential for adjusting to the quick and constant changes brought about by digitization, and education must alter to accommodate these new technologically enabled learning and teaching contexts (Pérez-Escoda et al., 2019).

Digital literacy is crucial for researchers and scientists in today’s world as it enables more efficient searching, analysis, and interpretation of large amounts of data. Additionally, digital literacy allows researchers to utilize advanced tools and technologies, such as data analysis software, simulations, and modeling, enhancing the speed and accuracy of research. The ability to collaborate via digital platforms is also increased, enabling researchers to share information and collaborate with colleagues worldwide. Critical thinking skills regarding digital sources are also becoming essential for the validity and integrity of research. In summary, digital literacy is key to improving efficiency, precision, and global collaboration in contemporary scientific research. Digitalization enhances people’s quality of life and education, promotes economic expansion and environmental preservation, and raises a nation’s competitiveness (Marti and Puertas, 2023). The need of expediting the digitization of all facets of socio-economic growth has intensified due to the COVID-19 pandemic’s expansion (Kolupaieva, Tiesheva, 2023).

Technology has a significant influence on society, thus it is crucial to make sure that it is created, implemented, and utilized in ways that uphold human values and advance societal well-being. Negative effects like digital divides, uneven access to technology, data breaches, job losses, cultural homogeneity, and the deterioration of democratic governance may result from failing to take the social aspect of digital transformation into account. Through tackling the social aspects of digital transformation, society can guarantee that technology is employed to advance human growth and bolster societal advancement. Stated differently, the social sustainability of digital transformation should assess how technology affects society and how society can guarantee that everyone can benefit from technology (Nosratabadi, et al., 2023).

The Interdependence of Digital Literacy and Successful Communication

The more purely social facets of community life, such as interacting with people and relating to them through digital tools inaccessible to those who are not proficient in their use, naturally come to mind when discussing the subject of digital literacy (Vitković, 2023; Campanozzi, et al., 2023). The capacity to locate, assess, use, exchange, and develop ideas responsibly and ethically utilizing Information Communication Technology (ICT) tools and technologies in conjunction with the Internet is essential in this period of exponential technological prominence and acceptance. Digital literacy refers to this new human quality. To survive and prosper in today’s digital world, digital literacy is a necessary component of everyone’s personal and professional lives. The responsibility for promoting digital literacy globally rests with higher education institutions. The institutions are essential in helping the younger generation become digitally literate so they can successfully contribute to the advancement and development of the person, society, and country (Reddy, et al., 2022).

The concept of «digital literacy» must largely include some understanding of the benefits that «digital» provides. The continuous increase in the use of online media content for gathering information also challenges students and the wider population to nonlinearly organize information and integrate visual media to synthesize information, making this set of skills also referred to as digital literacy. A collection of cognitive thinking techniques employed by users of digital information is referred to as digital literacy. Other terminology, such as information and communication technology (ICT) literacy, computer literacy, internet literacy, 21st-century literacy, and online reading comprehension, are used in literature and practice. While each word has a precise meaning, they are all grouped together theoretically under the

same «umbrella» of new literacies due to shared assumptions.

The conclusion is drawn that the majority of emerging literacies, encompassing digital literacy, are grounded in four principles: first, that these literacies encompass novel skills, strategies, dispositions, and social practices necessitated by new technologies in information and communication (Ilić et al., 2022); second, that these literacies are indispensable for complete engagement in the global community; third, that these literacies evolve with shifts in defining technologies; and fourth, that they are diverse and demand comprehension of all their facets.

The literature notes that the terminology itself is very confusing, leading to questions about the place of digital literacy in relation to information literacy, computer literacy, ICT, and e-literacy, as well as network and media literacy, and the relationship to concepts such as informativeness and fluidity. There are many approaches trying to dissect these relationships, and the essence is to identify the essence of digital literacy, as well as some forms of this education, and some of the questions that could be raised in this field.

New digital media can no longer be understood as just being about «information» or «technology,» thus it's important to understand «digital literacy» in a way that goes beyond some of the present methodologies used in the field of information technology in education. Our understanding of the connection between literacy and communication is also impacted by this. Although there is consensus on many theoretical issues in the fields of contemporary communication and digital literacy, different perspectives on learning and literacy can be observed, as well as a set of priorities that arise from them.

In one study (Vlajković, 2021), it was published that graduate students were excited about sharing their research with the public, even concerned about the long-term consequences of publishing their work in an online environment. Open and collaborative information networks created by digital conversations provide new participants with much greater visibility than was ever possible in the past. Participants have a larger audience but may also be subject to greater control; much needs to be done and explored before hitting «publish.» Acquiring digital technology skills is fundamental at all educational levels as a means of enhancing students' ability to identify and use relevant modern scientific and technological knowledge for the appropriate discipline (Xiao, 2024).

Today's students communicate in digital language and process information very differently from previous generations. Professors belong to the generation of digital immigrants, while students are digital natives; they simply speak different languages (Rizal, et al., 2019). Today's professors must make an effort to communicate in the language of their students. Everything is essentially a presentation, and besides changes in methodology, instructors need to keep in mind that the brain of today's generation has also changed. Digital natives think differently because they grow up with computers and other digital technologies that practically train them to think multidimensionally, to overlap their thoughts, to perform tasks in parallel rather than sequentially, one by one. If their attention in class drops, it is not because they are uninterested or unfocused, but because the presentation of material in such a way is not acceptable to them (Šmakić, 2012).

The capacity to locate, assess, produce, and share information requiring cognitive abilities via the use of information and communication technologies is known as digital literacy. In order to find and choose pertinent information, assess critically, be creative, work with others, communicate effectively, and still pay attention to aspects of electronic security and the sociocultural context that is expanding in society, one must also possess functional skills in addition to digital literacy. Digital literacy is a life skill that encompasses not only the use of ICT technologies but also social skills, human learning capacities, and attitudes, critical thinking, creativity, and inspiration. Digital literacy encompasses more than just reading proficiency; it also refers to reading comprehension and meaning. The capacity to comprehend, assess, and integrate information in a variety of computer-presented media is also a component of digital literacy. (Akhyar, et al., 2021).

The Impact of Digital Literacy on Science and Scientific Knowledge

Digital literacy, it is widely held, is an essential part of personal competency and improves the «marketability of the national education sector,» highlighting the fact that literacy is a more important skill than ever in today's knowledge-based society (Vučković, 2022; Vuković, et al. 2023). Digital literacy has a particular benefit for each individual as it lays the groundwork for skill development and lifetime learning.

It may raise everyone's standard of living and let them share in the economic prosperity of the country. These strategies, which mostly draw from human capital theories, seek to show that education and literacy investments are more important for sustained economic growth than capital gains over the long run. Thus, each person's wellbeing is taken into account while calculating aggregate welfare (Vuković, et al. 2023).

Digital literacy questions, however, surely have something to do with economic competition, the technocratic apparatus that governs people in the global economy, and the teaching of individual competencies for «networking,» even if they have nothing to do with ICTs, those electronic and invisible binary sequences of ones and zeros, or the previously mentioned promises.

The need for digital education was sparked by the advancement of technology and its application to digitalization. The usage of digital technology is growing at a rapid rate, thus it is important to take into account how people use it, interact with it online, and what skills they have to complete the tasks involved in digitalization. Thus, through creative learning trajectories, educational institutions facilitate the transfer of relevant digital skills to the next generation of workers (Reddy, et al., 2023). It is challenging for educators to keep up with the increasing number of ICT tools that are now accessible and to think about how they might utilize these resources to assist teaching, learning, and research in the most efficient and fruitful way possible. Researchers and practitioners create models of necessary knowledge for teachers and how they use such information to their own learning and teaching situations in order to support educators in developing ICT integration (Redmond, Lock, 2019).

The expansion of scientific knowledge has had the most significant impact on the advancement of human understanding. Science has taught us a great deal about how our bodies function, how celestial bodies operate, and much more. These pieces of information are astounding, especially when compared to our growing understanding of the mundane and routine aspects of life. Many philosophers of the 20th century believed that studying how scientific knowledge increases is a crucial task in epistemological research. Thus, some authors argue that scientific progress «follows the increase in scientific understanding, not the accumulation of knowledge» (Dellsén, 2016).

Today, the world is increasingly acquiring new knowledge through organized research and less through spontaneous and accidental discoveries. In recent years, many aspects of our lives have been drastically changed, or in many cases, completely transformed by digital transformation. This broad concept encompasses the adoption and use of digital technology, such as computers and the internet, for various applications, from communication to research. In one study examining research trends in digital literacy through scientometrics, focusing on journals indexed in WoS, it was concluded that to increase the originality of studies related to digital literacy, researchers and scientists can collaborate with colleagues from different countries and cultures to explore a broader spectrum of digital literacy environments (Hyejin, et al., 2021).

For example, the phenomenon of the mutual interaction of sciences was discussed by Dobrov as «inevitably and necessarily becoming more actively and consciously organized mutual interaction of different sciences» (Dobrov, 1969, 59-68). Leonardo da Vinci had numerous brilliant ideas that could not be realized at that time due to insufficient knowledge of science, collaboration, materials that did not exist at the time, and so on. However, today, thanks to «digital literacy,» scientists worldwide have access to the latest scientific discoveries. Digital literacy is an essential skill for scientific workers in the modern age (Dašić, 2023a). As technology continues to advance at an unprecedented rate, the ability to effectively navigate digital tools, platforms, and databases becomes increasingly important for conducting scientific research. One key aspect of digital literacy for scientific workers is the ability to access and evaluate information from various online sources. With a vast amount of information available on the internet, it is crucial for scientists to be able to distinguish reliable and accurate sources from misinformation or biased articles. Without digital literacy skills, scientific workers may fall victim to false or misleading information, which can significantly impact the validity of their research findings.

