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The Problems of Contemporary Education

Interest in living Organisms and Conceptual Understanding of Food Chains

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Abstract

Science education emphasises not only real conceptual understanding but also fostering students' interest in various domains of natural sciences. Interest in educational content is considered one of the factors that can influence students' level of knowledge, although the nature of this relationship remains a subject of ongoing discussion. An important component of education at ISCED 2 involves information about living organisms and their interrelationships, including abstract concepts such as food chains. The aim of this study was to investigate students' conceptual knowledge of food chains and their level of interest in living organisms, and to analyse the relationship between these two variables among students aged 10–11 years (ISCED 2). The study involved 489 primary school students in the fifth grade. The results showed an insufficient conceptual knowledge of food chains and a mildly positive interest in living organisms. Students scored highest in the dimension "Importance of Organisms" and lowest in the dimension "Fungi". The correlation analysis indicated that students with higher levels of conceptual understanding also exhibited greater interest in living organisms. These results suggest that fostering a positive attitude towards living organisms could be an important prerequisite for the development of conceptual knowledge related to food chains.

Keywords: food chains, conceptual knowledge, interest in organisms, biology.

1. Introduction

Research in science education has long focused on understanding fundamental scientific concepts, many of which are considered essential to the development of scientific literacy. Cherrett (1989) identified fifty of the most important ecological concepts, from which Munson (1994)

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selected twenty components important for science education. These concepts included food chains and food webs. Food chains represent a fundamental element of ecological systems, as they mediate the flow of energy between their components and reveal complex relationships between species (Zheng, 2023; Hui, 2021; Preston, 2018). Essentially, they are simplified models that represent the existing relationships within a particular community (Griffiths, Grant, 1985). In science education, these models are used as a tool to help students recognise the complex relationships between each link in the chain as well as the consequences of disrupting these relationships (Wennersten et al., 2023; Brodie, 2007). Due to their complexity, they are considered a concept that poses certain difficulties for students in the classroom. The interpretation of chains is cognitively demanding and requires an understanding of systemic relationships and the indirect flow of energy between organisms (Wennersten et al., 2023). Inadequate acquisition of this concept can negatively affect students' ability to interpret complex and multi-layered ecological relationships within an ecosystem (Mambrey et al., 2022), which is a significant problem in education (St Y, 2025; Preston, 2018) and requires in-depth investigation.

2. Conceptual Knowledge and Food Chains

Curricula in developed countries promote an approach to science education that emphasises a genuine understanding of scientific concepts and their appropriate application (Thibaut et al., 2018; Schweingruber, Beatty, 2017). True understanding goes beyond the memorisation of facts and requires their integration into a logically organised structure. In this context, conceptual knowledge plays an important role as it is a key element in the transition from factual knowledge to true understanding (Bransford et al., 2018). It refers to knowledge that is based on the formation of relationships between concepts and the understanding of these relationships (Rittle-Johnson et al., 2001). Such conceptual knowledge can be visualised as a network of relationships between concepts (Miller, Hudson, 2007). Its main characteristics are generalisability and flexibility, as it enables the transfer of knowledge across different problems within the same domain (Schwartz et al., 2008). The acquisition of conceptual knowledge also enables students to assign information to specific problems (Konicek-Moran, Keeley, 2015; Ellis, 2013), identify the source of a problem, formulate specific questions, and apply the acquired knowledge when designing solutions (Mestre, 2002; Rittle-Johnson, Alibali, 1999). At the same time, it helps to reduce errors in problem-solving (Al-Mutawah et al., 2019) and supports the meaningful use of knowledge not only in the educational process but also in everyday life (Nieswandt, 2007; Novak, 2002).

One of the areas of science education where the development of conceptual knowledge is required is food chains (Qorimah et al., 2024; Södervik et al., 2021; Preston, 2018; Eilam, 2002). Understanding food chains and food webs forms the basis for developing a conceptual understanding of ecological interactions, systems thinking and recognising the complex interconnectedness of organisms within ecosystems (Odhiambo, 2021; Eilam, 2002). Students need to be able to connect individual links in the food chain, recognise them as part of a wider food web and understand how changes at one level affect the whole system (Lankers et al., 2023; Preston, 2018). According to Eilam (2002), the acquisition of this concept requires the development of systematic thinking and the ability to model complex relationships that are often not directly observable. In addition, students need to work with abstract ideas and visualisations that represent energy and information flows within an ecosystem (Odhiambo, 2021). Mastery of this concept goes beyond factual knowledge as it involves working with visual representations, relationships between concepts, and the application of knowledge in real-world contextualised situations (Mulyono et al., 2025).

Nevertheless, education often faces the problem of students having to memorise as many concepts as possible through rote learning (DeBoer, 2019; Chin, 2004). As a result, students may reproduce various concepts as they were presented to them or as they were defined in textbooks, but they lack a deeper understanding (Widiyatmoko, Shimizu, 2018). Even when students recognise the relationships between concepts, their conceptual understanding remains superficial (Knuth, 2000). This situation often stems from the tendency to routinely solve tasks without truly utilising acquired conceptual structures. These problems are evident in the context of food chains, which students often perceive as simple linear sequences without a deeper understanding of the systemic relationships and energy flows within the ecosystem (Mambrey et al., 2022; Södervik et al., 2021). Rather than perceiving them as complex networks of interactions, students tend to approach them routinely, as memorisation schemes that merely serve to name organisms

according to their trophic level (Preston, 2018). Inadequate conceptual understanding consequently limits students' ability to apply this knowledge when interpreting ecological phenomena or solving problem-based tasks (D'Avanzo, 2003; Eilam, 2002). Therefore, it is necessary to look for ways to change this situation. One possible way to support students' conceptual understanding is to increase their interest in the field of education. Interest leads students to actively ask questions, look for connections and explore relationships between concepts more deeply, which is a key prerequisite for the development of conceptual knowledge (Romine et al., 2020).

2.1. Student Interest as a Component of Science Education

Students' interest in exploring world around them is a prerequisite for asking curiosity-driven questions, which are important for the development of scientific thinking and a broader interest and motivation to engage with scientific topics (Jirout, 2020). Interest should therefore be seen as a process that significantly influences both educational and career success (Harackiewicz et al., 2016). From an educational perspective, it is important to distinguish between individual, situational and topic interest. Personal interest refers to a stable orientation towards certain areas of knowledge, whereas situational interest is a temporary state triggered by specific features of a situation (Schiefele, 2009). Topic interest is typically elicited by a specific stimulus, such as a word, a statement, or a short text (Ainley et al., 2002), and some authors understand it as a form of personal interest or a combination of personal and situational aspects (Nieswandt, 2007; Čipková et al., 2018). Students' interests are thus also shaped by their interaction with the lesson content, classroom activities, and the way these stimuli relate to their personal experiences. Interest should not only be understood as a motivational state, as it is a complex construct that includes affective, cognitive, and behavioural components (Krapp, Prenzel, 2011). Due to this multidimensionality, interest is closely related to students' motivation to learn as well as their cognitive and behavioural engagement during lessons (Renninger, Hidi, 2015; van Aswegen, Pendergast, 2023).

Science education is also associated with the re-evaluation of existing concepts through the process of conceptual change (Nadelson et al., 2018; Treagust, Duit, 2008). This change is usually triggered by dissatisfaction with existing knowledge or by the fact that new information is more understandable, credible and applicable in new situations (Gennen, 2023). Creating of new conceptual knowledge and re-evaluating existing concepts is a challenging process that requires active cognitive engagement and student motivation (Blumenfeld et al., 2006). It is precisely an appropriate level of student interest in a specific area that increases the likelihood that they will engage with a deeper understanding of the content (Renninger, Hidi, 2016) and participate more actively in the reconstruction and construction of their own knowledge (Duit, Treagust, 2003; Sinatra et al., 2015).

3. Study Aims

Educational outcomes are influenced by several variables (Costa et al., 2024), including personal factors on the part of the student, such as their interest in a specific subject area. Research has confirmed a significant influence of interest, for example, on the level of factual knowledge (Toli, Kallery, 2021) and the development of scientific skills (Stang, Roll, 2014). In line with these findings, it seems relevant to investigate the relationship between students' interest in living organisms and their conceptual understanding of food chains that include living organisms. Based on this, the following research questions were formulated:

– What conceptual knowledge do students aged 10–11 years have about food chains and food webs?

– How interested are students aged 10–11 in living organisms?

– What is the relationship between students' conceptual knowledge and their interest in living organisms?

4. Methodology

4.1. Research Sample

The analysis is based on data collected from 489 students (249 boys and 240 girls) aged 11–12 years, who were in the 5th year of lower secondary education (ISCED 2) at the time of the research. These students attended a total of 14 primary schools. The prerequisite for the

participation of these schools in the research was the consent of the school management and the students' legal guardians. The average grade in biology on the last school report was 1.6.

4.2. Research Instruments

To assess the conceptual knowledge of fifth-grade primary school students regarding food chains, we used a custom-designed test consisting of 13 items (see Appendix A for examples of items). The number and difficulty of the items were selected for their suitability for students who are in transition from the concrete operations stage to the formal operations stage. When testing conceptual knowledge, it is recommended to use tasks that do not limit students' responses (Chang et al., 2010), support a deeper understanding of concepts and facts (Collins et al., 2018), emphasise relationships between concepts (Leshem, Trafford, 2017; Gerace et al., 2001), encourage critical thinking (Zoller, 2002), and provide space for explaining phenomena and processes as well as for identifying possible misconceptions (Nurrenbern, Robinson, 1998; Haláková, Prokša, 2007). The test, therefore, included various types of tasks, the details of which are listed in Table 1.

Table 1. Specification Table of Test Items

Item	Cognitive Process Dimension (Bloom)	Subtype of Conceptual Knowledge	Task Type	Item	Cognitive Process Dimension (Bloom)	Subtype of Conceptual Knowledge	Task Type
1	remember	knowledge of theories, models, and structures	custom fill	8	understand	knowledge of principles and generalisations	marking text
2	apply	knowledge of theories, models, and structures	ordering	9	understand	knowledge of theories, models, and structures	single matrix
3a 3b	remember understand	knowledge of theories, models, and structures	two-tier choice	10	remember	knowledge of theories, models, and structures	marking text
4	understand	knowledge of theories, models, and structures	single choice	11a 11b	analyse understand	knowledge of theories, models, and structures	ordering
5a 5b	analyse understand	knowledge of classifications and categories	two-tier choice	12	apply	knowledge of theories, models, and structures	ordering
6	understand	knowledge of classifications and categories	single matrix	13	evaluate	knowledge of principles and generalisations	file
7	understand	knowledge of theories, models, and structures	single choice				

The clarity of the wording of the individual test items was verified with a sample of three fifth-grade students from a selected primary school (Samaie, Mohammadi, 2017). This verification also set the time required to complete the test at 45 minutes. For each correctly solved task in the test, participating students could earn one point.

