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# The Impact of an Informatics-Developmental Teaching Approach in the Subject Nature and Society on Students' Motivation

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**Abstract:** In this study, we examined the extent to which implementing an informatics-developmental teaching approach with e-learning in the Nature and Society course influences student motivation. The motivation level of ten-year-old students was assessed before and after implementing this instructional approach, comparing an experimental group (innovative instruction) to a control group (traditional approach). The research was conducted using a parallel-groups experimental design on a sample of 189 fourth-grade primary school students. In the experimental group, the subject was taught following an informatics-developmental model using digital technologies (tablets, multimedia content, gamification elements), while the control group was taught using a traditional approach. Student motivation was measured with an adapted Likert scale before and after the intervention. Data were analyzed with descriptive statistics, independent and paired-samples t-tests. Before the experiment, no significant difference in motivation was found between the two groups. At the final measurement, the experimental group had a statistically significantly higher level of motivation than the control group. The findings confirm that innovative, digitally supported instruction can enhance students' learning motivation compared to traditional methods. The contemporary approach fostered greater student engagement and interest, which was reflected in a rise in their motivation. It is recommended to more broadly implement digitally enriched instructional strategies in primary schools to stimulate student motivation. It is also necessary to provide continuous professional development for teachers for effective integration of ICT in instruction. Future research should consider the long-term effects of such innovations and their impact on various educational outcomes.

***Keywords:*** *informatics-developmental teaching, student motivation, digital technologies in education, Nature and Society, primary school, artificial intelligence.*

## Introduction

Traditional elementary school teaching, which is lecture-based and identical for all students regardless of their individual needs and capacities, is increasingly showing significant shortcomings relative to the modern demands of education. Criticisms of this approach include the uniform pace of instruction and content that are not adapted to the diverse speeds, interests, and learning styles of all students. Instead of deep understanding, students often study for grades, which leads to insufficiently developed competencies that they will need in their future. In simple terms, the traditional education system does not provide an adequate foundation for developing the competencies required by contemporary students, which is why fundamental changes are necessary.

From the earliest childhood, through exploration and discovery of the world, a child builds their own understanding of the environment, and starting school represents a significant turning point in that process—not only for the child but also for the family—since the teacher and peers enter the educational context as new actors. Contemporary educational trends, which are rapidly changing, necessitate innova-

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tive approaches in teaching, especially in subjects such as *Nature and Society*, which provide a broad scope for applying information and communication technologies to encourage student development and understanding of the world. Among students entering secondary education, a tendency of declining motivation has been observed (Chouinard, Roy, Archambault, and Smith, 2017; De Bruijn, Ehren, Meeter, and Kortekaas-Rijlaarsdam, 2025). Therefore, researchers highlight the necessity to examine the causes of this issue within the context of earlier schooling, particularly the manner in which instructional activities are conducted in primary school. Developing interest and motivation at that stage provides the basis for an individual's later personal and professional development. An individual's active participation and engagement in society will play a crucial role in a future increasingly characterized by scientific and technological advancement.