Digital literacy has a profound impact on science and research across various disciplines. Digital literacy enables scientists to access a vast amount of information through online databases, journals, and repositories. Digital literacy is crucial for handling large datasets that are common in modern scientific research. Digital tools facilitate collaboration among scientists across the globe. Researchers can collaborate in real-time, share data, and communicate findings using various online platforms, leading to more efficient and diverse research outcomes. Digital literacy allows scientists to use advanced computational tools for simulations and modeling. This is particularly important in fields like physics, chemistry, and biology, where experiments may be expensive, dangerous, or logistically challenging.

Digital literacy is essential for publishing research in online journals and disseminating findings through various digital channels. This accelerates the sharing of knowledge and increases the visibility of scientific work. Digital literacy is critical for scientists to leverage machine learning and artificial intelligence in their research. These technologies can automate data analysis, identify patterns, and make predictions, enhancing the efficiency and accuracy of scientific investigations. In one study (Wang, Si, 2023), articles related to the COVID-19 period were selected from the same dataset, and 3961 papers published between January 1, 2020, and December 31, 2022, were analyzed to explore trends that emerged in digital literacy research during the pandemic. Researchers examined the use of keywords by authors of scientific papers and identified the terms most commonly used. According to their study, two concepts that frequently appeared in digital literacy research during the pandemic were “health literacy” (153) and “Covid-19”.

Digital literacy supports the principles of open science, where research findings, data, and methodologies are openly shared. This fosters transparency, reproducibility, and collaboration in the scientific community. With the increasing reliance on digital platforms, scientists need to be digitally literate in terms of cybersecurity to protect sensitive research data and maintain the integrity of their work. So, Digital literacy is integral to the advancement of science and research by providing scientists with the tools and skills needed to navigate the digital landscape, collaborate effectively, analyze complex data, and communicate their findings to a global audience. Georgina and Hosford (2009) looked at how university staff perceived digital skills in order to investigate literacy skills among teachers. They discovered that the new objective in higher education is to enable a university-wide professoriate to improve both their information literacy and technology literacy skills.

Furthermore, digital literacy empowers scientific workers to effectively communicate their research findings to a wider audience. Gone are the days when scientific research was solely presented in print journals. Nowadays, it is common for researchers to communicate their findings through digital platforms such as online journals, blogs, or social media (Dašić, 2023b). Being digitally literate allows scientists to reach a broader audience and promote their work to the public. Additionally, digital tools and software enable scientists to present their research in interactive and engaging ways, such as through data visualization or multimedia presentations. By acquiring digital literacy skills, scientific workers can enhance the dissemination of their findings, making them more accessible and understandable to diverse audiences.

Lastly, digital literacy plays a crucial role in fostering collaboration and innovation among scientific communities (Dašić, 2023a). Many scientific breakthroughs have been made through collaborative efforts, as researchers from different disciplines come together to tackle complex problems. Digital tools facilitate seamless communication and information sharing, allowing scientists to collaborate across distances and time zones. Furthermore, digital literacy enables scientific workers to leverage emerging technologies and platforms, such as machine learning algorithms or cloud computing, to analyze vast datasets or conduct simulations. By embracing these digital tools, scientists can significantly enhance their research capabilities, accelerate the discovery process, and promote cross-disciplinary collaboration. Overall, digital literacy has brought about a paradigm shift in the field of science. The ability to navigate, utilize, and harness digital tools and technologies is no longer optional but essential for success in the scientific realm. By embracing digital literacy, scientists can effectively tackle complex scientific challenges, collaborate on an unprecedented scale, and contribute to scientific advancements that have the potential to positively impact society as a whole.

Conclusion

Digital literacy is vital for scientific workers in today's technologically driven era. It not only enables them to access and evaluate reliable information, but also equips them with the skills needed to communicate their research findings effectively. Moreover, digital literacy fosters collaboration and innovation within scientific communities by enabling seamless communication and leveraging emerging technologies. As technology continues to evolve, it is crucial for scientific workers to continually cultivate their digital literacy skills to remain at the forefront of scientific advancement.

Digital literacy plays a crucial role in shaping the field of science today. The ability to access and analyze vast amounts of data, collaborate with researchers from across the globe, and utilize sophisticated

software and simulations has revolutionized the scientific landscape. Digital literacy not only enhances the efficiency and accuracy of scientific experiments, but it also enables scientists to make groundbreaking discoveries that were previously unimaginable.

With the internet, researchers can now access a wealth of scientific literature, research papers, and scholarly articles at the click of a button. This ease of access allows researchers to stay updated with the latest advancements in their field, saving time and effort. Moreover, digital platforms enable scientists to share their own findings instantly, fostering collaboration and knowledge exchange. This interconnectedness has accelerated the pace of scientific discovery and facilitated interdisciplinary research, leading to breakthroughs in various scientific disciplines.

Advanced software and simulations not only facilitate the design and execution of experiments but also enable scientists to model complex phenomena and predict outcomes. For instance, researchers can use computational models to simulate the behavior of molecules to study the properties of materials or simulate the impact of climate change on ecosystems. These digital tools not only reduce the need for costly and time-consuming experiments but also enhance the reproducibility and reliability of scientific findings. Digital literacy empowers scientists to leverage these tools effectively, thereby increasing the rigor and validity of scientific research.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization: D.D.; methodology: D.D.; resources: M.V. and M.I.K., supervision: M.P.; writing—original draft preparation: D.D. and M.P.; writing—review and editing: M.I.K. and M.V. All authors have read and agreed to the published version of the manuscript.

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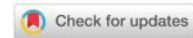
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Criminal Profiling as a Method of Detecting Lies in Nonverbal Communication

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Abstract: The exponential growth of crime, violence, and wrongdoing is linked to dysfunction in restraining aggressive impulses, leading to neglect and disrespect of others' feelings, rights, and needs. Two basic forms of communication, verbal and nonverbal, serve individuals to interact and exchange ideas and attitudes with other people in everyday life situations, including within the framework of criminal investigations and criminal justice. The purpose of this study was to draw an analogy between verbal communication (oral speech, written speech) and nonverbal communication (body language, gestures, and silence), with the tendency to explore different components of nonverbal communication and place them in the context of criminal profiling as a method for detecting lies in nonverbal communication. The aim of this study was to emphasize the importance of nonverbal communication as an equal part of the communication process, and often a predominant one in this domain, which helps us demystify suspects, perpetrators, and criminal acts.

Keywords: nonverbal communication, verbal communication, criminal profiling, lie detection.

Introduction

We live in a world full of contradictions. Very often, the destructive character of people prevails over reason as their essential trait. This implication gives rise to numerous sociopathological phenomena. Instead of well-being and striving for harmony and peace, social anomalies have led to the expansion of crimes against humanity, such as modern slavery (Bjelajac, 2014a), and have complicated the ubiquitous violence (Bjelajac, 2013), which is increasingly manifesting in digital/virtual form (Bjelajac, 2012). In fact, what makes our time different and disturbing is the intensity of psychodynamics and the escalation of violence in all its forms, in which anyone can become a victim due to the transformation of ordinary individuals who directly or indirectly support criminal behavior. This directs us to the need for a more comprehensive understanding of human nature, the emotional and psychological dimensions of violence, and the clear tendency towards the brutalization of this phenomenon. Moreover, human nature is determined by a series of natural, striking characteristics, which among other things relate to ways of thinking, feeling, and acting, as a product of our inherited or innate traits and our individual experience acquired in the environment in which we exist (Bjelajac, 2023). Unfortunately, this experience suggests to us that the increasingly prevalent alienation of man from man (Bjelajac, 2014b) in the era of scientific and technological development and globalization contributes to the rise and diversity of organized crime with catastrophically high rates of violence and chaos in our living environment.

"The world is a dangerous place to live, not because of the people who are evil, but because of the good people who do nothing," said Albert Einstein. In the spirit of this wise thought, as part of the response to crime, in the context of crime prevention policy (Bjelajac, 2015), we present criminal profiling as a relatively new criminal investigative method/tool that law enforcement agencies use as a

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systemic approach to investigate the background of a criminal act and create a psychological profile of the criminal based on evidence from the crime scene. Profiling is often used in cases of particularly serious crimes such as murders and rapes to find unknown perpetrators in the absence of evidence collected by conventional means (conventional evidence) and/or when a criminal investigation reaches a deadlock. In order to have an effective insight into the thought processes, personality characteristics, and motivations of offenders, we must understand the origins of criminal behavior (developmental risk factors, biological factors, learning, and situational factors) and the behavior trends of current and potential delinquents.

Profilers, while observing suspects, witnesses, and victims, monitor verbal and nonverbal communication. It is known that verbal communication is more under the control of consciousness, so criminals characterized by “indifference” with a lack and/or absence of empathy, along with pronounced manipulative character with good intellectual abilities and potential for “acting,” can master “words” that will exclude their guilt due to lack of evidence. Nevertheless, if we have a pronounced ability to perceive microfacial expressions and “body language” in nonverbal communication, we have an instrument that helps us to uncover and better understand lies, and thereby demystify the criminal and the crime.

