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Impact assessment of learner motivation and learning outcomes in different e-learning environments

Doctoral (PhD) Dissertation Theses

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Eger, 31 August 2025

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Introduction

The rise of digital technologies has been one of the most significant changes in education in recent decades. E-learning environments and digital platforms are increasingly complementing and, in many cases, transforming traditional teaching methods. These environments not only facilitate access to knowledge but also influence the learning experience, motivation and learner achievement.

The coronavirus pandemic has accelerated the digital transition in particular: the rapid introduction of online forms of education has become necessary worldwide, which has posed new challenges for teachers and students. Generations Z and "Alpha" see technological tools as a natural medium, so their expectations are also different from those of previous generations: they may require immediate feedback, interactivity and flexible forms of learning.

National and international research (Molnár, Szűcs, Komenczi, Racskó) emphasizes that digital environments are not merely technological innovations, but bring profound pedagogical change. These transformations create new methodological approaches, support for learner motivation and opportunities for personalized learning. The European Union's Digital Education Action Plan (2021–2027) and the National Core Curriculum (2020) both highlight the need to develop digital competences and to make education flexible, experience-based and supportive of lifelong learning.

The digital competence of teachers plays a key role in this process: it is decisive not only in the delivery of content but also in the management of the learning process and in strengthening student involvement. Research shows that teachers who consciously use digital tools are able to motivate students more effectively and promote better learning outcomes. My research fits into this professional and social context.

1. Topic and objective of the research

The research focuses on the impact of e-learning environments on student motivation and learning outcome. The rapid development of digital technologies and the transformation of education have made it urgent to examine how different online and ICT-based solutions can contribute to the success of the learning process.

The purpose of the study is twofold. On the one hand, it aims to explore how interactive, digital learning environments affect student motivation, student engagement and the development of independent learning strategies. On the other hand, it seeks to understand the

impact of these tools and methods on learning outcomes and the extent to which they contribute to the effectiveness of education. During the research, special attention will be paid to the comparison of traditional ICT tools and interactive Web 2.0 technologies. The aim is to explore how different their effects may be on student motivation and performance, and which factors help learning success the most in digital environments. As the dissertation emphasizes, "the objective of the research is to explore how different electronic learning environments affect learning motivation and learning effectiveness." This central question determines the structure of the entire investigation, the formulation of hypotheses and the empirical analyses. The analysis discusses the opportunities and challenges that digital tools and methods bring to learning, and how environments can be created that simultaneously support personalized learning, learner autonomy and the achievement of effective performance. The rise of e-learning environments offers new opportunities in education but also challenges such as how to ensure learners' active participation and intrinsic motivation. In this context, it is of paramount importance to compare traditional ICT tools and interactive Web2.0 technologies, as it highlights the different ways in which different technologies affect student engagement and engagement.

In my dissertation, I consider the widely used electronic educational tools (e.g., "classical" audio-visual teaching aids, video, Power Point-supported lessons) as part of traditional education because they are part of the daily routine in today's educational practice. In a broader sense, this includes everything that the literature defines as Web.1.0. While traditional ICT tools basically supported static, one-way communication, Web2.0 technologies – such as social media, blogs or collaboration platforms – enable dynamic, multidirectional interactions. Web2.0 technologies have greater potential as they not only create opportunities for personalized learning but also bring community experiences to the forefront, which can strengthen engagement throughout the learning process.

The main goal of my research is to draw conclusions that help educational institutions to improve their methods, thus supporting personalized learning and commitment to lifelong learning. With the right application of technological tools, education becomes not only more effective but also more relevant, helping to ensure that students are prepared to face the challenges of the future.

3. Theoretical framework and context

The transformation of education in the 21st century is closely related to the rapid development of digitalisation, which has fundamentally transformed learning environments and student needs. The theoretical framework of the research is provided by three key factors: the theories of student motivation, the examination of learning effectiveness, and the pedagogical significance of electronic learning environments and artificial intelligence-based developments.