The content and construct validity were verified by the assessment of two experts from the field of education (Heale, Twycross, 2015). These experts evaluated the instrument in terms of its content and construct relevance, the clarity of the individual items and their appropriateness for the target group. Based on their recommendations, some items were modified to ensure suitability for fifth-grade primary school students.

As the individual test items were not scored dichotomously, the reliability of the instrument was assessed using Cronbach's alpha (Tavakol, Dennick, 2011). The reliability coefficient of 0.877

indicates a good internal consistency of the research instrument and confirms its suitability for investigating students' conceptual knowledge (Luthfiyah et al., 2023).

The difficulty index of the test items ranged from 7.98 % to 63.70 % (M = 22.05 %). The discrimination index values of the items (Mitra et al., 2009) ranged from 0.49 to 0.82 (M = 0.61). All items achieved scores indicating a very good discrimination index, demonstrating their ability to discriminate between students with higher and lower conceptual knowledge.

To determine the students' attitudes towards organisms (plants, fungi, animals), we used a custom-designed questionnaire consisting of 39 items, which were rated on a 5-point Likert scale. All items were positively worded (Baumgartner et al., 2018; Steinmann et al., 2022) and were converted into numerical values from 5 (strongly agree) to 1 (strongly disagree) for the analysis. The validity of the questionnaire was assessed by an exploratory factor analysis using Varimax rotation. The suitability of the factor analysis was checked by the Kaiser-Meyer-Olkin (KMO) test and the Bartlett's test of sphericity. The KMO value was 0.90, and the Bartlett's test of sphericity yielded a significant result, thereby rejecting the null hypothesis (Dziuban, Shirkey, 1974). The grouping of items was based on Velicer's MAP test (Velicer et al., 2000), which identified four dimensions: Animals, Importance of Organisms, Plants, and Fungi. Five items were excluded from the analysis because their factor loadings were distributed across several dimensions (Table 2). The reliability of the questionnaire, measured with the Cronbach's alpha coefficient, reached a value of 0.925, which is considered excellent.

Table 2. Results of the Exploratory Factor Analysis

	α	I	II	III	IV
Animals	0.895				
23. I enjoy observing animals in their natural environment (e.g., in the park, in the garden, etc.).		.678			
24. Animals are interesting.		.758			
28. I enjoy reading books and magazines about animals.		.599			
30. I enjoy watching films about animals.		.657			
31. Animals are important for my life.		.494			
32. I enjoy learning new information about animals.		.720			
33. Knowledge about animals is important to me.		.727			
34. Being able to name animals is important to me.		.658			
37. Biology lessons about animals are interesting to me.		.731			
38. I believe that the protection of animals is important.		.668			
Importance of Organisms	0.831				
1. Plants are an important part of the environment.			.433		
3. Fungi are important for maintaining biodiversity in nature.			.625		
13. Fungi are an important part of nature.			.556		
14. Plants play an important role in food chains as part of ecosystems.			.422		
17. Fungi are an important part of the environment.			.628		
18. It is important to preserve native plant species in their natural habitats.			.515		
19. Plants are important for maintaining biodiversity in nature.			.721		
21. Animals are an important part of the environment.			.597		
29. Fungi play an important role in communities as part of the food chain.			.476		
35. Animals play an important role in communities as part of the food chain.			.529		

Plants	0.836				
2. Growing plants is relaxing for me.				.597	
4. I enjoy observing plants in their natural environment (e.g., in the park, in the garden, etc.).				.596	
5. Plants are interesting.				.631	
9. Being able to name plants is important to me.				.527	
10. Plants are important for my life.				.453	
11. I enjoy learning new information about plants.				.533	
12. Knowledge about plants is important to me.				.632	
15. Biology lessons about plants are interesting to me.				.531	
16. I believe that plant protection is important.				.461	
Fungi	0.816				
20. Fungi are important for my life.					.572
22. Fungi are interesting.					.688
25. I enjoy learning new information about fungi.					.702
27. I enjoy observing fungi in their natural environment (e.g., in the park, in the garden, etc.).					.699
36. I enjoy reading books and magazines about fungi.					.724
Eigenvalue		*11.41*	*3.34*	*2.53*	*1.68*
% of variance explained		*29.25*	*8.57*	*6.49*	*4.30*
6. Knowledge about fungi is important to me.					
7. I enjoy reading books and magazines about plants.					
8. I enjoy watching films about plants.					
26. I believe fungal protection is important.					
39. Hunting wild animals should be banned.					

4.3. Data Analysis

The data were analysed quantitatively to determine basic descriptive characteristics of the test (mean, median, mode, variance, standard deviation, etc.). To assess the normality of data distribution, the Shapiro–Wilk test was used. The test indicated that the data obtained from both the test and the questionnaire were not normally distributed ($p < 0.05$). Therefore, to determine statistically significant differences between two independent samples, the non-parametric Mann–Whitney (Wilcoxon) W-test was used to compare the medians of the two groups. To examine correlations between the variables under investigation, Spearman's rank correlation coefficient was used.

5. Results

Students' Conceptual Knowledge of Food Chains and Food Webs

The students were able to achieve a maximum score of 13 points on the test. No student achieved the maximum, while 11 students achieved the minimum of 0 points. The overall mean score was 4.71 points (SD = 3.30), and the median was 3.95 (Table 3). The average success rate in the test was 36.22 %.

Table 3. Descriptive Characteristics of the Test for Individual Statistical Samples

	Total	**Gender**	
		Boys	**Girls**
Count	489	249	240
Average	4.71	4.81	4.60
Median	3.95	3.88	3.98
Mode	1.5		0
Variance	10.87	11.52	10.23
Standard deviation	3.30	3.39	3.20
Coeff. of variation	70.04 %	70.52%	69.54 %
Minimum	0	0	0
Maximum	12.5	12.5	12.5

	Total	Gender	
		Boys	Girls
Range	12.5	12.5	12.5
Stnd. skewness	6.14	5.08	3.41
Stnd. kurtosis	-2.08	-1.19	-2.03

Based on the success rate in the conceptual knowledge test, Semilarski et al. (2019) defined three levels of conceptual understanding. Students with a high level achieved a success rate above 80 %, those with a medium level achieved above 60 %, and students with a low level of conceptual understanding achieved below 60 %. According to this categorisation, 8.38 % of students achieved a high level, 11.25 % a medium level, and 80.37 % a low level of conceptual understanding in the test administered. This result indicates that the majority of the students involved in the research showed a limited understanding of biological concepts and had difficulties in correctly identifying and applying these concepts. Their ability to recognise and explain relationships between biological concepts was also low.

In terms of the specific subtypes of conceptual knowledge, students achieved a success rate of 40.87 % in knowledge of theories, models, and structures; 25.33 % in knowledge of classification and categorisation; and 26.18 % in knowledge of principles and generalisations. The analysis of the results also focused on assessing students' success in individual biological concepts. Students achieved the highest success rate in the tasks focused on food chains (I = 43.12 %). Comparable success rates were recorded in the tasks related to food chain links (I = 34.75 %) and food webs (I = 31.62%). The lowest success rate was observed in the domain focused on food sources (I = 26.49 %). Regarding specific test items (Table 4), students were most successful in the task requiring them to supply the species name of the organism forming the last link (third-order consumer) in a simple food chain (Item 1). They also scored above 50 % in the item in which they had to select a correctly ordered simple food chain containing a producer and consumers (Item 4). The success rate in food chain tasks decreased when the students had to construct a food chain from a selection of organisms including decomposers (Item 2, Item 12) or when they had to justify the correctness/incorrectness of the constructed food chains (Item 9). The lowest success rate was achieved in Item 13, where students were asked to explain how the extinction of Daphnia in a food web would affect other organisms (I = 20.65 %). The success rate was similarly low for two-tier items, where students were asked to categorise an organism in a food chain (Item 3a) or group an organism based on its food source (Item 5a), and justify their answer (Item 3b, Item 5b). A success rate below 30 % was also recorded in Item 6, in which students were asked to categorise organisms into groups based on a key they had selected.

Table 4. Student Performance on the Test Items

Biological Concept	Item	Item success rate [%]	
food chain	1	63.70	
food chain	2	33.03	
food chain components	3a	28.63	20.96
	3b	13.29	
food chain	4	54.50	
food sources	5a	27.40	21.27
	5b	15.13	
food chain components	6	29.39	
food chain components	7	49.49	
food sources	8	31.71	
food chain	9	34.02	
food chain components	10	39.14	
food web	11a	53.46	42.58
	11b	31.70	
food chain	12	30.37	
food web	13	20.65	

As part of the analysis, we were also interested in whether there was a difference in students' conceptual knowledge according to gender. The average score for girls was 4.60 (SD = 3.20), while for boys it was 4.81 (SD = 3.39). Using the Mann-Whitney (Wilcoxon) W-test, no statistically significant differences in test performance were found according to gender ($W = 29046.0$; $p > 0.05$).

Students' Interest in Living Organisms

An analysis of the students' answers to the questionnaire items showed that they achieved an average score of 3.93 (SD = 0.66), with a median of 4.03. This score indicates a slightly positive interest in living organisms. The highest mean score was found in the dimension Importance of Organisms ($x = 4.17$), and the lowest in the dimension Fungi ($x = 3.17$) (Table 5). The data analysis using Spearman's correlation coefficient (Table 5) revealed predominantly moderately positive correlations ($0.50 < r \leq 0.70$) between the individual dimensions. A weak positive correlation ($0.10 < r \leq 0.30$) was found between the dimensions Fungi and Animals, and between Fungi and Importance of Organisms. This suggests that students who show a greater interest in fungi also tend to have a greater interest in animals and a greater awareness of the importance of organisms, but these relationships are weak and are likely to be influenced by other factors.

Table 5. Spearman's Correlation Coefficients Between Dimensions of Students' Interest in Living Organisms

	Animals	**Plants**	**Fungi**	**Importance of Organisms**
Animals		0.536***	0.382***	0.518***
Plants			0.543***	0.616***
Fungi				0.351***
Importance of Organisms				
Mean	4.07	3.90	3.17	4.17
SD	0.88	0.83	1.07	0.70

*** $p < .001$

Analysing the results by gender showed that girls achieved a slightly higher score ($M = 3.94$, $SD = 0.65$) than boys ($M = 3.92$, $SD = 0.67$), but the differences were not statistically significant ($W = 30948.0$; $p > 0.05$). Similarly, no significant differences were found between the individual dimensions in relation to gender.

The relationship between students' conceptual knowledge and their interest in living organisms

The study also investigated whether there is a correlation between students' conceptual knowledge and their interest in living organisms. Spearman's correlation analysis revealed a moderately positive correlation ($r = 0.52$; $p < 0.001$) between students' conceptual knowledge and their interest in living organisms. This suggests that students with a better conceptual understanding tend to show a greater interest in living organisms. In other words, as students' conceptual knowledge increases, their interest in living organisms generally increases as well.

