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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; Iivari 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 VanBerschot, 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 sript 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 Ha:

Ha: 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.

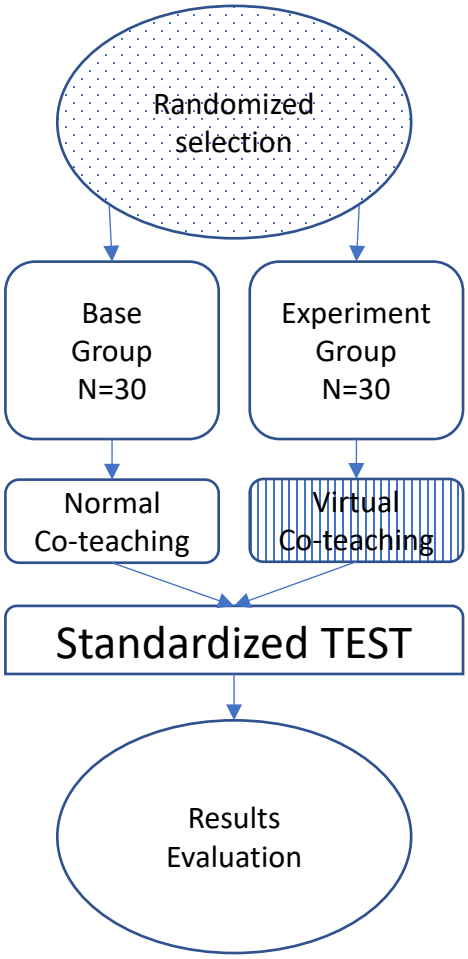


*Figure 1. Description of experiment.*

## 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.

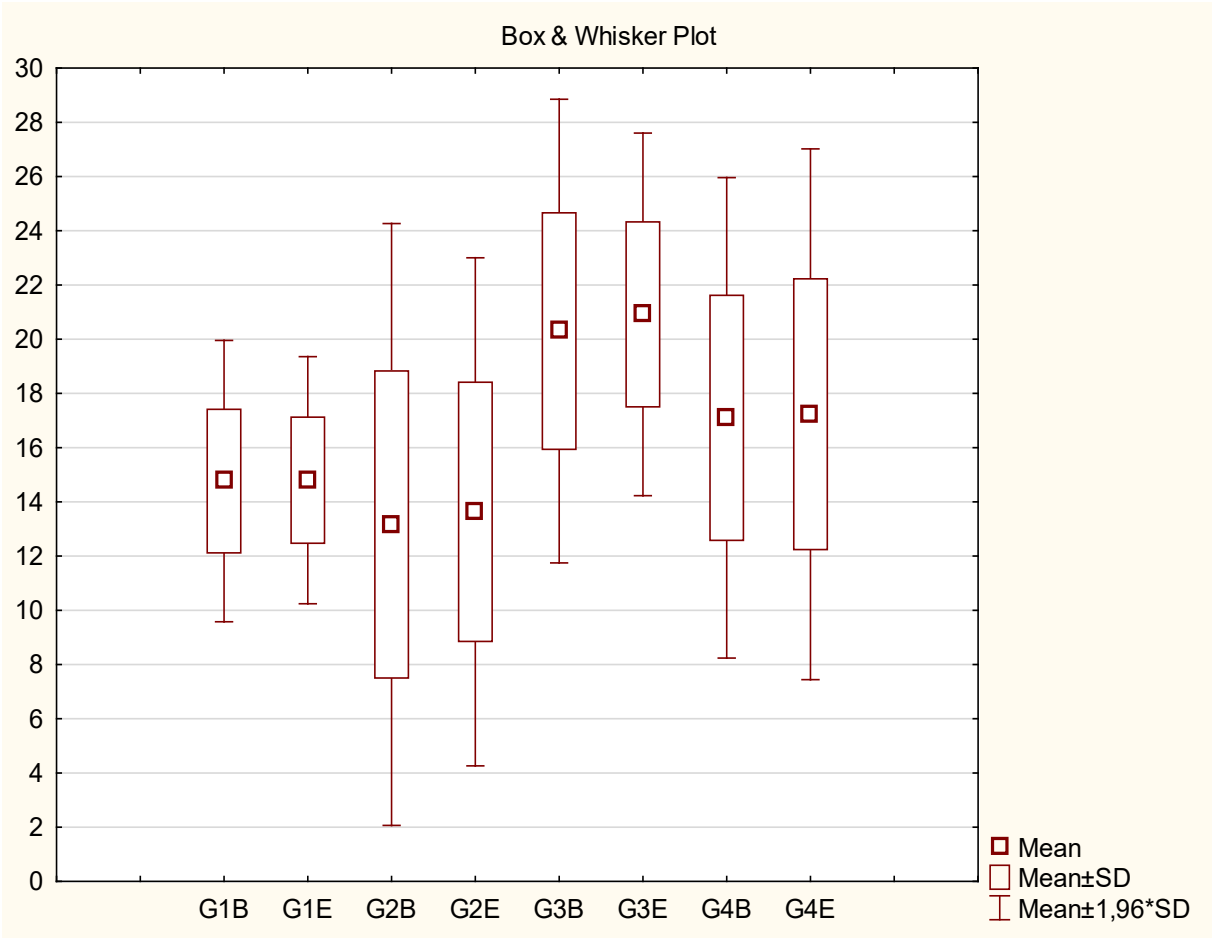


*Figure 2. Summary statistics – comparison of all groups test results.*

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

IIn 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-teachnig 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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