Theories of student motivation

In the research, various motivational theories helped to understand how digital learning environments affect students' motivation and effectiveness. According to **Maslow's hierarchy of needs**, students' motivation can only be strengthened if their basic needs, such as security, are ensured. Digital environments can support higher levels of learner motivation by addressing these needs. **Bandura**'s social cognitive theory focuses on the fact that learning can occur not only individually but also through the observation of others. This is particularly important for digital platforms, where learners can connect with each other in an interactive way. **Deci-Ryan's theory** emphasizes the importance of autonomy, competence, and connection, which can be achieved in digital learning environments through individual progress and social learning, thus strengthening motivation. Keller's **ARCS model** focuses on attracting attention, relevance, building confidence, and ensuring satisfaction. In my research, through interactive tools and immediate feedback, these factors strongly support the increase of student motivation. **Béla Kozéki's theory,** based on the combination of emotional and cognitive elements, emphasizes that the experiential and personal relevance of learning are also fundamentally important. Experiential learning environments can help with this when learning with digital tools. Finally**, Endre Réthy**'s theory supports that teacher competence fundamentally influences student motivation. Further research in educational psychology, such as the work of **Schunk, Pintrich, and Meece** (2014; 2023), emphasizes the role of objectives and self-regulation. Digital learning environments offer a suitable terrain for the development of self-directed learning, which is one of the most important conditions for maintaining motivation.

These theories confirm that digital learning environments can increase learners' motivation and effectiveness, especially by strengthening autonomy, competence, and social relationships. The results of the research are in line with the foundations of these theories and contributed to the understanding of the enhancement of student motivation.

Examination of learning outcomes

The study of learning outcomes and achievements in the field of education and psychology has played a key role in the past decades. Outstanding researchers and theories have contributed to a better understanding of learning processes and how to achieve student effectiveness.

Among these, **Benjamin Bloom**'s work on the systematization of learning goals, especially Bloom's Taxonomy, serves as an essential tool for educators to determine learning levels. According to Bloom, the different levels of learning – knowledge, understanding, application, analysis, synthesis and assessment – help to apply targeted teaching methods and provide opportunities for gradual development of students. This theory has also been applied in educational practice when defining learning goals. **Jean Piaget**, with his constructivist theory of learning, fundamentally influenced the world of education, as learning is an active process in which students build their knowledge based on their own experiences. Piaget's theory helped us understand how students process the world and how they are affected by the different stages of development. His theory strengthened the importance of student-centred, experiential learning in research. **John Hattie**, in his work "Visible Learning", examines the visibility of learning outcomes and the improvement of pedagogical effectiveness. Based on Hattie's research, teacher feedback, clear objectives and students' self-regulation skills have a fundamental impact on the effectiveness of learning. Applying this theory, I emphasized the importance of immediate feedback in my dissertation. **Grant Wiggins and Jay McTighe** developed the "Understanding by Design" framework, which helps to ensure the effectiveness of education by clearly defining learning objectives and assessment criteria. This framework has served as an important tool in research, educational planning and the development of evaluation criteria. **István Nahalka** examines student performance through the personality model of effectiveness, emphasizing that student performance is determined not only by innate abilities but also by diligence and environmental factors. Digital learning environments are particularly suitable for measuring effectiveness as they are able to capture detailed data on learner activity, interaction and progress. **Molnár** (2019) emphasizes that adaptive learning systems make it possible to interpret effectiveness in a personalized way: the system adapts tasks to the individual strengths and shortcomings of the student, thus ensuring optimal conditions for development.

The above-mentioned researchers and theories helped us to better understand the theoretical framework and the effectiveness of digital learning environments that underpin my research. The results and recommendations of these studies have made a fundamental contribution to the development of educational practice, especially in the field of increasing student motivation and performance.