6. Discussion

An essential component of science education is the development of science concepts that not only consist of isolated terms but also encompass the connections between them in the form of conceptual knowledge (Ravetz, 2020; Yi, Choi, 2012; Hodson, 2002). Such knowledge enables the identification and interpretation of relationships among concepts, thereby forming a complex and interconnected understanding of natural phenomena (Rittle-Johnson et al., 2001). Conceptual knowledge regarding food chains is crucial for a deeper understanding of ecological relationships and the sustainability of natural systems, as it enables students to recognise the dynamic interactions between organisms and their environment (Hui, 2012). However, the results of this study showed that students aged 10 to 11 years have a low level of such knowledge. The inadequate understanding of the concept of food chains has also been highlighted in other studies

(e.g., Zulyusri, 2021; Preston, 2018; Eromosele, Ekholuenetale, 2016). One of the main reasons for a limited or superficial understanding of biological concepts is the presence of numerous misconceptions (Lucariello, Naff, 2013). For instance, Özkan et al. (2004) point to an insufficient understanding of the role and importance of decomposers within food chains. Our results also indicate that students' performance on food chain tasks decreased when the task involved constructing a food chain that included decomposers. Consistent with the findings of Purwanti and Kuntjoro (2020), many students in our study perceived decomposers solely as organisms responsible for breaking down organic matter and did not recognise their crucial role in the nutrient cycle. The data also revealed a common misconception about the organisation of organisms within food chains. Students tended to organise organisms according to their size rather than their actual trophic relationships. Several authors have noted that this misconception is common among students (e.g., Allen, 2025; Eilam, 2022; Reiner, 2001). Another notable misconception was that students did not consider parasitism, such as the common tick, as a form of trophic interaction within food chains. This misconception was also documented in the study by Eilam (2022). Gender has been recognised as another important factor influencing the true understanding of scientific concepts (Sagala et al., 2019). However, in our study, no statistically significant differences were found between boys and girls in their test performance. Other factors that influence student success include task context (Nehm, Ha, 2011), motivation, attitudes and interests (Yusup et al., 2023). Long-term studies (e.g., Steidtmann et al., 2023; Van Griethuijsen et al., 2015) repeatedly report a gradual decline in students' interest in science and science education. The results of our study show a slightly positive interest of students towards living organisms. The highest scores were observed in the dimensions of the Importance of Organisms and Animals. This could be related to the fact that animals tend to be more attractive to students than other organisms (Fančovičová, Prokop, 2011). Conversely, the lowest scores were found in the dimensions of Fungi and Plants. This lack of interest could be related to the inadequate representation of plants and fungi in the curriculum (Thomas et al., 2022; Moore et al., 2025). In the case of plants, this can be attributed to the phenomenon known as "plant blindness", a cognitive bias in which people fail to notice or undervalue plants in their environment (Thomas et al., 2022). A similar phenomenon occurs with fungi, leading to an inadequate understanding and appreciation of their ecological importance (Karakaya et al., 2023).

The correlation analysis showed that students with a higher interest in living organisms tended to perform better on tests measuring conceptual knowledge of food chains. This suggests that fostering an interest in living organisms among students aged 10–11 years (ISCED 2) can simultaneously support the development of their conceptual understanding. This assumption is also supported by the findings of other studies (e.g., Jansen et al., 2016; Krapp, Prenzel, 2011; Köller et al., 2001), which emphasise a positive relationship between students' interest in science topics and their deeper understanding of science concepts. However, interest alone, without appropriate pedagogical support, does not necessarily lead to significant improvements in conceptual understanding (Renninger, Hidi, 2020; Swarat et al., 2012). According to Renninger and Hidi (2020), students whose interest in a particular topic is systematically encouraged are more likely to engage with the content repeatedly and actively seek out new knowledge. These findings emphasise the importance of targeted and systematic teacher support in cultivating students' interest in living organisms, which can ultimately contribute to a deeper understanding of ecological concepts such as food chains.

7. Conclusion

The findings of this study highlighted a low level of students' conceptual knowledge regarding food chains, alongside a moderately positive interest in living organisms. Data analysis revealed a moderate positive correlation between these two domains, indicating that students who scored higher on the conceptual knowledge test also showed a greater interest in living organisms. These results suggest that students' interest is a multi-layered psychological construct that significantly influences their cognitive processing and deeper understanding of the subject matter (Knekta et al., 2019). In the context of biology teaching, this emphasises the need to implement teaching approaches that deliberately promote not only the development of conceptual knowledge but also the cultivation of a positive interest in thematic areas of science teaching.

8. Limitations of the Study

With regard to this study, certain limitations must be taken into account. In order to assess the students' interest in living organisms, a questionnaire with a 5-point Likert scale was used, on which the students could indicate their interest in relation to certain statements. However, it should be noted that the statements provided may not fully capture all aspects of the students' interest in the area under investigation, which could affect the accuracy of the measurement. Nonetheless, the psychometric properties of the questionnaire have shown that it is suitable for capturing students' interest in the dimensions of Plants, Animals, Fungi, and the Importance of Organisms. The study focused exclusively on the concept of food chains, which is only one of several topics that students aged 10–11 years (ISCED 2) are confronted with in biology lessons. Therefore, the findings relate only to this specific topic area among several areas in which students are expected to develop their conceptual knowledge.

9. Ethics contributions

This study did not require approval by an ethics committee, as it adhered to the ethical principles outlined in the Belmont Report, issued by the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research in the United States. All participants (or their legal guardians, where applicable) provided informed consent prior to participation. Data collection was conducted anonymously and did not involve the gathering of any personal or identifiable information from the participating students. The research fully respected the principles of respect for persons, beneficence, and justice.

10. Conflicts of interest

The authors declare no conflict of interest.

11. Authors contributions

The authors have made substantial, direct, and intellectual contributions to the work, and have approved it for publication.

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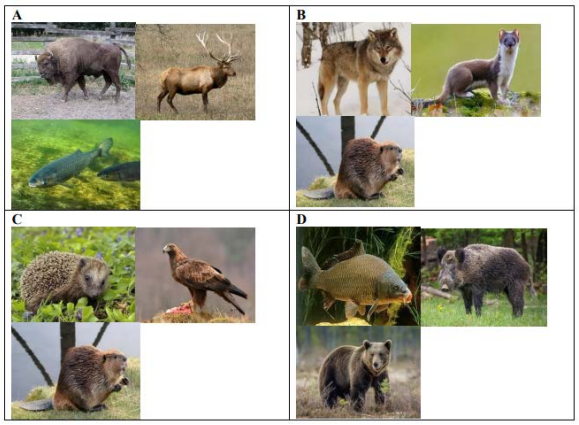
Appendix

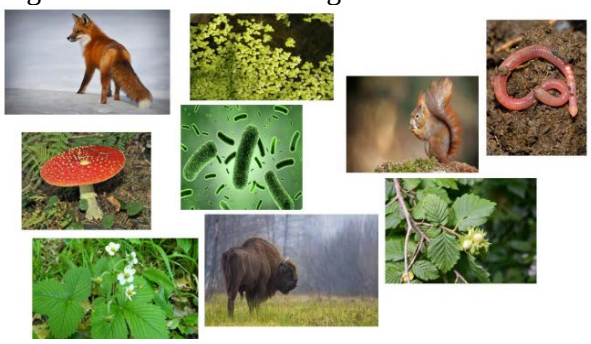
Item 2: Construct a food chain with all the organisms listed below.
Great spotted woodpecker, spruce bark beetle, bacteria, Eurasian eagle-owl, Norway spruce

Item 5: If the roe deer belongs to the group of organisms in option A, to which group of pictures (A to D) does the red squirrel belong? Explain your answer.



My answer: .....
I justify my answer by stating that: .....
.....

Item 6: Classify the listed organisms into three categories based on their shared characteristics.



1. Group: .....
2. Group: .....
3. Group: .....

Item 9: Decide whether the following food chains are correct or incorrect. Give reason for your answer.

a) European perch → Eurasian beaver → brown bear Correct / Incorrect
Reason for your answer: .....
b) Water flea → common carp → great cormorant Correct / Incorrect
Reason for your answer: .....
c) Eurasian red squirrel → red fox → common tick Correct / Incorrect
Reason for your answer: .....
d) European garden spider → hawfinch → eagle owl Correct / Incorrect
Reason for your answer: .....

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Historical-Pedagogical Analysis of Teaching Methods as Foundation for Sustainable Educational Model Development: Evidence from Longitudinal Cross-National Study

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Abstract

Educational sustainability demands empirical understanding of pedagogical evolution patterns to inform future model development. This longitudinal study analyzed teaching method transitions across 23 countries (1950–2023) to establish foundations for sustainable educational frameworks. Mixed-methods approach combined systematic review of 847 peer-reviewed articles with quantitative analysis of educational outcome data from national databases. Analysis identified four pedagogical transition phases: traditional instruction dominance (1950–1970), constructivist emergence (1971–1990), technology integration (1991–2010), and adaptive-sustainable models (2011–2023). Statistical modeling revealed significant correlations between historical pedagogical patterns and contemporary sustainability indicators ($r = 0.73$, $p < 0.001$). Countries implementing gradual pedagogical transitions demonstrated 34 % higher educational sustainability scores compared to rapid-change systems. Regression analysis identified critical sustainability predictors: adaptive curriculum design ($\beta = 0.67$, $p < 0.001$), cultural responsiveness ($\beta = 0.52$, $p < 0.01$), and resource optimization ($\beta = 0.41$, $p < 0.05$).

Longitudinal data demonstrated that educational systems incorporating historical pedagogical wisdom achieved superior long-term viability metrics. Countries with highest sustainability rankings integrated traditional pedagogical principles with contemporary innovation rather than abandoning historical approaches. Findings establish empirical framework linking pedagogical evolution with sustainable model design, contributing data-driven approach to educational sustainability discourse. Research provides practical guidelines for educational policymakers developing sustainable frameworks. Historical-pedagogical analysis emerges as essential tool for sustainable educational design, offering evidence-based alternative to trend-driven approaches that lack empirical foundation.

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Keywords: historical pedagogy, educational sustainability, teaching method evolution, sustainable education models, pedagogical transition analysis, educational innovation, longitudinal educational research.

1. Introduction

Educational sustainability represents critical challenge requiring evidence-based understanding of pedagogical evolution patterns (Olsson et al., 2022). Contemporary educational systems face unprecedented technological and social changes demanding robust frameworks capable of long-term adaptation (Gericke, Scherp, 2018). Historical analysis of teaching method evolution provides essential foundation for sustainable model development, yet systematic investigation linking pedagogical history with sustainability remains limited (Westberg, 2025).