Methodology

In the process of conducting descriptive research, we formulated research questions in an appropriate and concise manner to explore the perspective of detecting lies in nonverbal communication. We utilized qualitative research methods to conduct a deeper analysis and provide more detailed explanations, offering a comprehensive and broader picture of nonverbal communication in this domain, and addressing why this form of communication is important and unjustly neglected. Through the method of comparative analysis, we uncovered common and different characteristics of verbal and nonverbal communication as two fundamental and key forms of human interaction. We interpreted that there are pronounced capacities of nonverbal communication manifested through the presence of characteristic behavioral signals accompanying lying or manipulative behavior.

The analogy between verbal and non-verbal communication

Verbal and nonverbal communication are two fundamental ways of human interaction that play a primary role in expressing and conveying messages, emotions, ideas, information, and intentions among different individuals. A proper understanding of the differences between these two basic forms of communication is crucial for effective relationships among people.

Figure 1. *Tabular Difference Between Verbal and Non-verbal communication*

Aspect	Verbal Communication	Non-Verbal Communication
Medium	Spoken or written words	Body language, facial expressions, gestures, etc.
Channel	Auditory and visual	Primarily visual
Language Barriers	Language proficiency can affect understanding	More universal, transcending language barriers.
Speed of Delivery	Faster in conveying information	Slower, allowing for more subtle nuances
Conscious Control	Often requires conscious effort and articulation	Often unconscious and spontaneous.
Ambiguity	Can be more precise and explicit	Can be ambiguous and open to interpretation.

Aspect	Verbal Communication	Non-Verbal Communication
Emotional Expression	Tone of voice conveys emotions	Facial expressions and body language convey emotions.
Memory Retention	Easier to remember and recall	Non-verbal cues can be challenging to recall accurately.
Cultural Differences	Language may have cultural nuances	Non-verbal cues can vary significantly across cultures.
Scope	Covers a broad range of topics	More effective for expressing feelings and attitudes.

Source: Difference Between Verbal and Non-Verbal Communication, (2024)

According to Albert Mehrabian, “Verbal communication refers to the use of words in conveying the desired message. The main components of verbal communication are sound, words, speech, and language. Three elements differently explain our liking for the person conveying the message about their feelings: words account for 7%, tone of voice for 38%, and facial expression for 55% liking. It becomes more likely for the receiver to believe the prevailing form of communication, which, according to Mehrabian’s findings, is the nonverbal influence of tone + facial expression (38% + 55%), rather than the literal meaning of words (7%). This is known as the “7%-38%-55% rule” (Mehrabian, 1971). Verbal communication can be direct or indirect, formal and informal, and the variation can also be reflected in the pitch of the tone, depending on how a particular message is perceived.

When considering nonverbal communication, it is advisable to refer to a quote from the famous philosopher Friedrich Nietzsche: “The most understandable in language is not the word itself, but the tone, strength, modulations, tempo with which a series of words is spoken - in short; the music behind the words, the person behind that passion: thus, everything that cannot be written.” According to David Matsumoto, one of the recognized experts in the field of nonverbal communication, it is “the process of sending and receiving messages without the use of words, either spoken or written.” Therefore, this form of communication can convey emotions stronger than words and includes eye contact, facial expressions, hand gestures, tone of voice, and body language.

Body language, tone of voice, and physical appearance greatly influence our communication on our behalf. Most people are not aware that besides verbal language, our brains subconsciously process microexpressions, general “vibes,” and appearance to assess almost everyone we come into contact with. If someone were to pretend to punch you while walking down the street without saying a word, how would you react? You would probably instinctively react by running, flinching, or retaliating with a punch. Reacting to a fake punch is a subconscious reaction that is easy to recognize, but what if someone crosses their arms or establishes awkward eye contact while talking to you? Are you aware of how your body naturally reacts? By understanding nonverbal cues (vibes), you can be more aware of what your subconscious picks up and more aware of how you present yourself to others (Conscious Vibe, 2021). Microexpressions are unconscious, extremely fast, sometimes full expressions of emotions. Sometimes they are partial and very subtle expressions of emotions. But since they are extremely fast and unconscious, when they appear, they often last less than half a second - sometimes even a tenth of a second or even a fifteenth of a second. Most people don’t see them. Some people see them but don’t know what they see. They see something that has changed on the face, but they don’t know exactly what has changed. It is very short-lived, but if you freeze-frame on video, you will see that many times there is a large facial expression that clearly speaks to the person’s mental state (Hamilton, 2016). Facial expressions of emotion are universal in the sense that everyone around the world, regardless of race, culture, nationality, gender, etc., regardless of the demographic variable, we all show the same facial muscle expressions on our faces when we have the same emotions (Hamilton, 2016), anger, sadness, rage, joy. This suggests the

importance of paying attention to nonverbal communication in everything, from intercultural exchanges to criminal investigations, because understanding facial expressions/changes or body language can signal a variety of different emotions, which guide us to what is being sought.

The Mode of Recognizing Lies in Non-Verbal Communication

In our often cruel and harsh world, gripped by a global crisis of morality, lying has become a “normal” trait in the existence of the modern individual. Hypocrisy and deceit cloak selfish aims of individuals, aiming to conceal crimes, deny acts such as rape, robbery, theft, and perpetrate other serious offenses in the most insidious manner. Individuals who lie about transgressions typically appear more disturbed than those speaking the truth, often exhibiting more inhibition in their gestures signaling deceit.

Psychologist Robert Feldman from the University of Massachusetts has been studying lying for over a decade, and his research has led to astonishing conclusions. Most shockingly, 60% of people lie during a typical 10-minute conversation and average two to three lies during that short time frame. In Feldman’s studies, most people do not even realize all the lies they have told until after the conversation when it is played back to them on video (Bradberry, 2016). Everyone has been caught in a lie at some point in their life, and it seems this event remains in the memory of most people through stories about those experiences. Vrij, Edward, Roberts, and Bull (Vrij, Edward, Roberts, and Bull, 2000) suggest that a liar can be caught in three different ways. One strategy is observing the behavior of the individual (i.e., whether they make restless movements or avert their gaze). Another strategy is to analyze what they say (i.e., whether they stutter, have hesitations in their voice, or take long pauses in speech). Lastly, a liar can be caught by measuring physiological correlates, which can be explicitly measured (i.e., pulse, GSR). Verbal cues are linguistic traces of deceit expressed in an individual’s statement, such as stuttering, variations in pitch, etc. Nonverbal cues are traces of deceit expressed through facial expressions, eye movements, and body language (Wang, Chen and Atabakhsh, 2004; Hicks and Ulvestad, 2011). Therefore, learning to read microexpressions and nonverbal behavior in general can be very valuable for anyone whose job is to understand the true feelings, thoughts, motivations, personalities, or intentions of others. These would be people in the criminal justice system, police, national security, intelligence services - people whose job is to try to uncover whether a person is withholding knowledge or has some information that would be useful for solving crimes or obtaining other data (Hamilton, 2016). “Interviewers must be able to properly use their own knowledge and skills about nonverbal communication. Facial expressions can reveal attitudes of sincerity, shock, surprise, humor, sadness, or concern. Meaningful communication also depends on tone of voice, inflection in delivery, emphasis on words, use of guttural sounds, body space, body movements and gestures, proper timing, control of vulgarity and slang, appropriate physical appearance, and study of clothing usage. When interviewees lie, skilled interviewers can recognize countless biological and physiological processes occurring in their minds and bodies. Indicators of lying include sweating; flushing or paling of the skin; increase or decrease in pulse, which is visible from the appearance of visible veins on the head, neck, and throat; dry mouth and tongue; excessive swallowing; respiratory changes; muscle twitching; lip licking; thick and blurred speech; stuttering; rapid eye movements; body stiffness; ‘playing’ with hands; clenched fists; and cold, clammy palms (Kuhlman, 1980).” Signals for detecting lies in nonverbal communication are most noticeable on the face in the form of ticks. Individuals often display “irregular” eye contact, dust off their clothing, or are preoccupied with “fiddling” with objects. However, not all individuals express the same meaning of nonverbal communication in similar circumstances. For example, blushing on someone’s face after a question does not necessarily mean that person is hiding the truth.