E-learning environments and AI-based developments

From the point of view of the definition of the concept of electronic learning environment, many other similar concepts are used in the public consciousness, and from the point of view of research, it is expedient to define these concepts, which are included in detail in this chapter in the dissertation. E-learning environments play a decisive role in modern education. **Komenczi** (2009) and **Racskó** (2017) emphasize that these environments are not simple technological tools but also necessitate a transformation of pedagogical approach. In addition to ICT tools, Web 2.0 technologies such as social media, collaborative platforms and digital simulations provide opportunities to improve student interaction and collaboration. **Szűts** (2020) and **Selwyn** (2014) emphasize that digital pedagogy is not only a methodological issue but also includes social and critical dimensions: how the role of the teacher is changing, how student identities are evolving, and what new challenges digital inequality poses. Among the latest developments, learning systems based on artificial intelligence occupy a prominent place. **Safarifard et al**. (2024) point out that many e-learning platforms do not have sufficient didactic foundations, so they urge a more conscious incorporation of a constructivist approach. AI-powered tutors and adaptive systems can offer personalized learning materials, track student progress, and provide real-time feedback. These systems are particularly suitable for the needs of Generation Z and Alpha, as their need for rapid feedback, interactivity and experiential learning is extremely strong. The explosion of online learning over the past few decades, especially with platforms like Coursera, Udemy, and Khan Academy, has fundamentally transformed the educational landscape. **Salman Khan**, founder of Khan Academy, is one of the pioneers of online learning to provide interactive, personalized educational opportunities that help students develop independently and reduce educational inequalities. The latest e-learning trends focus on the effectiveness of adaptive learning systems, increasing student engagement and the scientific foundation of pedagogical models. **Fontaine et al**. (2019) state that adaptive platforms can significantly increase skill development while **El-Sabagh and**

Hamed (2021) suggest that adaptivity enhances not only learning outcomes but also student engagement.

4. Research questions and hypotheses

Based on the researched literature and my own experience as a teacher, in the first round I formulated the most important research questions related to the research problem, and then the hypotheses were also set up based on these.

The open research questions are the following to which I am looking for answers:

- What is the relationship between digital learning tools, motivation and academic achievement?
- Is the interactive learning environment more effective than traditional ICT, which can also be detected in learning outcomes?
- Does the e-learning environment really contribute to the motivation of learners?
- Are students more actively involved in the classroom learning processes during online learning?
- How does the ICT-supported environment affect the role of the teacher?
- Is it more active to work independently and together during the lesson when an interactive interface is used as opposed to the traditional ICT teaching method?
- Is critical thinking, problem-solving, and creativity more effective by using online platforms?
- Does the immediate feedback of digital learning tools support the learning process?
- To what extent does it provide the opportunity for teaching within the lesson that is adapted to the individual level of the students, and can individualization be realized?

H1: "By using interactive, ICT-supported learning environments, more effective learning can be achieved, increasing student motivation, which can be significantly demonstrated in learning outcomes."

Interpretation: This hypothesis is based on the ability of digitally assisted environments to enhance student engagement, which is directly reflected in better performance and measurable outcomes.

H2: "The use of ICT tools in teaching not only increases student motivation and learning outcomes but also significantly promotes the development of critical thinking skills and cooperation and communication between students."

Interpretation: This assumption emphasizes the complex impact of digital tools: they not only affect individual motivation but also promote community learning and collaborative problem-solving.

H3: "The immediate feedback provided by the use of digital tools significantly increases the motivation to learn."

Interpretation: The hypothesis focuses on the idea that quick feedback, such as the immediate result of an online test, strengthens learners' engagement and persistence in the learning process.

H4: "The electronic learning environment creates a positive, supportive classroom atmosphere that greatly promotes the efficiency of the learning process."

Interpretation: Motivating, playful or interactive elements of digital environments can create a supportive learning atmosphere in which students are more willing to participate in tasks.

H5: "The use of digital tools in education significantly improves individualisation and adaptation to individual learning levels, resulting in more effective learning outcomes and greater student satisfaction compared to traditional teaching methods."

Interpretation: This hypothesis highlights the importance of individualized education: digital systems provide the opportunity to create personalized learning paths, which increases efficiency and satisfaction.