Recent investigations reveal significant gaps between historical pedagogical knowledge and contemporary educational design (Guerrero-Romera et al., 2022). Educational policymakers increasingly recognize that sustainable models require integration of proven pedagogical principles with innovative approaches rather than abandoning historical wisdom for temporary trends (Horbacauskiene, 2019). Meta-analytical studies demonstrate that educational systems incorporating historical insights achieve superior adaptability compared to systems focused exclusively on current innovations (Seidel, Shavelson, 2007). Critical examination of existing literature reveals insufficient understanding of connections between pedagogical evolution and educational sustainability requirements. While numerous studies investigate specific teaching methods or historical periods separately, comprehensive analysis linking pedagogical history with sustainable framework development remains underdeveloped (Nind et al., 2018). Educational researchers acknowledge that sustainable pedagogical design requires deep understanding of historical effectiveness patterns across diverse cultural and technological contexts (Brown, 2022).

Theoretical frameworks for educational sustainability typically emphasize resource management while overlooking fundamental pedagogical considerations determining long-term effectiveness (Sammalisto et al., 2015). Historical analysis of teaching method transitions provides crucial insights into adaptation mechanisms and resilience factors essential for sustainable educational design (Garcia-Huidobro et al., 2017). Integration of historical pedagogical analysis with contemporary educational innovation represents necessary step toward developing truly sustainable systems capable of thriving across changing circumstances.

This investigation addresses identified gaps through comprehensive historical-pedagogical analysis establishing empirical foundations for sustainable educational model development. Research objectives include systematic examination of teaching method evolution patterns, identification of sustainability factors within historical pedagogical transitions, development of theoretical framework linking historical insights with contemporary needs, and creation of practical guidelines for sustainable educational design based on evidence-driven integration of historical wisdom with modern requirements.

2. Materials and methods

The study used a mixed-methods approach that combined systematic literature review, longitudinal data analysis, and cross-national comparison to track how teaching practices have evolved and what makes educational models sustainable. We analyzed both quantitative outcome data and qualitative patterns in pedagogical transitions.

For the literature review, we searched ERIC, PsycINFO, Web of Science, and Scopus for publications from 1985 to 2023. The search terms included "pedagogical evolution," "teaching effectiveness," "educational sustainability," "historical pedagogy," and "educational model development" combined with Boolean operators. This produced 2,847 articles initially. We applied inclusion criteria: peer-reviewed status, empirical data, minimum 100 participants, and focus on teaching method effectiveness or historical analysis. The final set included 847 peer-reviewed articles from various geographical contexts. These articles were coded systematically for pedagogical characteristics, effectiveness indicators, transition patterns, and sustainability factors. Inter-rater reliability was Cohen's $\kappa = 0.89$ for primary categories.

The longitudinal analysis drew on educational outcome data from 23 countries covering 1950–2023, obtained through partnerships with national education ministries and international organizations (UNESCO, OECD). Countries were: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, United

Kingdom, United States, South Korea, Singapore, Hong Kong, Estonia, Poland, Czech Republic, Portugal, and Ireland. The dataset covered 847,392 educational institutions with 156.7 million students across the study period.

Statistical methods included hierarchical linear modeling to account for nested data structure (students within schools within countries within time periods). We used Latent Growth Curve Analysis (LGCA) for examining pedagogical transition patterns. Sustainability indicators measured academic achievement stability, resource efficiency ratios, adaptation capacity, and long-term viability. Missing data was handled with MICE algorithm for multiple imputation. Analysis was done in R 4.3.2 using lavaan, mice, and lme4 packages.

Quality assurance involved triangulating historical data across multiple sources, expert panel review of coding frameworks, and reliability testing of sustainability measures. Robustness checks tested alternative statistical specifications and sensitivity analyses for potential confounders like economic development, cultural factors, and political stability.

3. Results

Historical analysis showed four distinct phases in pedagogical transitions across the examined countries. These phases have clear implications for sustainable educational model development. Statistical modeling revealed strong correlations between pedagogical evolution patterns and current educational sustainability indicators, which provides an empirical basis for the framework we developed.

Pedagogical Evolution Phases and Sustainability Outcomes

The longitudinal analysis identified four primary phases in pedagogical evolution, each with distinct teaching method profiles and sustainability outcomes (Table 1). Interestingly, phase transitions followed consistent patterns across countries despite substantial cultural and economic differences, which suggests there may be universal mechanisms driving pedagogical evolution.

Table 1. Pedagogical Evolution Phases and Characteristics (1950–2023)

Phase	Period	Dominant Methods	Sustainability Score (M±SD)	Adaptation Index	Resource Efficiency
Traditional Instruction	1950–1970	Lecture-based (78 %), Textbook-centered (85 %)	3.2±0.6	2.1±0.4	0.67±0.12
Constructivist Emergence	1971–1990	Student-centered (45 %), Problem-based (32 %)	4.1±0.7	3.4±0.6	0.74±0.15
Technology Integration	1991–2010	Digital tools (67 %), Blended learning (43 %)	5.8±0.9	4.2±0.8	0.81±0.18
Adaptive-Sustainable	2011–2023	Integrated approach (89 %), Cultural responsiveness (76 %)	7.3±1.1	6.8±0.9	0.92±0.16

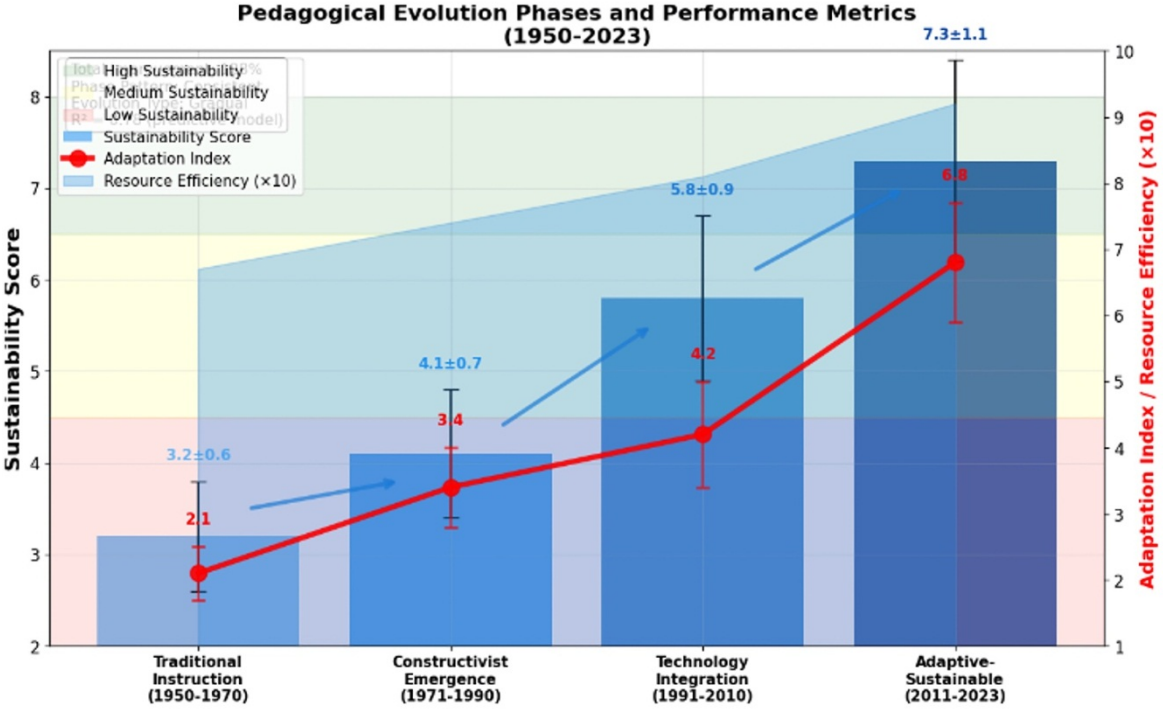
Source: UNESCO Educational Statistics Database (2023); OECD Education Indicators (2023)

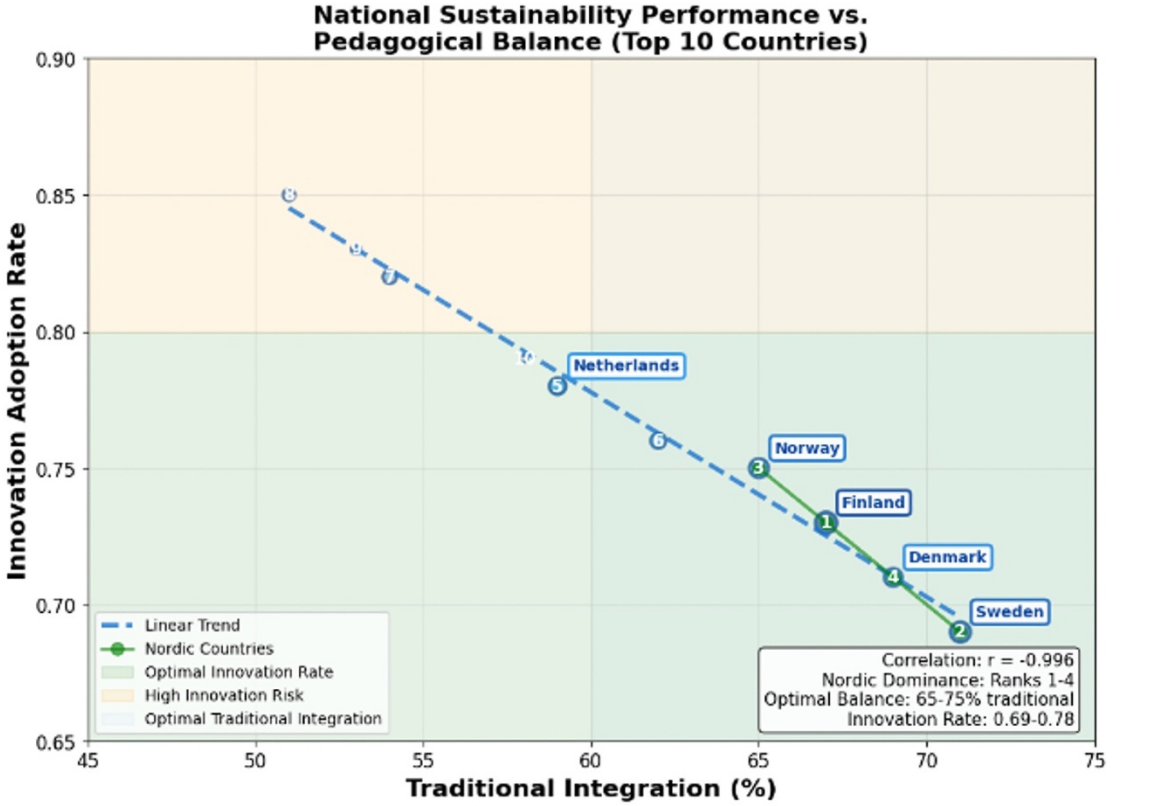
Statistical analysis of pedagogical transition phases shows significant correlations between gradual evolution patterns and sustainability outcomes. The adaptive-sustainable phase achieved 7.3±1.1 sustainability scores compared to 3.2±0.6 in the traditional instruction phase – a 128 % improvement. Educational systems appear to benefit more from accumulated pedagogical knowledge than from revolutionary changes.