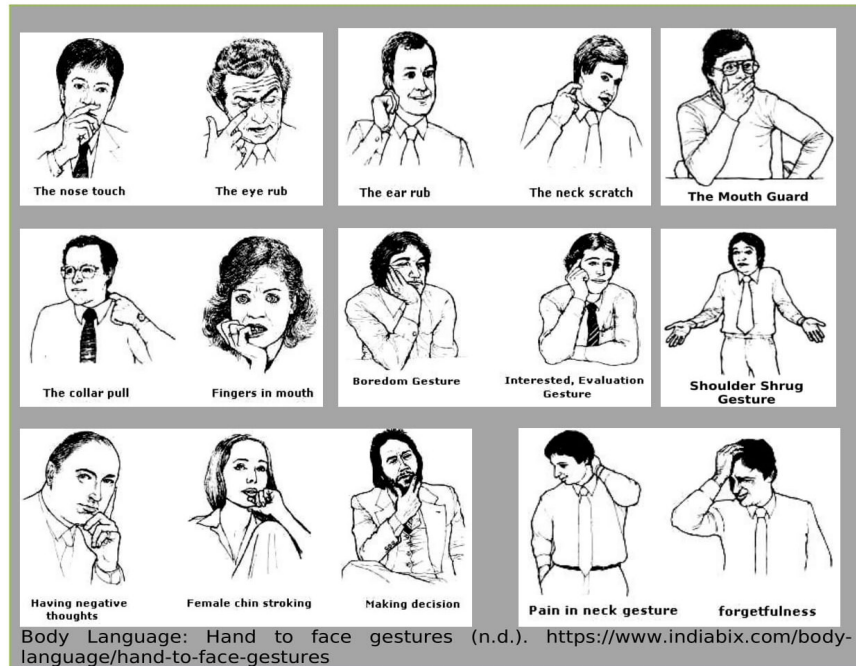
In many encounters between police and citizens, the primary focus is always on the verbal statements of suspects/citizens, rather than on how and what their body conveys while “telling a story.” This study advocates for an integrated approach in which police officers understand that they also communicate nonverbally with suspects and reveals that nonverbal communication, known as body language, proxemics, and kinesics behavior, often tends to make up a much larger part of police communication models than verbal communication, which should help police officers establish authority and dominance and provide a safe environment (Otu, 2023). Recognizing lies in nonverbal communication is not an imposed tool in police investigations, but it is an effective means that necessarily imposes itself as a powerful method serving criminal justice.

"Almost every person who lies feels nervous, although it may be more or less pronounced, depending on "professional experience." If you want to know if someone is lying to you, pay particular attention to their state and try to insist on discussing the suspicious topic as much as possible. Some signs of nervousness are nail-biting, restlessness, sweating, rubbing hands from legs, tapping feet, and playing with items in their pockets. What are the differences between men and women in nonverbal communication? Certain stereotypes and general characteristics attributed to men are aggression, dominance, loudness, and loud speech, while women are believed to be mainly emotional, tender, and sensitive to others, but also passive and prone to gossip. Everyday perceptions of non-verbal communication and the difference between men and women reflect these common beliefs about gender differences (Paunović and Orlandić, 2013)." "You may have noticed that when you ask someone a question, their eyes constantly move in a different direction. Research has shown a connection between the movements of the person's eyes and what they are thinking about at that moment. The research results further explain six different directions in which a person can look - up right, up left, middle right, middle left, down right, and down left. Each of these directions reflects what the person is currently thinking about. For example, if a person you are talking to looks up and to the left while telling you something, they are probably constructing a story they intend to tell, which may also mean they are lying to you (Paunović and Orlandić, 2013)." The question remains open whether the results of such research are sufficiently reliable. Critics point to a lack of empirical evidence and suggest that this is inductive reasoning, and every inductive conclusion carries within it elements of "problematic."

However, there are several nonverbal signals that when particularly appearing together, may suggest that someone is lying. These signs include:

- **Eye area** - A wandering gaze, left or right, indicates discomfort when a person is trying to find a way out of a dangerous and unpleasant situation; Excessive blinking may indicate stress; Avoiding eye contact may indicate lack of confidence or distancing from the interlocutor; Rolling eyes is an act of negative nonverbal communication, signaling disrespect, astonishment, and disapproval of the interlocutor's words; When a person closes their eyes for a few seconds, it can be interpreted as lying as a defense mechanism and at the same time implies that they do not want to be in the current situation; Rubbing the eyes and touching the eyelids during questioning is a gesture seeking some sort of "time-out" to devise a strategy. Also, this gesture represents the brain's attempt to block lies, deceit, or suspicion or to avoid looking the person they are lying to in the face; Raised eyebrows mostly represent surprise, while lowered ones indicate emotions of dominance, anger, disagreement, or sadness. Increased pupils, which in men can enlarge up to three times, are a sign of great excitement.
- **Mouth covering** - Hand or fingers or even a clenched fist over the mouth may signal that a person is hesitant to speak. The brain at a subconscious level instructs to suppress the false words being spoken. Many individuals mask this gesture with a fake cough.
- **Touching and rubbing the nose** - The person feels uncomfortable about lying, and this gesture is part of the "ritual." This gesture is, in fact, a sophisticated, concealed version of mouth covering gesture.
- **Insincere smile** - Only the mouth stretches. There are no signs of wrinkles around the eyes or visible. A twisted smile shows sarcasm. In females, the so-called tight-lipped smile is often a gesture of rejection, secretive thinking, or attitude.
- **"Lying through one's teeth"** is a term that denotes rubbing the eyes, with clenched teeth, and a fake smile accompanied by loud and unrestrained laughter/chuckling.
- **Ear grabbing** - Involves fiddling, scratching, and pulling the earlobe, symbolizing something one does not want to hear, the listener's attempt to "hear no evil."
- **"Pinocchio effect"** - A person lying often scratches their nose or the area behind the ear while covering their mouth. Lying also causes a tingling sensation on the neck due to increased blood pressure, and individuals tend to adjust collars, ties, and touch jewelry.
- **Licking and pressing lips** - Lying causes dryness in the mouth, which is a characteristic sign of insecurity and nervousness.
- **Nervous cough** - May indicate tremor but also increasing nervousness due to lying.
- **Face touching** - When people lie, a chemical reaction can lead to facial itching, reflected in scratching or touching the face.

Figure 2. Body Language – Hand to Face Gestures



Source: www.indiabix.com/body-language/hand-to-face-gestures, n.d.

- **Blushing** - Some individuals may blush after lying, which is certainly a sign that the person feels uncomfortable in the situation they are in. This is an involuntary reflex caused by the sympathetic nervous system and arises due to the secretion of adrenaline.
- **Excessive sweating** - People who lie sweat more than in other situations, which is usually visible on the forehead, cheeks, or the back of the neck.
- **Irregular breathing** - It is a sure sign of discomfort, which can be recognized by actively observing the other person.
- **Foot tapping** - Nervously tapping the feet is one of the most recognizable signs of tension. The reason is usually lying and the desire to leave the exposure situation as soon as possible.
- **Fidgeting with various tics** - Interlocutors recognize these as negative acts of nonverbal communication. Twirling hair, touching jewelry, looking at the watch, squirming are gestures that indicate a loss of control over oneself and insecurity.
- **Palms** - People who lie often hide their palms.
- **Neck rubbing** - Indicates stress relief and reveals present anxiety.
- **Chin movements** - Can be a signal that the listener is making a decision. When the index finger is directed up the cheek, and the thumb supports the chin, the listener has negative or critical thoughts about the speaker.
- **Nail biting** - Is extremely poor nonverbal communication and another habit that shows other people that you are nervous.
- **Shrugging shoulders** - A universal gesture used to indicate that a person has no knowledge or does not understand what you are talking about. Usually accompanied by hunched shoulders, raised eyebrows, and exposed palms.

There are also other signals in nonverbal communication that can indicate deception. For example, through body posture, one can notice a person's level of confidence and interpret insecurity. Crossed legs or arms indicate a defensive stance, withdrawal, discomfort, disinterest, and unwillingness to engage with the other person. Finger tapping and foot trembling are characteristic body language signs that usually indicate stress, agitation, or boredom. Crossed ankles convey a sense of discomfort and a stance as if being on the "defendant's bench." "Fidgeting with clothes," holding objects, adjusting hair or makeup, smoking, and holding cigarettes may indicate that the person feels uneasy or uncomfortable. Therefore,

as observed, there are many different gestures in nonverbal communication that can suggest that a person is insincere and lying.

It seems that the detection of lies in nonverbal communication was most notably promoted by the American crime series "Lie to Me," a dramatic series about a psychologist who is a "human lie detector," or an expert in reading facial and body language that reveals deceit. He collaborates with a female clinical psychologist and opens an agency that offers private investigation and crime-solving services. Tim Roth plays Cal Lightman, the world's leading deception expert who studies facial expressions and involuntary body language to uncover not only if someone is lying but also why. Based on the scientific discoveries of Dr. Paul Ekman, the series follows Lightman and his team of deception experts as they assist law enforcement agencies and government agencies in uncovering the truth behind lies ([Lie to Me, 2009](#)). Cal focuses on the prisoner's changes in facial expression in a fraction of a second, which unconsciously reveal the location where the bomb was placed. Facing a room full of undercover police officers, Cal replays the video of this interrogation on a polygraph, pausing to illustrate - using extreme close-ups - small twitches at the corners of the eyes and mouth that gave him the information he wanted. In another case, Cal investigates the recent murder of a teacher in a high school. The main suspect is a 16-year-old, one of her students. During the interrogation, Cal notices "irregular eye contact patterns," so the boy's failure to avoid eye contact indicates that he is lying about never being in or near the teacher's house. Interestingly, when asked about the teacher's death, he furrows his brows, meaning he is sad and has nothing to do with the murder. Cal then questions the boy's schoolmates, who point out that he was withdrawn and unadjusted to society, with one girl noticeably showing nervousness and unusual breathing patterns. In this complex plot, Cal found the real culprit who wanted to skillfully "frame" the boy for the crime and uncovered the background of the boy's behavior related to a fantasy relationship and obsessive desire for the teacher, which included stalking. When he saw her dead, he panicked and ran away ([Lie to Me – Season 1, Episode 1](#)).