5. Research methodology

The research was an empirical study based on pedagogical observation, during which I used a self-developed measurement tool to systematically record student motivation, activity, critical thinking, cooperation and learning achievement, among others. The aim of the study was to compare the learning environment (Web 1.0) supported by traditional ICT tools with the interactive learning environment based on Web 2.0 technologies. The logical course of the investigation consisted of several steps built on each other. First, I designated the control and experimental groups: in five classes, the education took place in a traditional learning environment, and in another five classes, using interactive platforms. The research focused on three subjects: English, Mathematics and History. Before starting the intervention, I performed an input measurement (pre-test), which recorded the students' initial knowledge level with the help of knowledge assessment worksheets compiled for each subject. After that, I documented the student's and teacher's behaviour, activity and environment with a standardized observation sheet during the entire teaching phase. The assessment tool evaluated student participation along several dimensions: affective effects (interest, joy, motivation), active work and attention,

critical thinking and problem-solving, cooperation and communication, and the quality of teacher support and feedback. The use of the assessment tool allowed the learning process to be examined in real-life classroom situations rather than on the basis of self-reported questionnaires. At the end of the curriculum units, I performed a post-test. In the course of this, I assessed the students' acquired knowledge with the help of worksheets that are equivalent in content to the input tests, but not identical. The comparison of the input and output scores provided an opportunity to quantify the learning outcome.

The sample consisted of a total of 179 people: 159 secondary school students aged 14–17 and 20 teachers. The participants came from secondary schools in Heves county, and the sampling was carried out using a concentrated and not random procedure. The composition of the control and experimental groups thus made it possible to compare the two learning environments.

I used several statistical methods to process the data. The description of the sample and the basic characteristics of the scales of the measuring device were given with statistical indicators. In the study of learning outcomes, I used the **Boxplot analysis** and **the Mann–Whitney test** to compare the input and output measurement and to show the difference between the two groups. To explore the correlations, **I carried out correlation studies** between motivation and activity. **Structural equation modelling** (PLS-SEM) was used to analyse complex relationships, which provided an opportunity to detect direct and indirect effects between latent variables, and to determine the explained **variance (R^2).** The reliability of the measuring device was checked with **Cronbach-alpha and composite reliability (CR) indicators**, which showed adequate values in all cases. The validity was verified on the basis of the **mean extracted variance (AVE)** and the convergent and discriminant validity tests. In the PLS-SEM model, **the path coefficients** and **the t-values and p-values** calculated using the **bootstrap method provided the statistical basis for the hypothesis investigations.** In the present research, various exploratory mathematical statistics were implemented using IBM-SPSS 29.0 (IBM, 2023) and Smart- PLS 4.1 (Ringle et al., 2024)

Overall, the methodological framework made it possible to examine student motivation and effectiveness based on real lessons, observation and input-output measurements. This provided a reliable and valid basis for testing hypotheses and formulating new scientific theses. The methodology ensured that the results of the research provided reliable and valid

conclusions. The complex analysis procedures made it possible to examine not only a single factor in isolation but the entire system of digital learning environments and its impact on the complex relationships between motivation and effectiveness.

6. Research results

Chapter 5 of the dissertation contains the research that served as the basis for the empirical research, as well as presents the entire research model. The purpose of the preliminary studies was to test and refine the self-developed measuring device on the one hand, and to check the main hypotheses on the other. After the preliminary tests, the conceptual model was defined with the help of path coefficients and moderator variables with the support of the PLS-SEM structural equation system.

The psychometric characteristics of the measuring device were examined in several steps. Internal consistency **was indicated by Cronbach-alpha** indicators with corresponding values on each scale. This was complemented by **composite reliability (CR),** which exceeded the 0.7 threshold for all major designs. The **convergent validity was confirmed** by the **mean extracted variance (AVE),** with values above 0.5 everywhere. The **discriminatory validity** was also adequate, i.e., the constructions were well separated from each other.

In addition to the measurement model, I **also checked the fit of the structural model**. The **SRMR** (Standardized Root Mean Square Residual) indicator remained below the limit expected in the literature, which showed a good fit of the model. Based **on the R^2 values**, the model explained the variance of student motivation and achievement to a significant extent, and the **f^2 effect measures** proved that certain variables (e.g., immediate feedback and interactive platform use) have a strong influence, while other factors (e.g., critical thinking) are associated with a medium or weaker effect on performance.

Chapter 5 thus demonstrated that the assessment tool is functional and able to capture relevant dimensions of motivation, learner activity and learning outcomes. Based on the preliminary research, it became clear that the impact of digital environments is enforced through several factors: strengthening motivation and attention, student cooperation, and teacher support.