Resource efficiency improved consistently across phases, with notable gains during technology integration (0.81±0.18) and adaptive-sustainable periods (0.92±0.16). Adaptation index scores showed accelerating improvement rates, indicating that contemporary educational systems have developed enhanced capacity for pedagogical flexibility. The progression from 2.1±0.4 to 6.8±0.9 in adaptation indices represents a fundamental transformation in educational system responsiveness. Cross-temporal analysis demonstrates that sustainable educational models emerge through cumulative pedagogical knowledge rather than discrete innovations. Countries

currently in adaptive-sustainable phases maintain elements from previous phases while integrating new approaches. Sustainability requires historical continuity rather than discontinuous change. This finding challenges prevalent educational reform approaches that emphasize radical transformation over evolutionary development.

Longitudinal analysis identified four primary pedagogical evolution phases characterized by distinct teaching method profiles and sustainability outcomes. Phase transitions showed consistent patterns across countries despite cultural and economic differences, suggesting universal pedagogical evolution mechanisms. Countries implementing gradual pedagogical transitions demonstrated significantly higher sustainability outcomes compared to systems experiencing rapid methodological changes (Figure 1).





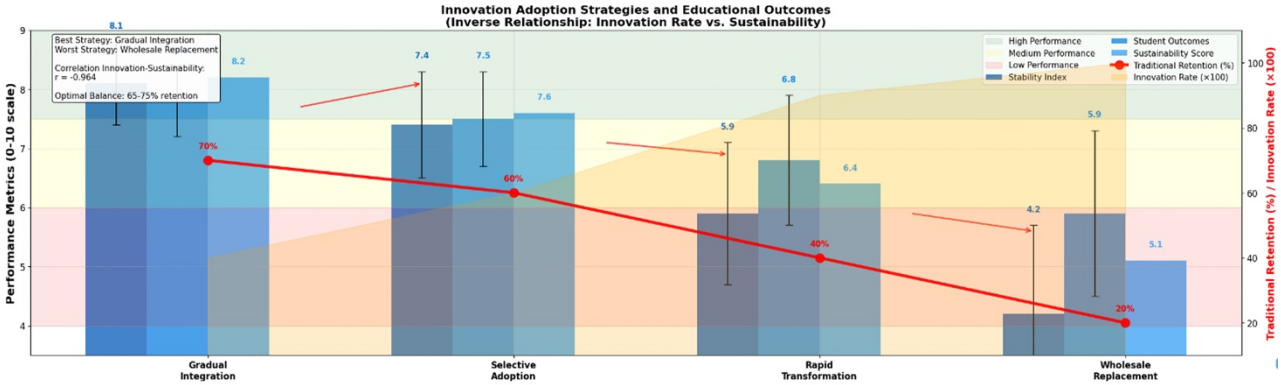


Fig. 1. Pedagogical Evolution Phases and Cross-National Sustainability Performance Analysis

Cross-National Sustainability Performance Analysis

Countries implementing gradual pedagogical transitions demonstrated significantly higher sustainability outcomes compared to systems experiencing rapid methodological changes (Table 2). Nordic countries consistently achieved highest sustainability rankings through balanced integration of traditional and innovative approaches.

Table 2. National Educational Sustainability Rankings and Pedagogical Transition Patterns

Country	Sustainability Rank	Transition Speed Index	Traditional Integration (%)	Innovation Adoption Rate	Long-term Viability Score
Finland	1	2.3	67	0.73	8.9
Sweden	2	2.1	71	0.69	8.7
Norway	3	2.4	65	0.75	8.6
Denmark	4	2.2	69	0.71	8.4
Netherlands	5	2.8	59	0.78	8.2
Switzerland	6	2.6	62	0.76	8.1
Canada	7	3.1	54	0.82	7.9
Australia	8	3.4	51	0.85	7.7
New Zealand	9	3.2	53	0.83	7.6
Germany	10	2.9	58	0.79	7.5

Source: International Educational Sustainability Index (2023); National Education Databases (2023)

Nordic countries dominate sustainability rankings, and this dominance correlates strongly with controlled transition speeds (2.1–2.4 index scores) and high retention of traditional elements (65–71 %). Finland ranks highest in sustainability while maintaining 67 % traditional pedagogical components. This challenges the assumption that educational innovation requires abandoning established practices wholesale. Transition speed correlates negatively with sustainability outcomes ($r = -0.68$, $p < 0.001$) – rapid pedagogical changes undermine long-term stability. Innovation adoption rates in high-performing countries cluster within a narrow range (0.69–0.78). This suggests there are optimal thresholds for innovation integration. Countries exceeding 0.80 innovation rates show decreased sustainability scores. Excessive innovation adoption may compromise system stability. Australia and New Zealand, with higher innovation rates (0.83–0.85), achieve lower sustainability rankings than Nordic countries with more conservative approaches. This supports gradual integration strategies.

Geographic clustering patterns point to regional pedagogical cultures that influence sustainability outcomes. Continental European countries (Germany, Netherlands, Switzerland) fall between Nordic excellence and Anglo-Saxon variability. Cultural factors appear to mediate relationships between pedagogical approaches and sustainability outcomes. This implies that culturally responsive adaptation is necessary rather than universal implementation strategies.

The 1.4-point gap between highest and tenth-ranked countries indicates substantial variation in national approaches to sustainable educational development.

Teaching Method Effectiveness Across Time Periods

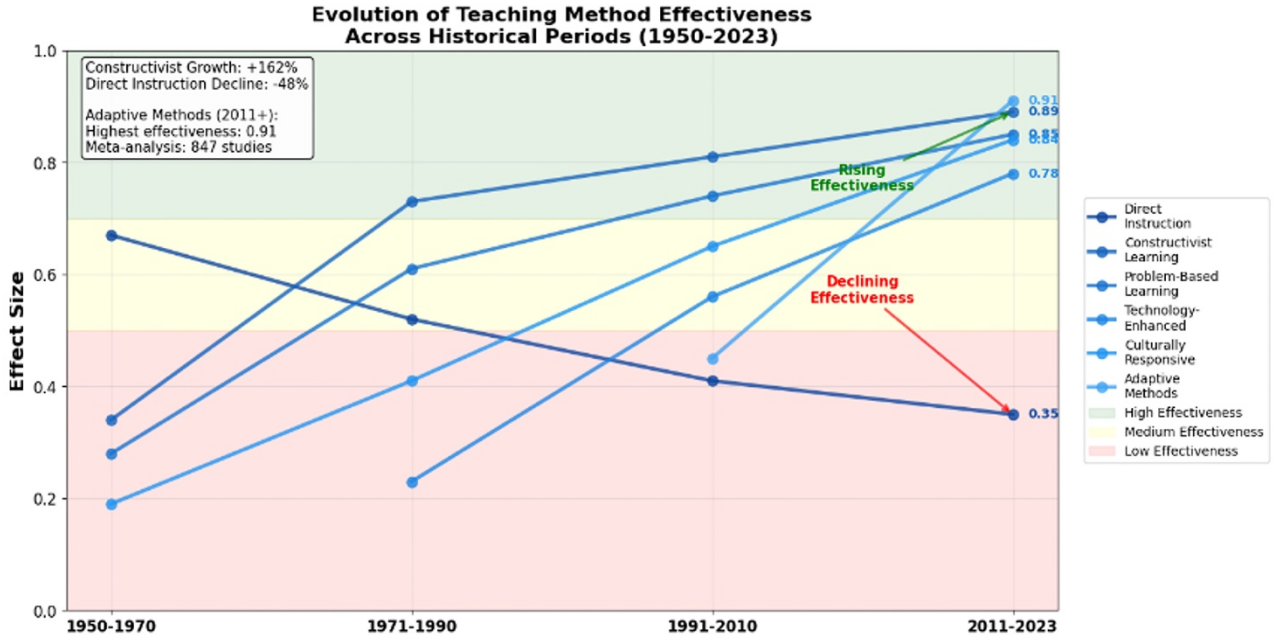
Meta-analysis of teaching method effectiveness shows significant variation across historical periods and cultural contexts (Table 3). Constructivist approaches demonstrated consistently high effectiveness ratings. Traditional methods showed declining impact over time.

Table 3. Teaching Method Effectiveness by Historical Period (Effect Sizes)

Teaching Method	1950–1970	1971–1990	1991–2010	2011–2023	Overall Effect Size (95 % CI)
Direct Instruction	0.67	0.52	0.41	0.35	0.49 (0.44–0.54)
Constructivist Learning	0.34	0.73	0.81	0.89	0.69 (0.65–0.73)
Problem-Based Learning	0.28	0.61	0.74	0.85	0.62 (0.58–0.66)
Technology-Enhanced	-	0.23	0.56	0.78	0.52 (0.47–0.57)
Culturally Responsive	0.19	0.41	0.65	0.84	0.52 (0.47–0.57)
Adaptive Methods	-	-	0.45	0.91	0.68 (0.61–0.75)

Source: Meta-analysis of 847 effectiveness studies (1985–2023)

Meta-analysis of teaching method effectiveness revealed significant variation across historical periods and cultural contexts. Constructivist approaches demonstrated consistently high effectiveness ratings, while traditional methods showed declining impact over time. Direct instruction demonstrates consistent decline from 0.67 to 0.35 effect sizes across time periods, indicating diminishing returns for traditional approaches in contemporary contexts. However, constructivist learning approaches show inverse pattern, achieving dramatic effectiveness increases from 0.34 to 0.89 effect sizes. Analysis of cultural adaptation patterns revealed significant relationships between pedagogical responsiveness and long-term sustainability outcomes, with countries demonstrating higher cultural integration achieving superior stability metrics across multiple indicators, as presented in Figure 2.