Discussion

In the past forty years, several studies have been conducted that recorded and analyzed people's behaviors during lying with the aim of determining whether there are specific signs that would indicate deception. Such signs are called objective signs of lying, and they differ from subjective signs of lying in that subjective signs are those that people believe appear during lying, i.e., those signs of lying that represent the beliefs of the majority of people. The results of research conducted so far do not fully agree on which forms of behavior occur in liars ([Banjac, 2018](#)). Vrij, Edward, and Bull, in their research, observed significant individual differences in the behavior of individuals who manifest lies and deception as a denial of truth, suggesting that there is no uniform behavior for lying that would establish absolute standards in a given context ([Vrij, Edward, and Bull, 2001](#)).

Although lie detection has a long historical background primarily within psychology, the origins of criminal behavior, and criminal investigations, there are still very conflicting studies regarding lie detection in nonverbal communication. Some studies indicate that people are limited in recognizing lies, but much more accurate in recognizing truth, this phenomenon is called the "truth effect" ([Strömwall, Granhag, and Jonsson, 2003](#)). Certain authors believe that Paul Ekman's popular hypothesis on micro-expressions of the face as indicators of lying, advertised in many popular courses, lacks scientific support ([Porter, S., and ten Brinke, 2008](#)). For example, a recent study, which examined the effect of micro-expression training on lie detection and involved the presentation of real video footage of high-stakes liars, found that trained participants achieved lower chances of detecting lies, similar to untrained or falsely trained participants ([Jordan et al., 2019](#)). In some studies, research on lie detection has shown that observers relying solely on signs correctly classify an average of 54% truths or lies ([Vrij, Meissner and Kassir, 2015](#)). Despite the expressed reservation regarding the adequate recognition of lies in nonverbal communication, there is a significant number of credible researchers and criminal investigators who argue convincingly that it is possible to detect liars, as opposed to those telling the truth, based on the nonverbal signals sent by the sender.

By the mid-1960s, Ekman initiated a series of cross-cultural studies focusing on facial expressions, emotions, and gestures. In addition to basic research on emotions and their expression, he also dealt with deception. In 1991, Ekman conducted a study focusing on the ability to identify lies by individuals of

different professions. This mainly concerned professions where lies are more common. The participants were members of secret services, psychiatrists, judges, police officers, polygraph staff, and a group of students. Individuals were asked to describe changes in behavior, facial expressions, and intonation of the voice of a woman testifying, and based on these clues, come to a conclusion whether her statement was true or false. The most successful group turned out to be the group of secret service agents (Vicianova, 2015; Ekman, O'Sullivan, and Frank, 1999). Indeed, there is tangible evidence that certain categories of professionals such as members of secret services, clinical psychologists, and criminal investigators experienced in interrogating suspects are indeed more successful in lie detection.

Studies on what people believe about lying and deception identify a range of nonverbal signs associated with lying (Vrij, 2000; Vrij, 2008; Global Deception Research Team, 2006) - avoiding eye contact, fidgeting, restless movements of the feet and legs, frequent changes in body posture. Such beliefs are not limited to laypeople, but are also held by legal and psychological experts (Bogaard, Meijer, Vrij, and Merckelbach, 2016; Dickens and Curtis, 2019). Based on such everyday ideas, many organizations offer courses and programs promising the ability to detect lies (Brennen and Magnussen, 2020), scientifically proven methods for interpreting body language, detecting micro-expressions mainly manifested when a person tries to suppress their emotions, leading to rapid display of micro-expressions. These programs offer training not only for detecting lies in criminal investigations but also teach participants to verify the credibility of interlocutors in a business environment during meetings, interviews, or when concluding business contracts. This suggests that there is definitely a future for this line of research.

Conclusion

"There are very few evil people, yet so much evil happens in the world, most of that evil falls on the shoulders of many other people, who are nothing but good people," said Johann Nestroy. Evil people are destructive and self-destructive beings because they emit aggressiveness, alienation, selfishness, lack of empathy... Ultimately, the inability to control aggressive impulses leads to neglecting and disrespecting the feelings, rights, and needs of others, which leads individuals into criminal activities and acts of crime. Therefore, it is up to the "rest" of good people to find mechanisms to restrain the malignant nature of human behavior, separating good from evil and lies from truth. All the more so, as the number of security challenges, risks, and threats is exponentially increasing. A large part of these threats can be prevented and/or brought to a level tolerable for society through proactive action.

In that direction, as a segment of crime suppression policy, adequately proactive action is crucial, as a set of measures and procedures for eliminating, reducing, and timely recognizing future problems. By emphasizing nonverbal communication, compared to known patterns of verbal communication, in the context of criminal profiling as a method for detecting lies in criminal and "preventive" investigations, we wanted to highlight the potential of this "tool" that can contribute to elucidating challenging and complicated crimes through the analysis of specific psychological aspects.

Research and detection of lies have a significant place in the field of forensic psychology. We witness everyday lies in interpersonal communications that can cause human problems and tragedies in addition to personal discomfort. However, lying in criminal investigations and in court seems to have been the leading concern for scientific research interest in lie detection. It is known that testimonies of suspects, witnesses, and victims are crucial for the verdict's decision-making and sustainability, which depends on the perceived credibility of the given statements, especially in cases where there is a lack of undisputed facts and evidence. Therefore, it is crucial to identify liars, not only based on verbal communication but also through the analysis of unconscious nonverbal signals they emit.

Current studies on the accuracy of deception detection using verbal and nonverbal cues focus on two lines of research. The first "line" gives importance to verbal communication over nonverbal communication, as such ideas are not supported by appropriate empirical research, while the second "line" does not dispute the capacities of verbal communication but emphasizes the importance of the existence of characteristic behavioral signals accompanying lying or manipulative behavior, which are neglected in criminal investigations and court proceedings. For criminal investigators and profilers, it is certainly important to follow strategies and principles that involve taking into account both verbal and nonverbal communication cues, which are unjustly neglected.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

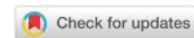
Conceptualization, Ž.B and B.B.; methodology, Ž.B.; resources, Ž.B. and B.B., validation, B.B., writing—original draft preparation, Ž.B.; writing—review and editing, Ž.B and B.B. All authors have read and agreed to the published version of the manuscript.

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Parental Supervision and Control as a Predictive Factor of Juvenile Delinquency

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Abstract: Parental control and supervision is considered one of the key factors in raising children. There are numerous studies and researches in the literature that have tried to prove the correlation between parental control and juvenile delinquency. The results of these studies have varied, sometimes confirming and sometimes denying a direct link between parental control and certain forms of juvenile delinquent behavior. However, the modern child and family go through a new socialization process that brings challenges for both children and parents. The goal of our paper is to clarify the terminological confusions present in this area and highlight the actuality of the issue of parental control over the behavior of minors. Through a review of existing domestic and foreign scientific literature, using quantitative and qualitative content analysis, comparative analysis and comparative and historical methods, we want to point out the importance of parental control and supervision in shaping the behavior of minors, with special reference to the manifestation of delinquent patterns. The results of our research indicate a significant correlation between different forms of parental control and supervision with the behavior of minors, with noticeable changes compared to traditional methods of control. The obtained results emphasize the need for educating and advising parents about modern achievements in this area, as well as providing support in adapting to new trends and security challenges, including the impact of information technology, social media and other factors that are now part of everyday life and were not present in the past. The practical importance of our research implies that the theoretical conclusions can be used as a basis for further research in the field of parental control and supervision, as well as juvenile delinquency, with the aim of developing measures for its prevention.

Keywords: *parental supervision, parental control, juvenile delinquency, prevention.*

Introduction

Parental supervision and control are terms used in different scientific disciplines, and the very definition of these terms is difficult to unify and give a generally acceptable definition that would satisfy all theoreticians and practitioners. Children are the focus of parental control, and this control intensifies during adolescence. The association of this term with the delinquent and antisocial behavior of young people gives it a new dimension that is attracting a lot of attention in criminological and criminal justice disciplines. Numerous theoretical viewpoints tried to determine the reasons for juvenile delinquency through the prism of explaining criminal behavior. Most of these explanations focus on trying to understand the period of adolescence as a very sensitive period in the development of each individual. Adolescence is a period of human development between childhood and adulthood dominated by certain characteristics that affect both the individual and the family. In the period of high school, young people face great challenges in adaptation, many changes that impose the need to harmonize new qualities of roles (biological, social, educational) (Gutvajn and Kovačević Lepojević, 2020, p. 2). It is a period of greater social and peer involvement, as well as an opportunity to show greater independence from their parents (Keijsers et al., 2012). During adolescence, parent-child relationships transform from hierarchical to relatively more egalitarian (Branje, 2018). Raising children is a delicate task that requires serious efforts, knowledge and skills in order to build a child's personality. It represents a situational context in which parents provide

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children with informal support, in contrast to e.g. school system that provides formal support. In general, parental support brings about social learning techniques that enhance prosocial behavior while preventing moral decadence (Fisher et al., 2015).