Overall, these studies contributed to the foundation of the main empirical research by supporting the relevance of the hypotheses and demonstrating the reliability and validity of the measure. Their results were closely in line with the concept of the PLS study presented and predicted the correlations shown in the research model.

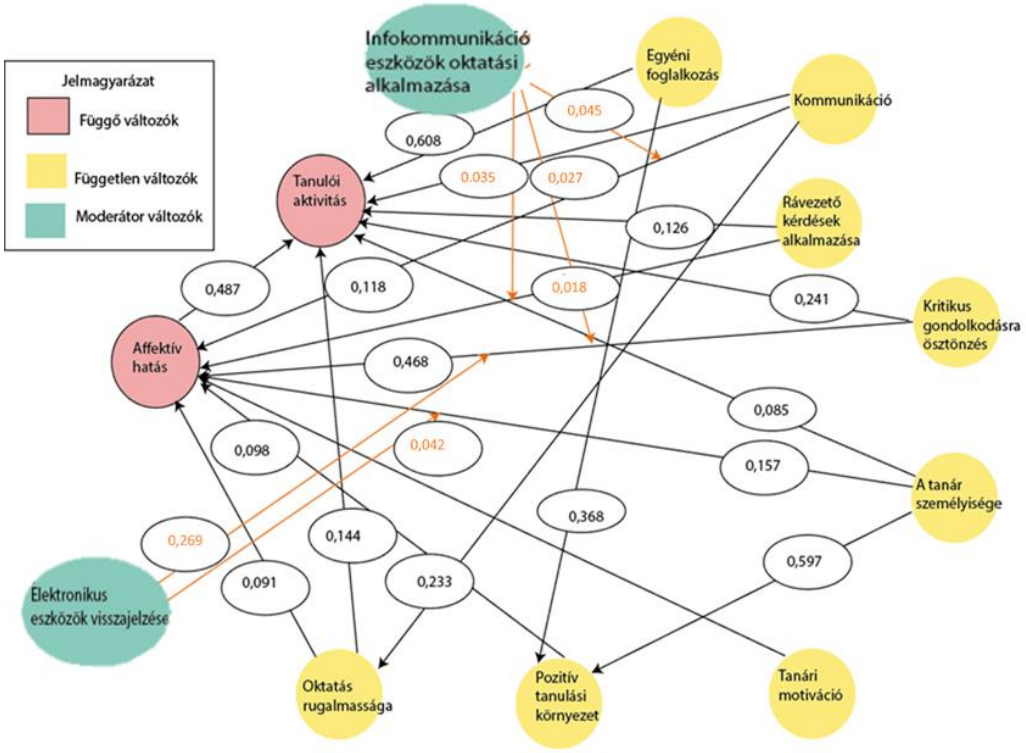
Implementation model of the research

After the preliminary studies, the path coefficient is one of the central elements of structural equation modelling (SEM), which expresses the extent to which an independent (exogenous or latent) variable affects another (endogenous) variable within the structure of the model. The aim of the model used in the dissertation was to explore the relationships between directly measured variables (e.g., teacher communication, use of digital devices) and latent factors (e.g., affective effect, student activity), and to prove their correlations in a quantitative way.

Based on the above statistical procedures, a model of the research was compiled, which depicts the relationships between the variables.

Figure 1

Conceptual model of the research



Source: Author's own editing edit

The aim of my research is to present a conceptual model that examines active student participation and its affective effects in the context of interactive digital learning environments. Assessing the direct and indirect effects between the latent variables in the model is key to understanding the effectiveness of education and learner motivation. In the following, I present the most important effects and associations that reflect the relationships between the variables in the research.

a, The relationship between student activity and affective effect

Based on the model, affective factors (e.g., emotional motivation, positive attitude) directly influence active student work (β=0.487), showing a strong positive relationship. This indicates that students' emotional engagement, which is shaped by the positive emotions and experiences they feel during the learning experience, has a direct impact on how actively they participate in learning. Emotional commitment therefore has not only a motivational but also an activity effect, as students who have a positive emotional attitude are more likely to actively participate in learning processes.