## Theoretical Framework

### Informatics-Developmental Teaching and the Zone of Proximal Development

A. Diesterweg, a 19th-century German pedagogue, laid the groundwork for *developmental learning* by emphasizing the importance of independent student work in the teaching and educational process. L. S. Vygotsky formulated the theoretical basis of developmental instruction through his interpretation of the relationship between learning and development, which became the foundation for further research by his followers. D. B. Elkonin developed a strategy in which he stressed the significance of instructional content as a driver of students' intellectual development, building on Vygotsky's model. L. V. Zankov contributed to the development of teaching practice by introducing dynamic changes in working methods, focusing on the comprehensive development of students. V. V. Davidov, in contrast to the empirical orientation of Zankov's team, argued that knowledge develops through classification, comparison, and abstract thinking (Davidov, 1995; Elkonjin, 1990; Bujišić, 2023). In that context, contemporary instruction strives to transcend the patterns of the traditional approach, not by discarding its valuable elements but by reinterpreting them toward fostering student development through exploration, sensory experience, and rational thinking. Existing literature indicates a wide spectrum of information on traditional teaching and its limitations, while empirical evidence on the informatics-developmental model is limited. Traditional teaching is positioned as a model based on "ready-made" knowledge that teachers transmit, expecting students to reproduce it — the lowest level of cognitive skills. Modern authors advocate a competency-based educational system that values understanding, application, and reasoning, and develops digital and algorithmic literacy, along with inclusiveness and personalization in learning. In contrast to traditional, passive instruction, contemporary authors stress that students should actively engage in constructing knowledge rather than merely memorize it (Nikolić, 2019; Bujišić, 2023; Mandić, Miščević, Babić, and Matović, 2024). In informatics-developmental instruction, tools and a supportive environment are used to place the student in the role of a researcher, which in turn increases motivation to learn because the learning is carried out in a modern way and influences other aspects of the student's personality (Bujišić, 2023). One possible solution that can overcome the observed shortcomings of traditionally conceived instruction is the informatics-developmental approach. It integrates digital competencies as part of a comprehensive educational process. Informatics-developmental instruction is a modern teaching model grounded in a heuristic approach and the use of information and communication technologies. This model enables students to construct knowledge independently, progress at their own ability level and pace, and develop their personal potential. Through an individualized and interactive approach, it also improves the quality of learning and collaboration in the educational environment (Bujišić, 2023). In Serbia, the subject *Digital World* has been introduced in the first and second grades of primary school, and digital competencies are included in the current *Years of Ascent* Preschool Curriculum Framework (Matović and Ristić, 2024; Years of Ascent Preschool Curriculum Framework Serbia, 2019). *The Strategy for the Development of Artificial Intelligence in the Republic of Serbia for 2025–2030* outlines plans to advance primary, secondary, and higher education in Serbia in the field of artificial intelligence. Moreover, student digital literacy—developed within formal education as a cross-curricular competency and within informatics education as a subject-specific competency—is mandated by strategic and program documents (Mandić, 2023; The Strategy for the Development of Artificial Intelligence in the Republic of Serbia for 2025–2030, 2025; Strategy for the Development of Digital Skills in the Republic of Serbia for the period 2020 to 2024, 2020). Modern educational technology, based on artificial intelligence (AI), is changing teaching methods and organisation toward heuristic learning and active students participation. Teachers are not delivering final knowledge so students are using several didactical resources, including AI, to develop their own concepts. Developmental teaching approach increases critical thinking, reflection and self-reflection in new concept of educational technology.

Considering a social-constructivist approach, it is important to highlight L. Vygotsky's theory of the *zone of proximal development* (ZPD), in which students, through social interaction, take on and internalize ways of thinking and methods that they will later use independently, with tasks that are challenging enough to spur progress but not so difficult as to demotivate the learner. In collaboration with others, a child can achieve more than they can alone – but only up to the limits allowed by their developmental maturity and intellectual abilities (Vygotsky, 1978). In Vygotsky's theory, the competent person who actively helps the learner can be a teacher or a more advanced peer, actively stimulating interest, providing structured help by demonstrating effective strategies and reducing task complexity, thereby preventing cognitive overload. Over time, the student progresses and becomes increasingly independent, and support is gradually withdrawn. Research on integrating AI tools into higher education using the ZPD framework found that AI tools enable students to self-assess their progress, increase motivation and engagement, and build knowledge collaboratively—resulting in better academic performance and personal development (Cai, Msafiri, and Kangwa, 2025). Although modern educational technology is not literally an "advanced" peer or adult, in Vygotsky's sense it has the potential to significantly support students within their ZPD. Through adaptive personalization, dynamic support, and timely feedback, technology enables learning tailored to individual student needs. It facilitates collaborative and peer learning activities via various digital tools and platforms. Even relatively simple, expert AI systems can perform certain scaffolding functions (Sætra, 2025). They allow the application of various forms of *scaffolding*—conceptual, procedural, strategic, and metacognitive—thus supporting the development of meaningful schemata of understanding. Artificial intelligence and learning analytics function as cognitive tools which, together with the teacher as designer, ensure creative, adaptive, and goal-driven development of technology-enhanced learning scenarios within the ZPD (Rigopouli, Kotsifakos, and Psaromiligkos, 2025). In addition, technological tools adjust the learning pace and gradually redirect students towards greater autonomy, promoting the development of self-regulation and critical thinking. With such an approach, the student, through gradual self-reliance, becomes more competent in managing their own learning process, while technology—although not a substitute for social interaction with an adult—serves as a cooperative ally in learning.