Through adolescence, young people try to break free from parental control and strive to belong to peer groups. During the periods when they spend time outside the home and school, there is no parent or other adult to control their behavior and activities. The need for safety and care, the feeling of helplessness and dependence, in children, represent a suitable ground for various forms of victimization (Bjelajac and Merdović, 2019, p. 192). On the other hand, an increase in uncontrolled and unstructured free time can provide opportunities for experimentation with antisocial and delinquent forms of behavior (Mahoney and Stattin, 2000). What is it that parents, in addition to all their responsibilities at work, at home, in the community, can do to help the adolescent build socially acceptable patterns of behavior? One of the most frequently emphasized parenting skills and behaviors directed in that direction is the supervision and control of children, as well as the desire and need of parents to have as much information as possible about how and in what way their children spend their time. First of all, this refers to the way in which free time is spent, with whom children spend time outside the home, but also on the Internet and social networks. The latter has become a dominant problem in the last few years. The development of the Internet and IT technology has changed the way children grow up and mature, which, in addition to all the positive things they make possible for children, also carries a number of security risks. On the other hand, the alienation and separation of children from their peers (Bjelajac, 2014) and the increasing amount of time spent on the Internet creates a number of health problems as well as an increased risk of delinquent activities connected to the Internet. To what extent parents can control children in this sphere, whether they have enough knowledge and skills, what control mechanisms and models can exist, are questions that are posed to the scientific public. It is evident that parents who know and are aware of how and with whom their child spends time, with what content it is filled with, can react in a timely manner to the manifestation of certain antisocial forms of behavior, but also act preventively to prevent such manifestations from occurring. Thus, adequate parental monitoring could potentially be key to helping a child navigate safely and successfully through the adolescent years (Keijsers, 2016). The evolution of research on parental supervision and control has not given us convincing results on whether certain parental behavior is an attempt to gain control over the child's psychological world or is an attempt to regulate the child's behavior. Which style and methods of monitoring and control parents will choose depends on many factors. They are not always chosen deliberately and consciously, and the declared principles are not always applied correctly and consistently in everyday communication with the child. They develop mostly spontaneously, under the influence of many multidirectional and multilevel factors. Such factors include individual characteristics of parents and children, family traditions of upbringing, family lifestyle, family structure, the nature of intra-family relations, cultural and religious traditions of upbringing that the family adheres to, historical and epochal trends that determine the understanding of the goals, tasks and ideals of upbringing (Andreyeva and Danilova, 2017).

The goal of this paper is to point out numerous terminological doubts that are evident in this area, which, by clarifying in the first part of the paper, we will try to state more concisely what it is that parents can do without in any way jeopardizing the individuality of the child, which is inevitable and desirable during adolescence. In the second part of the paper, by analyzing the results of various studies related to the supervision and control of children's behavior, we will point out certain disagreements that certain authors point out and refer to the way and mechanisms of the control itself. We will also point out certain scientific disagreements about whether, in general, control and supervision give positive results or whether children should be stimulated to provide their parents with information about their activities and behavior. We believe that it is extremely important to understand the two-way relationship of family ties that will indicate whether the supervision and control of adolescent behavior leads to changes in future delinquent activities or only the manifestation of certain unacceptable forms of behavior causes parental supervision and control.

Terminological confusions and conceptual delimitation

As we mentioned, the period of adolescence is a period in which intense physical, psychological, emotional and personal changes take place. In terms of time, it includes the period of biological, psychological and social maturation between the beginning of puberty and adulthood, which begins at the age of 11-13 and lasts until 18-20 (Počuča et al., 2023, p.117). With entering puberty the adolescent exits the family environment to a wider social environment, while communication patterns in the parent-child relationship change. Each parent-child relationship is unique and depends on numerous variables (parenting skills, individual characteristics, family structure), but it is still subject to change at different stages of the child's development. During adolescence, the parent-child relationship must be realigned and adapted to the child's increasing needs for privacy and autonomy (Collins and Laursen, 2004). In such conditions, the possibility of direct control and supervision of the child decreases and parents are forced to rely more and more on building a relationship of trust with the child who will be ready to voluntarily provide them with information about how, where and with whom he spends time. As a consequence of such changes in the parent-child relationship, as well as changes in society, numerous doubts and terminological differences arose. Two perspectives of parenting are often cited, namely the dimensional (support and control) and categorical approach (different parenting styles (Pinquart, 2017). In scientific works, monitoring is usually described as monitoring the activities of children, gathering information about the activities of young people, direct monitoring, communicating with children, imposing rules, solving problems, etc. (Pelham et al. 2023). In the literature, we find several terms related to the supervision and control of parents and are aimed at obtaining knowledge and information related to the child's behavior, what are his activities in his free time, with whom he spends time and where he usually stays. Parents can find out about their children's activities in at least three ways. First, children could tell them spontaneously, without any prompting (child disclosure). Second, parents could ask their children and their children's friends for information (parental solicitation). Third, parents could impose rules and restrictions on their children's activities and socializing, thereby controlling the amount of free time children have for free activities (parental control) (Stattin and Kerr, 2000, p.1073). It follows from the above that we most often encounter the following terms: parental monitoring, parental control, solicitation, parental knowledge and child disclosure.

Parental monitoring

Parental monitoring is a term that first began to be used in the literature, and in the earliest studies it often implied both control and supervision. However, in recent studies, a clear boundary between these terms is set. In the literature, one of the most frequently cited definitions of parental monitoring is that it is an active set of behavioral strategies used by parents to monitor their child's whereabouts and activities (Dishion and McMahon, 1998, p.61). How and in what way a parent will monitor their child depends on numerous factors. These factors refer both to the parent and the child as separate individuals, as well as to the characteristics of the social environment, cultural characteristics of the society, expectations of the environment. Supervision constantly changes depending on the age of the child and ranges from direct supervision (characteristic of earlier stages of child development) to remote forms of supervision (adolescence period). Parental supervision should be a two-way process, in which the active role and participation of minors is acknowledged: parents' attempts to learn about their child's behavior must be matched by children's attachment to the parent and willingness to share and disclose information about themselves (Stattin and Kerr 2000, p 1083). This process takes place in several stages that follow one another. The first phase is monitoring pre-free time and gives parents the opportunity to provide clear rules and expectations for adolescent behavior when they are unsupervised. The second phase is the adolescent's unsupervised behavior, while the third phase, labeled free time monitoring, provides the parent with the opportunity to determine how, where, and with whom the adolescent spent his or her free time. The fourth stage, called parental response, provides parents with an opportunity to respond if their adolescent has violated rules or expectations, and the fifth stage, adolescent response, considers the adolescent's response to the parent's behavior (Hayes, Hudson and Matthews, 2003).

Parental supervision has been considered one of the best methods of protecting children from abuse, delinquency and other negative forms of behavior (Turner, Finkelhor and Ormrod, 2007). However,

studies linking parental monitoring to child victimization have been sparse and contradictory, the most common reason for this being that parents tend to increase monitoring efforts in response to initial child victimization (Esbensen, Huizinga and Menard, 1999). Parental monitoring is often defined as establishing such methods of parenting and family relationships that promote autonomy, closeness and connection (Fosco, Stormshak, Dishion and Winter, 2012). It also represents parents' awareness of the adolescent's daily activities (Copeland-Linder, Lambert, Chen and Lalongo, 2011). From all of the above, it can be concluded that parental monitoring represents a set of all parental behaviors with the aim of obtaining information about the activities and lives of young people (where they go, what they do, who they hang out with, how they behave, etc.) and they differ according to style, frequency, shape and context.

Parental control

Parental control of behavior is a form of monitoring in which parents require their children to inform them and ask for permission about their unsupervised free time, without parents having to provide additional guidance or feedback to their children (Vrolijk et al., 2023, p.1180). Control represents such child-rearing measures that are aimed at monitoring and regulating children's behavior by setting and implementing rules, standards and regulations (Barber and Xia, 2013). These rules can be rigid and flexible. The rigidity or strictness of the rules represents the demandingness of parents and the imposition of negative consequences in response to the observed negative behavior of children. It represents a parenting style that is closely related to parental control. Different forms of parental control can have different effects on child development: Behavioral control is conceptualized as a set of active parental strategies that include the communication of clear and consistent expectations for appropriate behavior and efforts to monitor the child's behavior in relation to these expectations (Akcinar and Bajdar, 2014). While behavioral control was often associated with positive outcomes for the child, harsh control (physical or verbal punishment and intrusiveness) was often associated with negative developmental outcomes (Janssens, et al., 2015).

When we talk about parental control in the literature, we often encounter a certain dichotomy related to behavioral control and psychological control. It is necessary to distinguish between these two forms of control. According to Barber, Olsen and Shagle (1994, p. 1120), these differences stem from the developmental characteristics of each child, which are reflected in the fact that:

- all developing children require an adequate degree of psychological autonomy, i.e. to learn through their social interactions that they are effective, competent persons with a clear sense of personal identity and
- sufficient regulation of behavior to enable them to learn that social interaction is governed by rules and structures that must be recognized and respected in order to be competent members of society.