b, Application of ICT tools and affective effect

The use of ICT tools also plays an important role in the relationship with the affective variable (β=0.264), indicating that electronic feedback mechanisms and interactive tools contribute to the emotional involvement of learners. These types of tools help learners to be more connected to the educational process, as instant feedback and interactivity enhance the learning experience and increase emotional engagement. This result also confirms that the use of ICT tools not only increases the effectiveness of learning but also strengthens emotional connections, which has a direct impact on active student participation.

c, Flexibility of teaching and in-class communication

According to the results of the research, the flexibility of education (β=0.233) is closely related to a positive learning environment that allows students to communicate effectively and increase satisfaction. Flexible education ensures that students can progress at their own pace teachers can also adapt the learning process to their individual needs. This also ensures more active participation of learners, as a flexible, learner-centred approach fosters active engagement among learners.

d, Encouraging critical thinking and student activity

The encouragement of critical thinking in the model (β=0.241) also has a significant impact on student activity. Thinking strategies, such as problem-solving and analytical skills, directly contribute to students' active participation. Students who are encouraged to think critically are likely to be more actively involved in the learning process, as this type of learning provides them with opportunities for deeper understanding and application.

e, Feedback from electronic devices and individual sessions

The link between feedback from digital tools (β=0.875) and individual sessions is extremely strong, which shows that personalised support provided by ICT tools makes a significant contribution to learners' development. Electronic feedback mechanisms not only help to improve learners' knowledge but also increase learners' engagement and activity by providing continuous, personalised support.

f, Positive learning environment and teacher motivation

The relationship between a positive learning environment (β=0.597) and teacher motivation is also very strong, which indicates that the motivation and activity of students are directly influenced by the teacher's charisma and a positive learning atmosphere. Charismatic teachers elicit greater satisfaction and emotional commitment from students, which promotes active participation in the learning process.

The results of the research clearly show that increasing student activity is closely related to affective factors, ICT tools, flexible educational environment and teacher motivation. The results support that interactive digital tools and the teacher's personality are key factors in promoting positive emotional responses and active participation of students.

The role of moderator variables

Moderator variables, electronic feedback and the use of digital tools have a significant impact on student motivation, indirectly strengthening student activity and emotional involvement. The research model confirms that the introduction and application of technological tools not only serves to improve learning outcomes but also supports students from an emotional and motivational point of view. This is especially important in strengthening

autonomy, sense of competence and intrinsic motivation, which are essential elements of long-term learning success.

The effect of moderator variables on the relationships between affective and learner activity-dependent variables:

The examination of moderator variables used in the structural model provides an opportunity to explore **how certain influencing factors modify the intensity and direction of the relationships between latent variables**. The moderator effect means that the presence of a third variable amplifies, weakens, or even transforms the relationship between two other variables. In the present research, we identified two moderating factors: **the educational application of infocommunication tools** and **the feedback of electronic devices**.

Moderator 1: Educational application of ICT tools

This moderator variable mainly depends on the **communication, critical thinking, teacher personality and positive teacher attitude** is modified by two main dependent factors – the **Affective effect** and **Active student work** . The moderating effect is manifested by the following values. Table 1

Impact of moderator variables

Connection	Moderator Effect Magnitude
Communication → Affective effect	0.045
Communication → Active Student Work	0.035
Critical thinking → Affective effect	0.023
Critical thinking → Active work	0.018
Teacher personality → Active student work	0.027
Teacher personality → Affective effect	0.021
Positive teacher attitude → Affective effect	0.045
Positive teacher attitude → Active student work	0.035

Source: Author's own editing

These effects are low-to-medium, but not negligible. It is particularly noteworthy that **ICT tools** mostly strengthen the effect of communication and a positive teacher attitude, both on affective experience and active participation. This suggests that **ICT tools are most effective when they are associated with human factors, such as positive interaction or empathetic teacher behaviour**.

2. Moderator: Feedback from electronic devices

This moderator mainly **influences the relationship** between critical thinking **and** the teacher's personality – motivational effect chain.