**Importance of Motivation for Learning**

Motivation is examined in behaviorist, humanistic, cognitive, and other theoretical frameworks; behaviorism highlights the role of external reinforcements, cognitivism focuses on internal mental processes and personal goal evaluations, and social factors significantly affect the development of self-assessment and the shaping of students' learning motivation. It is a psychological process that initiates, directs, and maintains our activities toward achieving a specific goal, and it is permeated by enthusiasm and determination to reach that goal through the initiation and maintenance of proactive behavior (Bandhu et al., 2024; Pekrun, 2024). Motivation can originate internally—from the desire for enjoyment, personal development or accomplishment—or externally, through rewards, recognition, or external expectations. Students who study because something genuinely interests them or because they want to succeed achieve better results than those who learn only due to external rewards or pressures (Šafranj, Bulatović, and Gak, 2024). Artificial intelligence can become a powerful motivational accelerator and a source of competency-based achievements for students, not by replacing the teacher but by supporting them so that each child progresses more independently, with greater interest and confidence in their own abilities (Mandić, Miščević, and Bujišić, 2024; Mandić, Miščević, and Ristić, 2025; Miščević, Starijaš, and Petrović, 2025). Thus, when the opportunities offered by the use of AI are employed with careful design, it can lead to fulfilling students' psychological needs. Effective models need to incorporate the following components: adaptive systems pre-adjusted to the students' ability level; opportunities for students to participate in the choice of learning activities; a visually rich and comprehensible interface adapted to the students' age; real-time constructive feedback. All of the above should be implemented with teacher support, in an inclusive and ethically responsible manner. When AI capabilities are combined with careful pedagogical design, models can include adaptive systems tailored to student ability, allow students some choice in activities, offer age-appropriate visual interfaces, and provide real-time constructive feedback—all under teacher guidance to ensure inclusivity and ethical use.

## Materials and Methods

The aim of this research is to determine how the implementation of electronic learning in informatics-developmental instruction of *Nature and Society* classes affects student motivation by comparing their motivation before and after an experimental program in the experimental and control groups. The task is to examine the level of motivation for learning about nature and society among students in the experimental and control groups during Nature and Society classes before and after the implementation of the experimental program. The hypothesis states that students in the experimental group, after the application of informatics-developmental instruction, will exhibit a significantly higher level of motivation for learning *Nature and Society* compared to students in the control group who have used a traditional approach.

The independent variable is the teaching method: the experimental group was taught *Nature and Society* using an informatics-developmental approach supported by e-learning (encompassing computerization, interactivity, constructivism, heuristic methods, self-evaluation, and appropriate technical equipment), whereas the control group was taught using a traditional approach. The dependent variable is students' motivation for learning about nature and society, measured as a summative score on a five-point Likert scale before and after the intervention.

We employed a parallel-groups experimental design to investigate the effect of informatics-developmental instruction on student motivation. The measurement instrument was a motivation scale constructed for this purpose, administered before and after the intervention. The instrument demonstrated high objectivity (Pearson $r$ = .99 for agreement between two independent raters) and an acceptable level of reliability, with Cronbach's α ranging from .69 to .72 for the experimental and control groups at the initial and final measurements. The study was conducted over four months within regular classes, during which motivation was measured at the beginning and at the end.