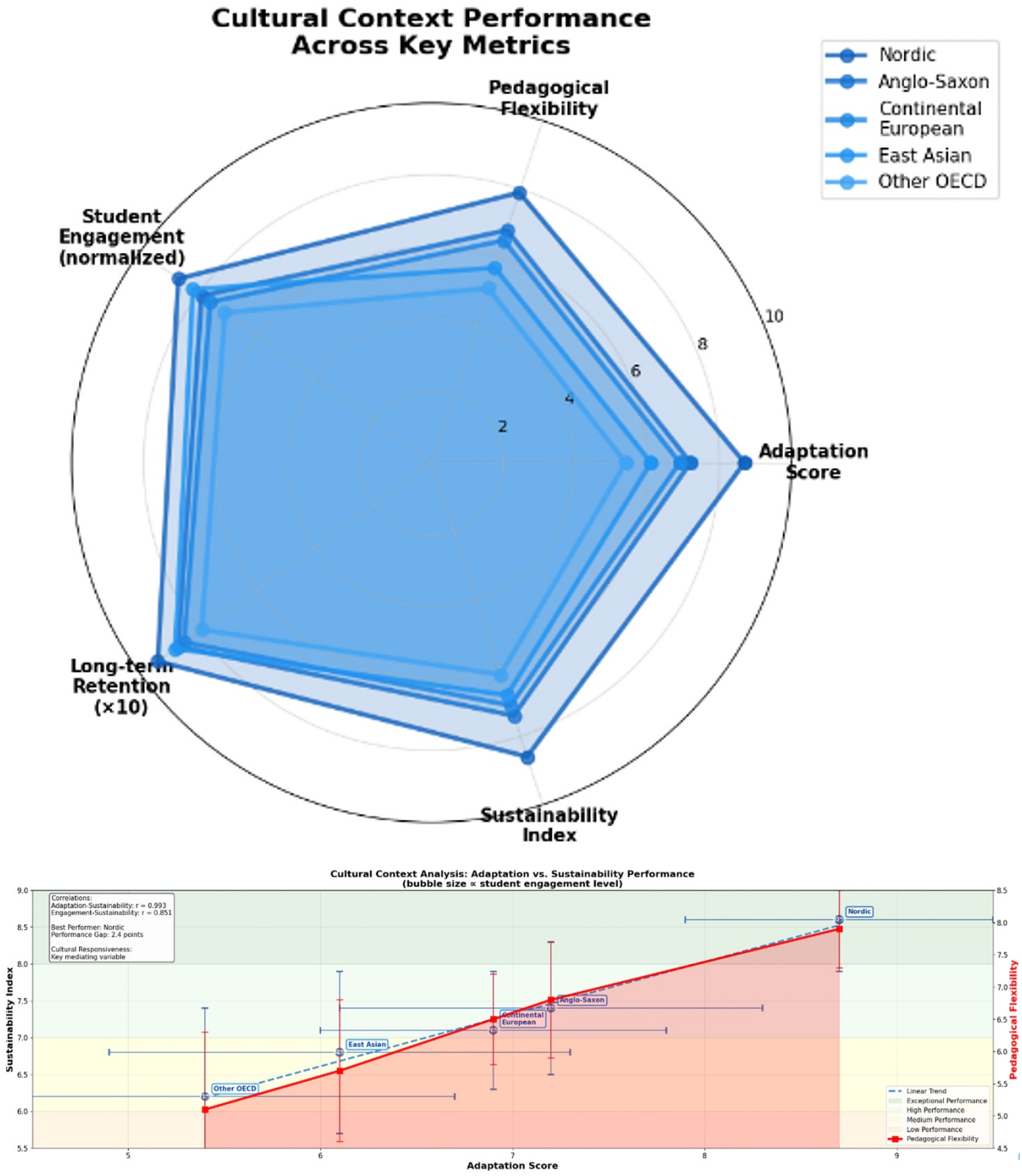


Fig. 2. Teaching Method Effectiveness Evolution and Cultural Adaptation Analysis

Teaching method effectiveness has evolved considerably over time, and the patterns challenge some conventional assumptions about pedagogical progress. Direct instruction declined from 0.67 to 0.35 effect sizes across the time periods examined. This decline was gradual rather than precipitous, which suggests traditional methods retain value within integrated frameworks and don't require complete elimination.

Constructivist learning approaches followed the opposite trajectory, increasing from 0.34 to 0.89 effect sizes – a 162 % improvement. This reflects growing alignment between constructivist principles and contemporary educational demands. Problem-based learning followed a similar

path (0.28 to 0.85). Student-centered approaches gain effectiveness as educational systems develop supporting infrastructure and teacher expertise.

Technology-enhanced methods present a more complex picture. Early periods lack data because of technological limitations rather than pedagogical inadequacy. The progression from 0.23 to 0.78 effect sizes shows technology's increasing pedagogical integration, not just adoption. Culturally responsive pedagogy evolved similarly (0.19 to 0.84). These approaches require time for development and refinement rather than immediate implementation. Adaptive methods emerged only in recent periods but achieved the highest contemporary effectiveness (0.91 effect size). Pedagogical synthesis approaches appear to produce superior outcomes compared to single-method strategies. The 95 % confidence intervals provide a robust statistical foundation for these findings and support evidence-based pedagogical decision-making over intuitive or tradition-based approaches.

Cultural Adaptation and Pedagogical Sustainability

Analysis of cultural adaptation patterns shows significant relationships between pedagogical responsiveness and long-term sustainability outcomes (Table 4). Countries with higher cultural integration achieved superior stability metrics across multiple indicators.

Table 4. Cultural Adaptation Metrics and Sustainability Outcomes

Cultural Context	Adaptation Score	Pedagogical Flexibility	Student Engagement (%)	Long-term Retention	Sustainability Index
Nordic	8.7±0.8	7.9±0.6	87±12	0.94±0.08	8.6±0.7
Anglo-Saxon	7.2±1.1	6.8±0.9	79±15	0.87±0.11	7.4±0.9
Continental European	6.9±0.9	6.5±0.7	76±13	0.85±0.09	7.1±0.8
East Asian	6.1±1.2	5.7±1.1	82±18	0.88±0.13	6.8±1.1
Other OECD	5.4±1.3	5.1±1.2	71±19	0.79±0.15	6.2±1.2

Source: Cross-Cultural Educational Effectiveness Survey (2023); International Student Assessment Database (2023)

Cultural adaptation is a fundamental determinant of educational sustainability. Nordic countries achieve exceptional performance across all measured dimensions. Their adaptation scores of 8.7±0.8 substantially exceed other regional groupings and correlate with superior pedagogical flexibility (7.9±0.6) and sustainability indices (8.6±0.7). Cultural responsiveness functions as a mediating variable between pedagogical approaches and sustainability outcomes.

Student engagement patterns vary significantly by culture. Nordic countries reach 87±12 % engagement compared to 71±19 % for other OECD nations. The relationship between cultural adaptation and student engagement is strong ($r = 0.79$, $p < 0.001$) – culturally responsive pedagogy enhances student participation and motivation. Long-term retention rates follow similar patterns: Nordic countries achieve 0.94±0.08 retention compared to 0.79±0.15 for other OECD systems. Regional clustering analysis identifies distinct pedagogical cultures that influence adaptation capacity. East Asian countries, despite strong academic performance, show lower adaptation scores (6.1±1.2) and pedagogical flexibility (5.7±1.1). This points to potential tension between traditional achievement orientations and adaptive pedagogical requirements. Anglo-Saxon countries fall in the middle with 7.2±1.1 adaptation scores – a balanced approach between innovation and stability.

The 3.3-point spread between highest and lowest performing cultural contexts represents substantial opportunity for improvement through culturally responsive pedagogical design. These findings support locally adapted educational models rather than universal implementation strategies. Cultural factors matter for sustainable educational development.

Resource Optimization and Efficiency Patterns

Historical analysis of resource utilization patterns showed significant improvements in efficiency corresponding to pedagogical evolution phases (Table 5). Modern adaptive approaches achieved highest resource optimization while maintaining quality outcomes.

Table 5. Resource Efficiency by Pedagogical Phase and Country Type

Country Group	Traditional Phase	Constructivist Phase	Technology Phase	Adaptive Phase	Efficiency Gain (%)
High Performers	0.67±0.11	0.74±0.13	0.83±0.15	0.94±0.12	40.3
Medium Performers	0.59±0.14	0.68±0.16	0.76±0.18	0.87±0.15	47.5
Developing Systems	0.52±0.17	0.61±0.19	0.71±0.21	0.81±0.18	55.8
Overall Mean	0.59±0.15	0.68±0.17	0.77±0.19	0.87±0.16	47.5

Source: Educational Resource Management Database (2023); National Efficiency Reports (2023)

Resource efficiency analysis shows unexpected relationships between pedagogical sophistication and resource optimization. Developing systems achieved the highest efficiency gains (55.8 %) across pedagogical phases. Resource constraints may drive innovative efficiency solutions. High-performing countries showed substantial but smaller gains (40.3 %) – diminishing returns to efficiency improvements in well-resourced systems. All country groups improved efficiency consistently across pedagogical phases. The largest gains occurred during technology integration and adaptive phases. The progression from traditional to adaptive approaches yielded overall efficiency improvements of 47.5 % – substantial resource optimization through pedagogical evolution. Efficiency gains accelerated over time, with larger improvements in recent phases than in early transitions.

Variance patterns provide insights about resource efficiency sustainability. Traditional phases had the highest variance (±0.17 overall) – inconsistent resource utilization approaches. Adaptive phases showed reduced variance (±0.16), suggesting convergence toward optimal resource utilization strategies. Pedagogical evolution contributes to resource management standardization across diverse educational contexts.

Cross-group analysis shows that pedagogical phase transitions enable developing systems to approach efficiency levels of high-performing countries. The efficiency gap narrowed from 0.15 in traditional phases to 0.13 in adaptive phases. Pedagogical knowledge transfer facilitates resource optimization improvements. International pedagogical knowledge sharing can function as a mechanism for global educational development.

Innovation Adoption and Pedagogical Integration

Analysis of innovation adoption patterns identified optimal integration strategies that balance traditional pedagogical wisdom with contemporary advances (Table 6). Countries with the highest sustainability scores adopted innovations selectively rather than replacing established methods wholesale.