Psychological control is a parenting style that tries to manipulate children's thoughts, emotions and behavior by suppressing their autonomy. This is accomplished through the use of tactics such as withholding love, imposing guilt, attacking the child's personality, ignoring their thoughts and feelings. This dysfunctional parenting strategy is believed to impair children's psychological development, and is therefore subject to numerous criticisms that consider it a form of child abuse. On the other hand, although parental control sets certain limits on children's independence, it also provides important parental supervision and guidance. This form of supervision allows parents to better understand the daily routine of their children, know where they are and enables them to communicate with the children in a timely manner in case of unacceptable behavior. This type of parental control helps prevent future behavioral problems and delinquency because children internalize basic principles and social norms through this interaction. Although children's autonomy and independence from parental influence is considered a desirable stage in development, in the literature we encounter the term "premature autonomy" which can be problematic. It occurs during puberty (13-14 years), when parents tend to give up support and monitoring, and adolescents tend to move away from parental support and supervision. Often, adolescents begin to become more involved in social activities with their peers (Stewart et al., 2019). The problem arises when an adolescent spends his free time with a society that is prone to antisocial forms of behavior and delinquency. The time of independence and autonomy of a child is different for each individual and depends on numerous factors of the child's personality, family capacity and parenting skills.

What is the connection between parental control and the manifestation of delinquent forms of behavior? The results of the research carried out so far show a certain degree of contradiction. [Hoeve et al. \(2009\)](#) meta-analysis found that parental control produced only a small to moderate effect on reducing delinquency while [Melotti et al. \(2018\)](#) prove that parental strictness, by itself, was ineffective in reducing delinquency. The method of obtaining information about parental control and delinquent behavior of children was also a problem in some researches. Information provided by parents themselves about their parenting and their children's problem behavior is often biased because parents tend to give socially desirable responses and avoid reporting problem behavior to others ([Morsbach and Prinz, 2006](#)).

Parental knowledge

Parental knowledge is a key concept that is often used in research dealing with parenting and parents' relationships with their children. It refers to the ability of parents to be aware of their children's activities and locations when they are outside their direct supervision or adult control ([Stattin and Kerr, 2000](#)). This concept is not the same as active monitoring or surveillance, although these elements are often linked. Research has shown that there is a difference between parental knowledge and active monitoring strategies ([Stewart et al., 2018](#)). While active monitoring involves parents' direct supervision and control over their children's activities, parental knowledge refers to informing parents about how their children spend their time when they are out of their direct control. This means that parental knowledge is not only a result of parenting style, but is more related to parents' awareness of their children's activities and their social circles. This information can contribute to a better understanding of the child's behavior, needs and challenges he faces, which can facilitate communication and support of parents.

Studies investigating the relationship between parental knowledge and adolescent delinquency or behavior problems have provided significant insights into the role of parental supervision and information in the prevention of such problems. Even those studies that measured parental supervision showed that they are based on determining the level of parental knowledge and information about children. Although supervision measures may have previously been believed to be key to reducing adolescent conduct problems, recent research suggests that parental knowledge is actually a result of parental supervision ([Hoeve et al., 2009](#); [Racz and McMahon, 2011](#)). These findings indicate that parents who actively monitor and communicate with their children are more likely to gain information about their children's activities and behavior. This knowledge, in turn, can help parents recognize potential behavioral problems and provide appropriate support and guidance to their children. According to the results of the study, a high level of knowledge and information of parents is highly correlated with a lower level of abuse of psychoactive substances ([Steinberg, 2001](#)) and delinquent behavior ([Rudi and Dworkin, 2018](#)).

Parental solicitation

One of the terms associated in the literature with parental monitoring and control is "parental solicitation". It is often defined as an active form of parental behavior that seeks information from the child and actively participates in gathering information from the child. It represents a form of monitoring in which parents ask or start conversations with their children about their activities ([Stattin and Kerr, 2000](#)) with the aim of gaining knowledge about everyday activities. From the above, we can see the connection with the previous terms parental monitoring and parental knowledge. It should also be noted that parental solicitation is different from the term that we will define in the next part, which refers to "child disclosure". This difference refers to the fact that with this term parents seek and initiate communication with children in order to obtain information, while with "child disclosure" young people decide for themselves what information they will give their parents about their activities.

Studies dealing with parental solicitation provided different data on the connection between this type of parental acquisition of knowledge and delinquency. Some suggested that there is no connection at all ([Tilton-Weaver et al. 2013](#)), while other studies found a significant connection between these two variables ([Crocetti et al., 2016](#)). Other studies have tried to explain why there are such different research results on the same phenomenon, which considered that the relationship between parental solicitation and delinquent behavior of young people is influenced by numerous other factors. The very feeling of children on parental solicitation is different and in some cases it can be perceived as aggressive and excessive, while other children can accept it as help and guidance. At the same time, parental abdication,

i.e. the tendency of parents to separate from their children when their behavior is more deviant, can have an impact on the parent-child relationship and indirectly on parental questioning (Crocetti et al., 2016).

Child disclosure

Child disclosure is an important concept in the research of parental behavior and the relationship between parents and children. It is a passive form of parental behavior in which the adolescent self-initiated and voluntarily shares information with parents about his activities, behavior and way of spending time, as well as his social contacts. In recent literature, child disclosure is considered one of the key predictors of juvenile delinquency and behavioral problems, and is related to parental behavior (Lahey et al., 2008). It is important to emphasize that adolescents will communicate information to their parents to varying degrees, which depends on various factors. One of the key factors is the trust that develops between parents and children. This trust is two-way and implies a feeling of security and openness in communication. The most significant form of open communication between children and their parents is that which is spontaneous and does not require coercion or imposition on the part of the parents. On the other hand, children's secrecy towards their parents is also an important construct that requires the attention of researchers.

Studies investigating the dynamics of child disclosure are particularly important in understanding the problem of delinquency. Research results suggest that certain parental behavior can facilitate child disclosure (Soenens et al. 2006), which confirms the importance of the role of parents in monitoring and preventing delinquency. However, there is a constant need for a better understanding of the dynamics of child disclosure and the identification of other factors that can facilitate this process.

As we can see from the above definitions of terms that are related to parental monitoring and control, it could be said that it is a collection of literature that deals with this field rather than a definition from different aspects. Each theoretical point of view from its own point of view tries to explain this term without clearly set boundaries between the activities of parents that are implied by the above terms.

Discussion

The emergence of delinquent behavior patterns among young people is associated with several factors, among which a low level or complete absence of parental supervision is considered key (Patterson et al. 2005). Two other risk factors responsible for the manifestation of antisocial behavior are adolescent membership in peer groups that are prone to committing criminal acts (Burnette et al., 2012) and exposure of adolescents and youth to violence (Barr et al., 2012). However, juvenile delinquency is a complex phenomenon whose etiology depends on numerous factors that cannot be observed in isolation. Given that a healthy and functional family is the basis of every society, and the patterns of behavior that are acquired in the family are the basis of the upbringing of each individual, while harmonious and functional family relationships are one of the most important conditions for the proper development and growth of children (Matijašević and Dragojlović, 2022, p. 92). The educational function of the family is one of its basic functions and represents the raising of new generations into acceptable and reliable members of the social community (Stattin and Kerr (2000)). The modern moment of growing up and raising children brings with it certain characteristics that did not even exist in the earlier period. Throughout history, parents have always had the need to know where their children are, how they spend their free time, who they hang out with, and what activities they engage in. As we stated in the previous part of the paper, the way in which parents came to these findings is different. Today, parents burdened with numerous obligations and with little free time, are less and less motivated to deal with their children, but they are also prevented from devoting themselves to children when there is a will and desire for it. How much do today's parents know, how can they know where their child is, do they have enough time to spend with their children and dedicate themselves to their education to the extent necessary? These are all questions that require answers from society, the state, and science. How to define monitoring after a large number of studies, analyzes and research, is a question to which there is no clear answer even today. Terminological vagueness prevents precise and clear evaluations of how and in what way parents should control their children, how to gather information about children, how to control without endangering the autonomy of their children. The maturity limit of adolescents and children has changed and decreased

over time, so that the level of knowledge and maturity of children in the modern moment is above the level of knowledge and maturity of their peers 20 years ago. Individual studies examined certain aspects of youth behavior (sexual behavior, externalizing problems, delinquency) and their connection with parental monitoring and control. The literature examining parental control and juvenile delinquency suggests that rule setting is only marginally effective in improving child or adolescent behavior. [Stattin and Kerr \(2000\)](#) found that parental control was significantly associated with lower rates of juvenile delinquency, but other factors, such as spontaneous disclosure of where the child was and what he was doing, were much more important in predicting delinquency.

What and how much do parents know?

In modern society, the problem of parental control is becoming more and more urgent and topical, especially considering the increasing frequency of teenage suicides, which are in some way connected to the Internet activities of young people. Among the many factors that contribute to these tragedies, the lack of involvement and detachment of parents from their children's lives, both in the real and virtual worlds, plays a significant role. Also, the inability of parents to build open and truly trusting relationships with their children further aggravates the situation.

The modern style of parental behavior reflects the low level of control function in modern families. In a world where technology and digital platforms are ubiquitous, parents face challenges they could not have imagined before. Children spend more and more time on the Internet, exposed to various contents and influences, and parents are often not sufficiently involved in their online activities. One of the special forms of violence that is more pronounced among children is digital violence, which is increasingly attracting the attention of experts ([Merdović and Vujović, 2022, p.68](#)). Parents have the illusion of the fact that the children are at home and in their room and that they are safe there. Lack of control and supervision can lead to problems such as cyberbullying, exposure to harmful content or the development of Internet addiction, all of which together can have serious consequences for the mental health and well-being of young people. Lack of openness and trust in parent-child relationships can contribute to feelings of loneliness, misunderstanding and lack of support among young people. When young people do not have a secure support in their parents, they can feel isolated and insecure, which can lead to depression, anxiety and, in extreme cases, even suicidal thoughts. Due to all of the above, the topic of parental control on the Internet is becoming more and more important.