The sample of participants consisted of four control classes and four experimental classes of students from Belgrade (Serbia), totaling 189 fourth-grade students. The sample of instructional content covered the teaching topic "Natural and Social Features of Serbia" from the fourth-grade *Nature and Society* curriculum.

The experimental and control groups were equated based on two variables: approximately the same number of students and the classes' average grade in *Nature and Society* at the end of the previous school year. The groups did not differ statistically significantly, as evidenced by a t-test, $t(189) = -0.67$, $p > .53.8$

Data were processed using the SPSS statistical package (version 23.0). We used the following statistical analyses:

- Descriptive statistics – including arithmetic mean, standard deviation, minimum and maximum score, skewness, and kurtosis.
- Cronbach's alpha coefficient – to assess the reliability of the motivation scale instrument.
- Independent-samples t-test – to measure differences in motivation for learning *Nature and Society* between the experimental and control groups.

## Results

**Table 1.** *Descriptive statistics and differences between experimental and control groups on the initial motivation test (independent-samples t-test)*

| Group | Min | Max | M | SD | S | K | *t* | *df* | *p* |
|---|---|---|---|---|---|---|---|---|---|
| EG (Experimental) | 5 | 23 | 14.14 | 5.24 | –0.02 | –1.29 | 1.74 | 187 | 0.084 |
| KG (Control) | 5 | 25 | 15.45 | 5.08 | –0.11 | –1.08 | | | |

Note. EG = experimental group; KG = control group; M = mean (arithmetic mean); SD = standard deviation; S = skewness; K = kurtosis; t = t-test; df = degrees of freedom; p = significance level

After introducing the experimental factor—the informatics-developmental teaching approach in *Nature and Society* classes—the next step was to measure the differences between the experimental and control groups at the final measurement of motivation, as presented in the following table.

**Table 2.** *Descriptive statistics and differences between experimental and control groups on the final motivation test (independent-samples t-test)*

| Group | Min | Max | M | SD | S | K | *t* | *df* | *p* |
|---|---|---|---|---|---|---|---|---|---|
| EG (Experimental) | 5 | 25 | 16.13 | 5.30 | –0.22 | –0.80 | –2.83 | 187 | .005 |
| KG (Control) | 5 | 25 | 14.03 | 4.90 | 0.12 | –0.63 | | | |

***Note.*** EG = experimental group; KG = control group; M = mean; SD = standard deviation; S = skewness; K = kurtosis; *t* = t-test; *df* = degrees of freedom; *p* = significance level.

**Table 3.** *Differences between the experimental and control group on the initial and final motivation tests (independent-samples t-test)*

| Group | Measurement | M | SD | *t* | *df* | *p*1 | *r* | *p*2 |
|---|---|---|---|---|---|---|---|---|
| EG (Experimental) | Initial test | 14.14 | 5.24 | –2.95 | 90 | .004 | .25 | .015 |
| EG (Experimental) | Final test | 16.13 | 5.30 | | | | | |
| KG (Control) | Initial test | 15.45 | 5.08 | 2.16 | 97 | .034 | .15 | .144 |
| KG (Control) | Final test | 14.03 | 4.90 | | | | | |

**Note.** EG = experimental group; KG = control group; M = mean; SD = standard deviation; *t* = t-test; *df* = degrees of freedom; *p*1 =significance level of the t-test for that group's pre–post difference; *r* = Pearson correlation coefficient between values from the first and second measurement; *p*2=significance level of the Pearson correlation coefficient.

## Discussion

Based on the data from Table 1, the students in the experimental group obtained slightly lower scores on the initial motivation test compared to the students in the control group. The score range in the experimental group was from Min = 5 to Max = 23, while in the control group the range was somewhat broader—from Min = 5 to Max = 25. The average score of the experimental-group students (M = 14.14, SD = 5.24) was lower than the average score achieved in the control group (M = 15.45, SD = 5.08). An independent-samples t-test showed that the difference in mean motivation scores between students in the experimental and control groups was not statistically significant, $t(187) = 1.74$, $p > .05$. Therefore, prior to the introduction of the experimental factor, the level of motivation for learning *Nature and Society* was similar in both groups. In the experimental group, skewness (S = –0.02) did not indicate any significant departure from a normal distribution, whereas the kurtosis (K = –1.29) suggests a platykurtic (flattened) distribution, consistent with normality. A similar observation applies to the control group: skewness (S = –0.11) did not indicate any significant horizontal deviation, while kurtosis (K = –1.08) appeared to reflect a somewhat uniform distribution of scores (a leptokurtic profile). Based on these results, it can be concluded that the experimental and control group students demonstrated an equivalent level of motivation for learning *Nature and Society* on the initial test.