Table 2

The changing influence of the moderator

Connection	Moderator Effect Magnitude
Critical thinking → Affective effect	0.269
Critical Thinking → Active Student Work	0.207
Teacher personality → Motivation → Affective effect	0.042
Teacher personality → Motivation → Active student work	0.032

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The **affective and activity effect of critical thinking** is moderated quite strongly **by feedback from electronic devices** (0.269 and 0.207), indicating that **digital feedback helps to translate students' higher levels of cognitive activity into emotional engagement and actual participation**. This is a particularly important pedagogical experience, as it confirms that **the use of tools is not only a technological issue but also a factor that shapes the learning experience**.

Based on the influence of both moderators, it can be stated that **digital tools – especially interactive feedback systems – are able to subtly but perceptibly shape the operation of pedagogical relationships**. It is a particularly important finding that **affective dimensions and learner activity can be effectively developed** if they are supported in an appropriate digital environment and interaction background.

Presentation of learning outcome measurements in different learning environments

The aim of the study presented in this chapter was to compare student performance numerically based on the performance of the **control group (traditional, Web 1.0 environment)** and the **experimental group (interactive, Web 2.0 environment).** For the measurement, the subject performance of the students participating in the research **was**

recorded with input (pre-test) and **output (post-test)** worksheets, then **the results were processed** by boxplot analysis **and a** Mann-Whitney test.

The input measurements showed that the knowledge level of the two groups was similar in all three subjects examined, and there was no significant difference. This ensured the validity of the comparison. However, a significant difference was already visible in the output measurements. The boxplot diagrams clearly showed that the distribution of the results of the experimental group shifted towards higher performances while the improvement in the control group was more moderate. According to the results of the analysis, the students of the experimental group achieved significantly better performance in the outcome measurement.

- **English**: the experimental group scored significantly higher ($p < 0.05$).
- **Mathematics**: the difference proved to be strongest here ($p < 0.01$).
- **History**: there was also a significant difference in favour of the experimental group ($p < 0.05$).

Thus, my results indicate that the **digital, interactive learning environment** had a positive effect on student performance in all the subjects examined. This is in line with the literature, which emphasizes the effectiveness of digital learning environments. Komenczi (2009) and Molnár (2019) point out that education supported by ICT tools is not only beneficial from a motivational point of view but also has an impact on learning outcomes. According to Selwyn (2014) and Szűts (2020), interactive digital platforms are particularly suitable for maintaining students' attention and supporting independent learning.

7. Conclusions - practical applicability

I found that by using interactive, ICT-supported learning environments, more effective learning can be achieved, increasing student motivation, which can be significantly detected in learning outcomes.

The results have shown that the use of ICT tools significantly increases learners' motivation and improves performance. There was a close relationship between device use and affective factors ($\beta=0.264$, $p<0.01$), and a positive correlation was also found with active student work ($\beta=0.128$, $p<0.01$). The outcome measurements indicated better results for all three subjects than those participating in digital education.

In the course of my research, I have proven that the use of ICT tools in teaching not only increases student motivation and learning outcomes but also significantly promotes the development of critical thinking skills as well as cooperation and communication between students.

Digital tools not only improve motivation and learning outcomes but also strengthen learners' collaboration and critical thinking. There was a strong relationship between interactive tools and critical thinking ($\beta=0.468$, $p<0.01$) while feedback functions further strengthened the association between affective effects and thinking skills (moderator: 0.269). This indicates that technology not only works on its own but also amplifies the impact of other pedagogical factors.

Based on the results of my work, I proved that the immediate feedback provided by the use of digital tools significantly increases student motivation.

The results confirmed the effectiveness of immediate electronic feedback: there was a significant relationship between device use and active student work ($\beta=0.128$, $p<0.01$). Feedback not only increases motivation and active participation but also develops independent learning skills, thus creating a more stimulating and effective learning environment in the long run.

Based on my research, I have shown that the electronic learning environment creates a positive, supportive classroom atmosphere, which greatly promotes the efficiency of the learning process.

The use of interactive digital tools has created a more supportive and inclusive classroom atmosphere. Electronic feedback strengthened the positive learning environment ($\beta=0.209$, $p<0.01$), promoting communication, collaboration and the development of group dynamics. More active participation of the students and the improved mood observed in the interactive situations contributed to the increase in motivation and the development of collaborative strategies, which was also reinforced by the moderator effect (0.045).