As a result of the violence suffered by children on the Internet, two suicides of minors took place in Serbia, while several more suicides of young people were recorded. One of the events that shook the whole society was the group murder that happened in May 2023 in the elementary school "Vladislav Ribnikar" in Belgrade, when a child killed 10 and wounded 6 people using a firearm. This event was a turning point in the actions of numerous state bodies and services. The responsibility of the security sector, educational institutions, society as a whole was demanded. It is difficult to explain the causes of this phenomenon, which happened for the first time in Serbia and which is characteristic primarily for the US, where for years there has been a great debate about how and in what way such criminal acts can be predicted ([Bjelajac and Merdović, 2019, p. 567](#)). After media pressure and general panic in society, the responsibility of parents was demanded. Many questions were asked: how did the child come into possession of the weapon, who taught him to use the weapon, what did the child do, how did he spend his time, how come the parents didn't notice anything? It is precisely because of such questions that parental control and monitoring are once again in the focus of interest. The criminal proceedings that were initiated against the child's parents have calmed the public to some extent and they are still in progress with the media bidding on how many fines they will receive. The lack of a system is reflected in the fact that society and the system do not have a clear answer to such situations. There are no legal mechanisms that will be applied to a person who does not have criminal capacity, and who commits such a crime. Criminal responsibility implies that the perpetrator is over 14 years old, which led us to a situation where the perpetrator of this crime of murder under special circumstances could only be placed in an institution for mentally ill persons with constant supervision and control by medical staff and physical security. But what about parental control, could parents have done more, should they have known what their child was doing on the Internet and what content he was using and visiting, how the child came into possession of the weapon? Questions to which we are all looking for an answer and call for vigilance for each of us

to ask where is the limit of control and where is the free assessment of respect for children's autonomy and independence. Parental responsibility is important and must exist. Legal qualifications also exist but are apparently not applied in practice. Our legislation, criminal and misdemeanor, foresees certain incriminations of parents and guardians in cases of educational neglect and neglect of children. Article 193 of the Criminal Code stipulates that "a parent, adoptive parent, guardian or other person who, by grossly neglecting his duty of care and education, abandons a minor whom he is obliged to take care of, shall be punished with imprisonment for up to three years". However, this wording refers more to the protection of the child itself from abandonment and neglect in terms of providing the best conditions for the child's development and takes into account the best interests of the child, and less refers to the responsibility of parents for the behavior of children and minors. It is similar with family law where, in accordance with international conventions, only the protection of children's interests is taken into account. These days in the US, the first judgment was passed against the parents, i.e. the mother of the mass murderer boy who killed 4 students and wounded 7 in the school in 2021. This is one of the first and rare cases in the world where the parents were convicted because they failed to take all measures as parents towards their child, because they did not provide him with adequate health care considering that he exhibited mental disorders and because she provided the child with free access to weapons ("Historic verdict in America...", 2024). Analysts believe that this case represents a turning point in the prosecution of mass murderers in the US, although they cite numerous arguments disputing the responsibility of parents.

This case, as well as numerous others that always cause public concern and sensationalist reporting in the media, initiates a debate among ordinary citizens about what the parents were doing and why they did not worry about where and what their child was doing. This is especially evident in events that are increasingly linked to the Internet and social networks.

It follows from the above that the urgency of the problem of parental control in modern society cannot be ignored. Parents should be actively involved in their children's lives, both offline and online. It is necessary to build open, confidential relationships based on mutual respect and understanding. Also, it is important to establish clear boundaries and rules regarding the use of technology and the Internet, providing children with support and guidance in the safe use of digital media. Only in this way can we reduce the risk of serious problems such as violence, delinquent behavior, self-aggression, etc.

Adapting educational methods to the modern moment is something that is necessary. Following trends and innovations, most parents try to control their child's movements by using digital location tracking devices (Smartphones, tablets) that children use (Burnell, Andrade, Kwiatek and Hoyle, 2023). In this way, parents try to know where the child is physically located, but they cannot know what the child was doing in that place and who he was with if there is no communication and trust in the parent-child relationship. Some parental control through certain applications on the phone can limit the time spent on the Internet, but not completely and control the content that the child uses and visits. There is also the question of how well parents are educated to control and monitor their children on the Internet. There is a very small number of studies that deal with this issue and especially the new ethical, developmental and sociocultural issues arising from the use of digital monitoring of children. There are numerous debates that are primarily related to the issues of consent, privacy, autonomy and independence of young people.

Each child carries with him or her individuality and specificity, so there are no unified methods of monitoring and control that are applicable to all children. The parent must make his own assessment of which educational methods and gathering information about the child will give the best results. Sometimes parents can rely on and give freedom and trust to children by relying on a wrong or unrealistic image of their level of maturity. Parental supervision and control represents forms of behavior aimed at obtaining information about the activities and life of young people. However, which monitoring behaviors are feasible, appropriate, and adaptive vary significantly across developmental and sociocultural contexts (Petersen, Choe and LeBeau, 2020). Many studies have shown that the nature or effectiveness of parental supervision may vary depending on the child, family (structure, family relationships, socio-economic status) and environmental characteristics.

In order to get a clearer picture of parental supervision and control, in addition to the factors mentioned above, it is important to mention some others that are very significant and can influence the outcomes of these forms of parental behavior. One of the important factors that affects the relationship between parental behavior styles and the manifestation of certain forms of behavioral disorders is the age of the child. This influence is most dominant at a younger age, and with the growing age of the child, this

influence weakens. That weakening is a consequence cumulative, reciprocal influences of each member of the parent-child relationship on each other over time (Reid, Patterson and Snyder, 2002). The gender of the child is one of the factors examined in numerous analyses. Lack of control and parental supervision in boys indicates a higher level of delinquent behavior (Kuppens, Laurent, Heyvaert and Onghena, 2013). Who supervises and controls, the father or the mother or both, is also one of the factors that affects the child's behavior differently. Usually, the mother is the one who cares more about the upbringing of the children and is more involved in the children's daily activities. Some studies examined the relationship between motherhood and the manifestation of delinquent behavior and found that this relationship is more significant than that of fathers (Kuppens et al., 2013).

Conclusion

Parental supervision is a key component in the relationship between parents and adolescents, and understanding its complexity is essential for the development of effective strategies for the prevention of juvenile delinquency and other forms of antisocial behavior. The paper analyzes the existing theoretical definitions and operationalization of parental supervision and control, from which the lack of clarity and agreement among researchers is recorded. In this context, the paper proposes new formulations that encompass multiple dimensions of supervision, including not only parental control, but also adolescent disclosure and trust. Through the analysis of deviant and antisocial behavior of adolescents, the paper shows how this multidimensional concept of parental control is reflected in the complex relationship between control and trust. The conclusion is that control alone, without trust and disclosure, can have a limited or even counterproductive effect in preventing deviant behavior in adolescents. These results emphasize the importance of promoting open communication and mutual trust between parents and adolescents as a key factor in the prevention of risky behaviors.

Although parental supervision can be an important factor in the prevention of juvenile delinquency, it is necessary to address the basic social and economic factors that contribute to the behavior of risky adolescents. It therefore calls for a holistic and preventive approach that should focus on correcting criminogenic environmental factors and providing support and resources to parents. We believe that parental supervision and control is a multidimensional construct that takes two-ways place in the parent-child relationship. We pointed out the fact that the occurrence and frequency of deviant and violent behavior in adolescents appears as a complex relationship between control and trust, which overcomes the old assumption that control of children is sufficient to prevent deviance. This seems to be an interesting result, along with the finding that parental control, where not accompanied by adolescent disclosure and/or parental trust, may even "encourage" such deviant actions. Our results could support professionals working with families in the development of educational and training programs where the emphasis is placed not only on control, as the only effective means of preventing adolescents from risk and antisocial forms of behavior, but rather on promoting mutual trust and open communication between parents and adolescents. The conclusion is that the existing legal solutions must be applied and not only exist declaratively. Modern families and parents are faced with numerous challenges in raising children, which they cannot ignore without the help of experts and the state. That is why the reaction of all relevant subjects in the education of parents about parenting techniques and parenting skills that give the most adequate results at a given moment is necessary. It is necessary to take all measures to protect children and young people from the negative influences of the external environment, especially in the online space. On the other hand, it is also necessary to find out how and in what way children spend their time without the direct supervision and control of parents and elders. The balance between control, supervision, entrusting children to their parents and the autonomy and independence of children is an ideal to strive for and a path to guide young people. Leaving and turning in either of these two directions leads to antisocial behavior of minors, which often turns into delinquency. The latest events in our society (mass shootings) call for vigilance and engagement of all segments of society, that minors must not be left to their own devices, but that supervision and control must always be present, with the building of a relationship of trust and respect in the parent-child relationship.

Juvenile crime is undoubtedly a complex social challenge that requires a multifaceted and diverse response, and while adequate parental supervision and control can indeed prove to be an effective

measure to reduce the incidence of criminal behavior among young people, this populist focus on parental responsibility must not distract from the need that society deals with the basic conditions of social and economic deprivation that worsen the difficulties of parenting and therefore cause delinquent behavior of young people who come from such families.

Conflict of interests

The authors declare no conflict of interest.

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