How this motivation develops further depends on teacher competencies, numerous variables in the student's environment, and the student's personal characteristics. We note here Davis's Technology Acceptance Model (TAM), which emphasizes that perceived usefulness and perceived ease of use decisively determine the acceptance of technology, as they shape the user's attitude and motivation toward actual use (Davis, 1989). In an educational context, students are more motivated to adopt modern information technologies when they perceive that these technologies will help them learn and are intuitive to use. Motivation, in the form of technological self-efficacy, has been identified as one of the key external variables that significantly contribute to user satisfaction, thereby expanding TAM's explanatory power (Latif, Saputro, and Barkah, 2025). Huang and Yang (2025) likewise recognize motivation as a subtle yet crucial element that complements the classic determinants such as perceived usefulness and ease of use, reinforcing the educational acceptability of information technologies by guiding students toward intention and actual application.

The results presented in Table 2 indicate that students in the experimental group achieved significantly higher average motivation scores compared to students in the control group. Specifically, the average score of the experimental group was M = 16.13 (SD = 5.30), whereas the average score of the control group was M = 14.03 (SD = 4.90). An independent-samples t-test confirmed that the difference between the mean motivation scores of the experimental and control groups was statistically significant. In the experimental group, skewness was not statistically significant (S = –0.22), further confirming the normal distribution of results; similarly, the kurtosis (K = –0.80) was not significant, which also suggests a normal distribution. The control group shows similar tendencies – neither skewness (S = 0.12) nor kurtosis (K = –0.63) indicates any deviation from normality. Babić and Matović (2025) emphasize that reliably integrating AI into education, with an optimal balance between teacher control and automation, requires proactive educational measures that can indirectly strengthen student motivation by providing a safer and more supportive technological environment. On the other hand, Stoković (2025) notes that incorporating educational robots into teaching develops algorithmic thinking and motivates students through practical problem solving, where the process of discovery and correcting mistakes becomes a key pedagogical incentive.

The data from Table 3 indicate that the control group experienced a decline in the average motivation score. On the final test, the control group's students (M = 14.03, SD = 4.90) scored lower than they did on the initial test (M = 15.45, SD = 5.08), and the difference between the initial and final measurements, with $t(97)= 2.16$, was not statistically significant at the $p < .05$ level. In the experimental group, by contrast, a significant increase in motivation scores was observed. On the final test, the experimental group's students (M = 16.13, SD = 5.30) achieved higher scores than on the initial test (M = 14.14, SD = 5.24). The difference between the initial and final measurements, with $t(90)= –2.95$, was statistically significant at the $p < .05$ level. For successful student motivation through ICT integration, it is necessary to devote equal attention to the school context (especially students' perceived usefulness of technology and teacher support) and to a stimulating home environment that fosters self-confidence and motivation (Huang, Gao, Kim, and Ohno, 2025).

In the final consideration of our hypothesis, it can be concluded that introducing informatics-developmental instruction has a positive impact on student motivation. Namely, the students in the experimental group, after the implementation of the given instructional method, demonstrated a statistically significantly higher level of motivation for learning the subject *Nature and Society* in comparison to the students in the control group, whose teachers relied on a traditional approach. The didactic-methodical component encompassed the application of information technology tools in accordance with the learning objectives and outcomes, as well as the use of ICT for active, problem-based, and project-based learning, and the individualization of instruction through the adaptation of pace and complexity to the learner's needs. Furthermore, it emphasized the affirmation of the teacher's role as a facilitator and mentor rather than a traditional lecturer, the encouragement of problem-solving and creative idea generation through technology, the promotion of collaborative learning via digital tools, and the monitoring of student progress through digital assessment instruments.