The results of my work supported my hypothesis that the use of digital tools in education significantly improves individualization and adaptation to individual learning levels,

resulting in more effective learning outcomes and higher levels of student satisfaction compared to traditional ICT teaching methods.

The fifth hypothesis has been confirmed: an individualized learning environment supported by digital tools has proven to be more effective. Personalized learning opportunities increased student satisfaction and motivation while providing opportunities to adapt to individual pace and preferences. There was a strong correlation between individualization and active student work ($\beta=0.608$, $p<0.01$), which supports that this approach not only provides better learning outcomes but also a richer learning experience.

The results of the research are also important from a practical point of view, as they help to develop education that meets the needs of Generation Z and Alpha. The use of ICT tools not only increases motivation and improves learning outcomes but also supports individualisation, critical thinking and a positive classroom atmosphere. From the point of view of teacher training, the development of digital pedagogical competencies is of paramount importance, so that teachers consciously use the tools to strengthen student motivation and emotional commitment. The results can contribute to the definition of the content of teacher training and in-service training.

At the level of education policy, the research supports the need to fine-tune the National Core Curriculum and other guidelines, especially in the field of the integration of digital pedagogy. In addition to teacher training and fine-tuning of educational policy principles, there may be other opportunities to support student individualization and create a positive classroom atmosphere

Overall, the results of the study can help to improve pedagogical practice and education policy, contributing to ensuring the quality of education in the 21st century and a successful learning experience for students. Based on my results, the use of digital learning environments is not only a complementary option, but one of the key factors in increasing student motivation and effectiveness. Therefore, it is advisable to integrate digital tools into the teaching process in an integrated way in school practice.

Limitations of the research

The results of the research clearly supported the positive impact of digital learning environments, but we have to interpret them within certain limits. The sample number of the study was limited (179 people) and it was geographically tied to one region, so the generalization is somewhat narrower. The participants were mainly secondary school students, so the conclusions can only be extended to other levels of education (primary school, higher education) cautiously. From a methodological point of view, the study was based on observation, and although the reliability of the measurement device was confirmed by Cronbach-alpha, composite reliability (CR) and AVE indicators, qualitative data (interviews, student diaries) were not included. This is in line with the claims of Selwyn (2016) and Hattie (2007), who emphasize that the complexity of the learning process requires data collection from multiple perspectives.

8. Conclusion

The research has clearly shown that the use of digital tools in education has a positive impact in several ways. ICT tools not only improve learners' learning outcomes but also contribute to increasing learners' motivation, adapting to individual learning needs, and developing critical thinking and collaboration skills. The results of the research highlight that the effectiveness of digital learning environments depends to a large extent on the quality of educational strategies, the digital competence of educators, and the level of technological access. The practical significance of the research lies in the fact that it can contribute to the development of teaching methods and the promotion of pedagogical innovation through the improvement of learners' motivation and learning outcomes. The research clearly indicates that in the future, further integration of ICT tools will be essential to improve the quality of education. However, this requires the continuous training of teachers and the development of technological infrastructure, especially in order to ensure equal opportunities for disadvantaged students. The results of the research clearly show that the use of ICT has a significant impact on learning outcomes, learner motivation and the quality of the learning process as a whole. One of the most important findings of the study is that digital tools enable the individualisation of education, through which learners can develop in line with their individual learning needs. This not only results in more effective learning outcomes but also greater satisfaction among both students and instructors.

The research showed that the importance of the role of teachers in digital learning environments is not hypothesis, but the roles of teachers were also examined during the

observation. In the examination of the teacher's personality and charisma, one of the strongest relationships is shown here, the path coefficient is 0.692, $p < 0.001$. This outstanding value clearly confirms that the motivational activity of the teacher stems directly from his personality and charisma, and this has an extraordinary effect on the students. The results show that the teacher does not only act as a facilitator but also plays an active role in motivating students, personalizing educational content and creating a positive classroom atmosphere. Based on values, the role of the teacher plays a key role in the learning process, especially in the development of an affective and positive learning environment. The research results thus clearly confirm that the personality and charisma of the teacher are unavoidable factors for successful teaching in digital learning environments, as well.

9. References

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