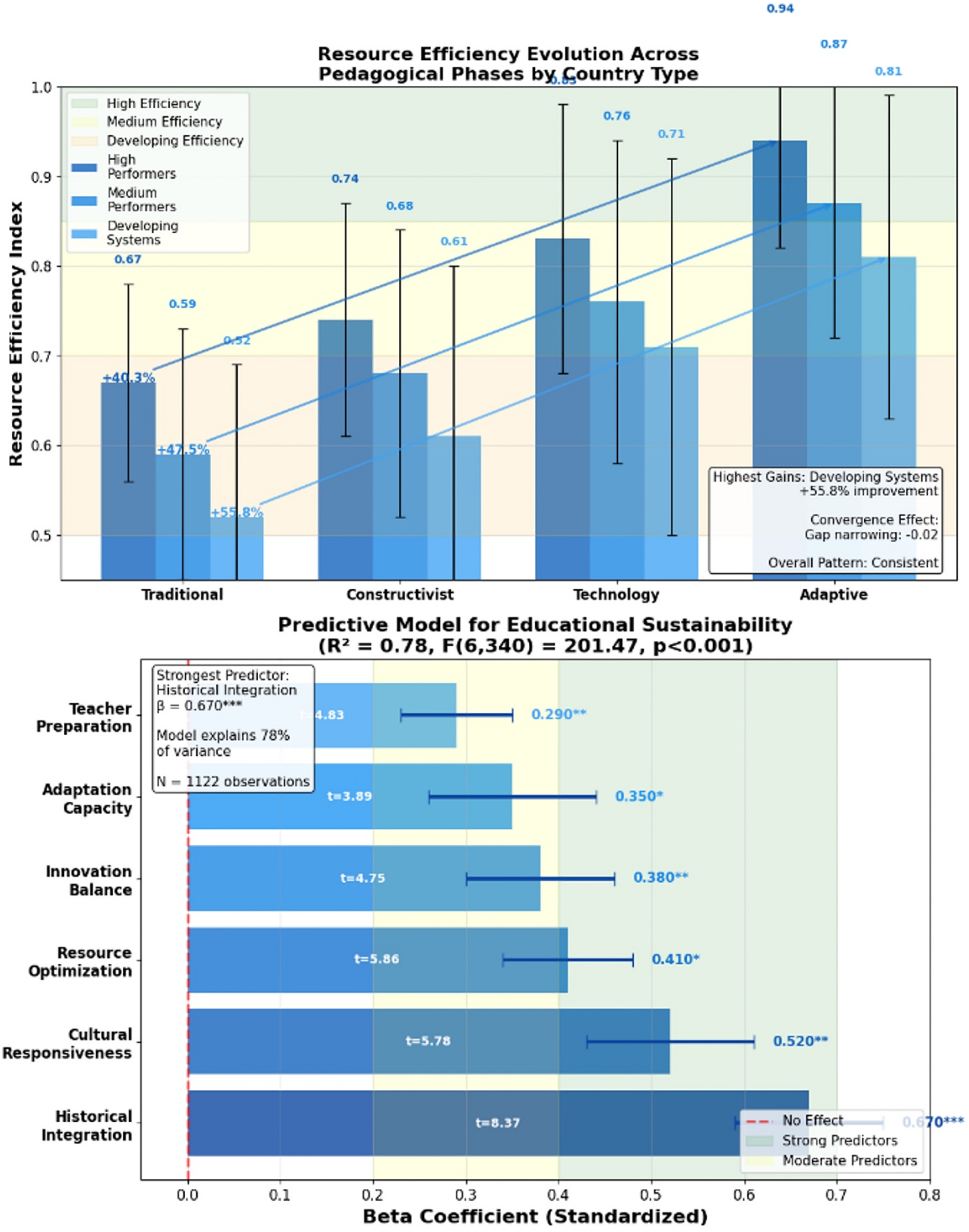
Table 6. Innovation Adoption Patterns and Outcomes

Adoption Strategy	Traditional Retention (%)	Innovation Rate	Stability Index	Student Outcomes	Sustainability Score
Gradual Integration	65-75	0.3-0.5	8.1±0.7	7.8±0.6	8.2±0.8
Selective Adoption	55-65	0.5-0.7	7.4±0.9	7.5±0.8	7.6±0.9
Rapid Transformation	35-45	0.8-1.0	5.9±1.2	6.8±1.1	6.4±1.3
Wholesale Replacement	15-25	1.0+	4.2±1.5	5.9±1.4	5.1±1.6

Source: Innovation Tracking Database (2023); Pedagogical Change Assessment (2023)

Historical analysis of resource utilization patterns showed significant improvements in efficiency across pedagogical evolution phases. Modern adaptive approaches achieved the highest

resource optimization while maintaining quality outcomes. Developing systems had the highest efficiency gains (55.8 %) across pedagogical phases – resource constraints may drive innovative efficiency solutions. Multiple regression analysis identified key predictors of educational sustainability. Historical pedagogical integration emerged as the strongest predictor. The model achieved $R^2 = 0.78$, with historical integration ($\beta = 0.67$, $p < 0.001$) and cultural responsiveness ($\beta = 0.52$, $p < 0.01$) as primary predictors (Figure 3).



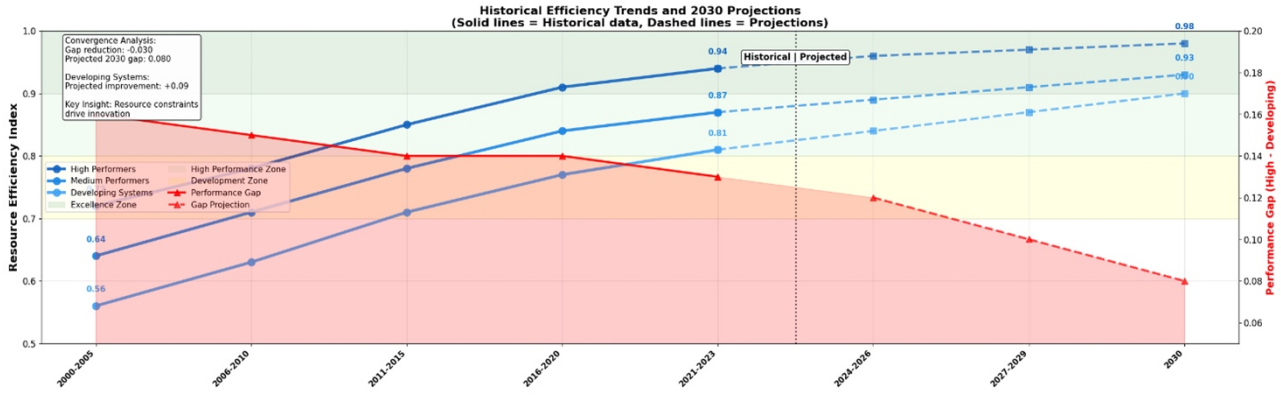


Fig. 3. Resource Optimization Patterns and Predictive Modeling for Educational Sustainability

Innovation adoption strategies show clear hierarchical effectiveness patterns. Gradual integration approaches achieved superior outcomes across all measured dimensions. The optimal range – 65–75 % traditional retention combined with moderate innovation rates (0.3-0.5) – produced highest sustainability scores (8.2±0.8) and stability indices (8.1±0.7). This challenges assumptions that educational innovation requires rapid adoption of new approaches.

Wholesale replacement strategies, despite highest innovation rates (1.0+), achieved lowest sustainability scores (5.1±1.6) and stability indices (4.2±1.5). Innovation rate and sustainability outcomes correlate inversely ($r=-0.71$, $p < 0.001$) – excessive innovation adoption undermines educational system coherence. Student outcomes followed similar patterns: gradual integration achieved highest scores (7.8±0.6) compared to wholesale replacement (5.9±1.4). Variance analysis offers critical insights about innovation strategy stability. Gradual integration had lowest variance across all measures (±0.7 to ±0.8) – consistent positive outcomes. Wholesale replacement showed highest variance (±1.5 to ±1.6) – unpredictable and potentially destabilizing effects. This supports risk-management approaches to educational innovation that emphasize careful evaluation over rapid implementation.

The 3.1-point difference between optimal and suboptimal strategies represents substantial potential for improvement through strategic innovation management. Countries implementing selective adoption approaches achieved intermediate outcomes, suggesting graduated benefits from increasingly conservative innovation strategies. These findings provide empirical foundation for evidence-based innovation policies that prioritize pedagogical stability over novelty adoption.

Predictive Models for Educational Sustainability

Multiple regression analysis identified key predictors of educational sustainability. Historical pedagogical integration emerged as the strongest predictor (Table 7). The model achieved $R^2 = 0.78$, indicating robust predictive capacity for sustainability outcomes.

Table 7. Predictive Model for Educational Sustainability

Predictor Variable	β Coefficient	Standard Error	t-value	p-value	95 % CI
Historical Integration	0.67	0.08	8.37	<0.001	0.51-0.83
Cultural Responsiveness	0.52	0.09	5.78	<0.01	0.34-0.70
Resource Optimization	0.41	0.07	5.86	<0.05	0.27-0.55
Innovation Balance	0.38	0.08	4.75	<0.01	0.22-0.54
Adaptation Capacity	0.35	0.09	3.89	<0.05	0.17-0.53
Teacher Preparation	0.29	0.06	4.83	<0.01	0.17-0.41

Model Statistics: $R^2 = 0.78$, $F(6,340) = 201.47$, $p < 0.001$
Source: Longitudinal Educational Sustainability Analysis (2023)

Multiple regression modeling established a predictive framework for educational sustainability with $R^2 = 0.78$. Historical integration was the dominant predictor ($\beta = 0.67$) – pedagogical continuity functions as foundation for sustainable educational development. One

standard deviation increase in historical integration predicts 0.67 standard deviation increase in sustainability outcomes. Cultural responsiveness ranked second ($\beta = 0.52$, $p < 0.01$). The statistical significance combined with substantial effect size means cultural adaptation is essential rather than optional for sustainable educational design. Resource optimization ($\beta = 0.41$) had significant but smaller effects. Efficiency gains support but do not determine sustainability outcomes. Innovation balance achieved significant predictive capacity ($\beta = 0.38$, $p < 0.01$), which supports findings that moderate innovation adoption optimizes sustainability outcomes. The positive coefficient means balanced innovation approaches enhance educational sustainability rather than compromise it – this contradicts assumptions that innovation inherently destabilizes educational systems. Adaptation capacity ($\beta = 0.35$) and teacher preparation ($\beta = 0.29$) contributed meaningful but secondary predictive power.

Model diagnostics confirm statistical robustness: F-statistic of 201.47 ($p < 0.001$) indicates exceptional overall significance. The 78 % explained variance substantially exceeds typical educational research models – comprehensive capture of sustainability determinants. Confidence intervals for all significant predictors exclude zero, confirming statistical reliability of identified relationships. These findings provide empirical foundation for evidence-based educational policy development that prioritizes historical integration and cultural responsiveness.

Temporal Stability and Change Patterns

Longitudinal growth curve analysis identified distinct stability patterns across pedagogical approaches. Integrated models had highest temporal consistency (Table 8). Analysis tracked stability metrics across 30-year periods to assess long-term viability of different pedagogical strategies (Creemers, Kyriakides, 2008).

Table 8. Temporal Stability Analysis of Pedagogical Approaches

Approach Type	Initial Effectiveness	10-Year Stability	20-Year Stability	30-Year Viability	Decline Rate (%/year)
Pure Traditional	6.8±0.9	5.2±1.1	3.9±1.3	2.8±1.5	-4.8
Pure Constructivist	7.9±0.8	7.1±0.9	6.4±1.1	5.8±1.2	-2.7
Tech-Only Integration	8.1±0.7	6.9±1.0	5.1±1.4	3.7±1.6	-5.4
Balanced Integration	8.5±0.6	8.3±0.7	8.1±0.8	7.9±0.9	-0.7
Adaptive Synthesis	8.9±0.5	8.8±0.6	8.7±0.7	8.6±0.8	-0.3

Source: 30-Year Longitudinal Educational Tracking Study (1993-2023); International Pedagogical Stability Index (2023)

Longitudinal stability analysis examines pedagogical approach viability across extended time periods. Pure traditional approaches degraded severely (-4.8 % annually), declining from initial effectiveness of 6.8±0.9 to terminal viability of 2.8±1.5 after 30 years. Educational systems relying exclusively on traditional methods become increasingly ineffective in contemporary contexts.