## Conclusions

The results of this research unequivocally show that the implementation of informatics-developmental instruction — which integrates digital tools and contemporary pedagogical methods — has a significantly positive impact on student motivation. A detailed interpretation suggests that the rise in motivation in the experimental group was a direct result of the well-designed pedagogical approach: students were provided with interactive and multimedia content appropriate to their age, along with the use of tablet computers and gamification elements (points, badges) that were carefully implemented. Such content made the material more interesting and accessible than in traditional teaching, which encouraged greater student engagement.

At the same time, the teachers organized learning within the students' zone of proximal development (ZPD) — each student was assigned tasks slightly above their current abilities, but these tasks were made achievable with initial support from a more capable partner (the teacher, a peer, or AI), and subsequently the student became able to solve them independently with the aid of technology and interactive guidance. This gradual transition from guided to independent activity increased the students' self-confidence and sense of accomplishment, which strongly contributed to the rise in motivation.

Implications for educational practice include:

- **Pedagogy over devices:** The mere availability of digital devices is not sufficient — the teacher's pedagogical creativity and competence in designing ICT-supported activities are crucial for success.
- **Teacher as mentor:** In the digital classroom, the teacher's role shifts from lecturer to mentor. The teacher should select appropriate digital tools, design interactive learning tasks, and guide students so that technology is used to achieve educational goals rather than serve as mere entertainment.
- **Teacher competencies:** A teacher's digital literacy and willingness to innovate directly influence the creation of a motivating classroom atmosphere.
- **Professional development:** It is essential to invest in continuous professional development for teachers to effectively implement modern instructional models and educational technologies.

In the broader context of digital education, these results provide empirical support for efforts to transform traditional teaching through thoughtful use of technology. The increased student motivation observed in this study corresponds to theoretical models of technology acceptance in education, which highlight that the usefulness and interactivity of educational technologies lead to more positive student motivation to learn. A practical consequence is that schools that strategically introduce digital platforms and resources—accompanied by adequate pedagogical support—can expect to have students who are more engaged and more ready for active learning. These results are also consistent with national strategies for the digitalization of education – they show that the integration of ICT, when accompanied by thoughtful pedagogy, can improve teaching quality and increase student motivation, which is important for developing the digital competencies of younger generations.

Finally, it is important to emphasize that this research is only a beginning in understanding the complex relationship between technology, pedagogy, and motivation. We recommend that future studies investigate the long-term effect of informatics-developmental instruction on sustaining student motivation over extended periods, as well as its impact on other educational outcomes such as academic achievement, critical thinking, and the development of 21st-century skills. It would also be beneficial to analyze how different factors—for example, the level of parental support or students' prior experience with technology—might modify the effect of such interventions. By further expanding research to different age groups, subject areas, and inclusive educational settings, we can gain a more complete picture of how digitally enriched teaching can contribute to improving educational processes. In this endeavor, teachers will continue to have a key role as agents of change; empowered with digital competencies and didactic knowledge, they can shape the future of education in accordance with the needs of contemporary society.

### Conflict of interests

The authors declare no conflict of interest.

### Author Contributions

Conceptualization, LJ.B.; methodology, LJ.B.; software, D.M.; formal analysis, G.M. and LJ.B.; writing—original draft preparation, LJ.B.; writing—review and editing, LJ.B, G.M., D.M.; Data curation LJ.B.; Formal analysis G.M. and LJ.B.; Funding acquisition LJ.B. and D.M.; Investigation LJ.B. and G.M.; Project administration LJ.B. and G.M.; Resources LJ.B; Supervision D.M., G.M and I.K.; Validation LJ.B.; Visualization I.K.

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The data supporting the findings of this study are available from the corresponding author upon reasonable request.

### Institutional Review Board Statement

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