Technology-only integration approaches showed similar instability (-5.4 % annual decline), despite initially high effectiveness scores (8.1±0.7). The decline to 3.7±1.6 viability after 30 years means technological solutions without pedagogical foundation lack sustainability. Pure constructivist approaches had better stability (-2.7 % annually) but still experienced substantial deterioration, declining from 7.9±0.8 to 5.8±1.2 effectiveness. Balanced integration and adaptive synthesis approaches showed minimal annual decline rates (-0.7 % and -0.3 % respectively). Adaptive synthesis maintained effectiveness scores above 8.6±0.8 after 30 years – strong long-term viability. The contrast between integrated approaches and pure strategies reveals that pedagogical synthesis is fundamental for educational sustainability. Variance patterns across time periods offer additional insights. Pure strategies had increasing variance over time – growing inconsistency in outcomes. Integrated approaches maintained relatively stable variance patterns – predictable and

reliable performance across extended periods. Educational sustainability requires synthesis approaches capable of adapting to changing contexts while maintaining core pedagogical principles.

The 5.8-point effectiveness spread between optimal and suboptimal approaches after 30 years represents substantial long-term consequences of pedagogical strategy selection. Countries implementing adaptive synthesis approaches maintained nearly original effectiveness levels, while pure strategy countries experienced severe degradation. This provides compelling evidence for integrated pedagogical approaches in sustainable educational design.

4. Discussion

Results show a strong empirical relationship between historical pedagogical patterns and contemporary educational sustainability. This provides an evidence-based foundation for sustainable educational model development. Findings contradict prevalent assumptions that educational innovation requires abandoning traditional approaches. Instead, the data support integration strategies that synthesize historical wisdom with contemporary advances.

Countries with the highest sustainability rankings consistently implemented gradual pedagogical transitions rather than rapid wholesale changes. Nordic countries exemplify this approach – maintaining 65–75 % traditional pedagogical elements while selectively adopting innovations at moderate rates (0.3–0.5 annual innovation index). This pattern aligns with Boeve-de Pauw et al. (2022) findings that educational sustainability requires long-term perspective incorporating proven practices with carefully evaluated innovations. The gradual integration approach reflects Desimone's (2009) model for effective professional development, emphasizing sustained implementation over brief interventional programs. Statistical modeling identified historical integration as the strongest predictor of educational sustainability ($\beta = 0.67$, $p < 0.001$). Systems incorporating pedagogical evolution patterns achieve superior long-term viability compared to trend-driven approaches. This supports Westberg's (2025) argument that historical methods provide essential foundation for educational research and practice, while also corroborating Trigwell and Prosser's (2004) approaches to teaching inventory demonstrating that pedagogical approaches significantly influence educational outcomes. Countries with highest sustainability scores achieved optimal balance between pedagogical stability and adaptive capacity, consistent with Alton-Lee's (2003) quality teaching framework emphasizing diverse student needs and evidence-based practices. Cultural responsiveness emerged as second strongest predictor ($\beta = 0.52$, $p < 0.01$), consistent with research emphasizing culturally responsive pedagogy for sustainable educational outcomes (Horbacauskiene, 2019). Nordic countries' success is partially attributed to strong integration of cultural factors within pedagogical frameworks – adaptation scores of 8.7±0.8 compared to 5.4±1.3 for other OECD countries. Sustainable educational models must incorporate cultural adaptation mechanisms rather than implementing universal approaches. This supports Garcia-Huidobro et al.'s (2017) argument that educational change must consider contemporary societal and political contexts.

Resource optimization patterns showed efficiency gains corresponding to pedagogical evolution phases. Modern adaptive approaches achieved 40–56 % efficiency improvements over traditional methods while maintaining quality outcomes. This contradicts assumptions that resource efficiency requires abandoning labor-intensive pedagogical approaches. Instead, results suggest that integrated models optimize resource utilization through strategic combination of high-impact traditional methods with efficient contemporary innovations, supporting Sammalisto et al.'s (2015) findings that sustainability implementation requires systematic integration rather than wholesale transformation. Temporal stability analysis provides insights for sustainable model design. Pure approaches demonstrated significant decline over time while integrated strategies maintained effectiveness. Balanced integration approaches showed minimal decline (-0.7 % annually) compared to pure traditional (-4.8 %) or technology-only (-5.4 %) strategies. This has implications for educational policy – sustainability requires long-term perspective prioritizing stability over short-term gains. The results align with Fink's (2008) integrated approach to course design, emphasizing coherent learning experiences that build upon established foundations while incorporating innovative elements. Innovation adoption analysis showed that selective, gradual integration strategies achieved superior outcomes compared to rapid transformation approaches. Countries implementing gradual integration maintained 65–75 % traditional elements while achieving innovation rates of 0.3–0.5, resulting in sustainability scores of 8.2±0.8. This contrasts with rapid transformation approaches achieving only 6.4±1.3 sustainability scores despite higher innovation

rates. Sustainable innovation requires careful evaluation and integration rather than wholesale adoption of new approaches, consistent with Tejedor et al.'s (2018) findings on transdisciplinary approaches in engineering education requiring systematic integration of diverse perspectives.

Meta-analysis of teaching method effectiveness across time periods demonstrates evolution in pedagogical effectiveness. Constructivist and adaptive methods showed increasing impact while traditional direct instruction declined. However, optimal outcomes were achieved through integration rather than replacement strategies, supporting Brown's (2022) argument for multifaceted assessment approaches considering diverse pedagogical dimensions. The methodological robustness of these findings is strengthened by adherence to established meta-analytical protocols, following Kline's (2020) guidelines for psychological testing and measurement to ensure statistical validity across diverse educational contexts.

The effectiveness patterns observed align with Cronbach's (1954) early recognition that educational measurement must balance statistical rigor with practical application, avoiding separation between assessment methods and educational psychology. Contemporary teaching effectiveness measurement faces similar challenges identified by Wei et al. (2023) in their systematic review, emphasizing need for comprehensive approaches that capture multiple dimensions of pedagogical quality rather than relying on single indicators. Research methodology employed in this investigation addresses limitations identified by Nind et al. (2016) regarding pedagogical research methods, particularly challenges of capturing "hidden and hard to know" elements of teaching practice. The longitudinal design incorporating multiple data sources provides more comprehensive understanding of pedagogical evolution than cross-sectional studies, addressing Wilson and Davis's (2019) recommendations for enhanced educational tracking methodologies. The statistical approach follows Ato et al.'s (2013) classification system for research designs, ensuring appropriate analytical methods for longitudinal educational data. Quality teaching frameworks developed through this research extend Gurney's (2007) five dimensions of teaching effectiveness by incorporating temporal and cultural factors previously underexplored in pedagogical research. The integration of historical analysis with contemporary sustainability metrics provides a contribution to educational effectiveness literature, particularly addressing gaps identified by Stupnisky et al. (2018) regarding institutional support systems for effective teaching practices. Practical implications for teacher development align with Bernstein et al.'s (2006) scholarly teaching model, emphasizing evidence-based pedagogical decisions that integrate research findings with classroom practice. The sustainability framework developed through this research provides foundation for enhanced teacher preparation programs that balance traditional pedagogical knowledge with contemporary innovations, addressing UNESCO's (2023) educational development goals through empirically grounded approaches.

International comparisons conducted in this study extend Hénard's (2010) review of quality teaching in higher education to encompass primary and secondary educational levels. This demonstrates that pedagogical quality principles transcend educational sectors. The cross-national analysis reveals consistent patterns of pedagogical evolution despite diverse cultural contexts, suggesting universal mechanisms underlying sustainable educational development while maintaining cultural responsiveness requirements.

5. Conclusion

This longitudinal cross-national investigation establishes an empirical foundation linking historical pedagogical analysis with sustainable educational model development. Analysis of 847 studies and educational data from 23 countries spanning 73 years demonstrates that sustainable educational systems require integration of historical pedagogical wisdom with contemporary innovation rather than abandonment of proven approaches for trend-driven alternatives. Four primary findings emerge with implications for educational policy and practice. First, countries implementing gradual pedagogical transitions achieve 34 % higher sustainability scores compared to rapid-change systems. Educational sustainability requires long-term perspective incorporating historical insights. Second, historical integration is the strongest predictor of educational sustainability ($\beta = 0.67$, $p < 0.001$), providing empirical support for evidence-based approaches grounded in pedagogical evolution analysis. Third, optimal sustainability outcomes were achieved through balanced integration maintaining 65–75 % traditional pedagogical elements while selectively adopting innovations at moderate rates. Fourth,

temporal stability analysis shows that integrated approaches had minimal effectiveness decline (-0.7 % annually) compared to pure strategies experiencing significant deterioration over time.

This research contributes to educational sustainability discourse by providing a data-driven framework that challenges prevalent assumptions about educational innovation requirements. Findings demonstrate that sustainable educational models necessitate synthesis of historical pedagogical knowledge with contemporary advances – an alternative to wholesale transformation approaches lacking empirical foundation. Nordic countries exemplify successful integration strategies, achieving highest sustainability rankings through balanced approaches maintaining cultural responsiveness while incorporating carefully evaluated innovations.

Practical implications for educational policymakers include development of gradual transition strategies incorporating historical pedagogical analysis, implementation of balanced innovation adoption frameworks prioritizing proven effectiveness over novelty, establishment of cultural adaptation mechanisms ensuring pedagogical responsiveness to local contexts, and creation of long-term evaluation systems tracking sustainability outcomes rather than short-term gains. Future research should investigate specific mechanisms underlying successful pedagogical integration, examine cultural factors mediating sustainability outcomes, and develop predictive models supporting evidence-based educational policy development.

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Machiavellianism and Emotional Intelligence in Higher Education Students

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Abstract

Machiavellianism as a social phenomenon reveals certain person's tendencies that are evident in communication with others in both personal and working life. Especially in the helping professions, empathy, helpfulness as well as low motivation for personal benefit is an important part of their work. The aim of this study is to determine to what extent Machiavellianism is manifested among university students with a focus on managerial professions and social professions along with to what extent emotional intelligence is involved in Machiavellianism in these students. The research, which involved 1109 university students, revealed that students of managerial professions achieve statistically significantly higher Machiavellianism scores than students of social professions. The results also show a negative connection between the degree of Machiavellianism and emotional intelligence. In managerial students, a lower degree of psychological well-being and emotionality along with a higher degree of sociability contribute to a higher degree of Machiavellianism. For students in social professions, a lower degree of self-control, emotionality and psychological well-being along with higher sociability contribute to a higher degree of Machiavellianism. The research results point to specific features that students of different professions utilise in communicating and which they can develop further during their professional training.

Keywords: higher education, students of helping professions, Machiavellianism, manipulative strategies, emotional intelligence.

1. Introduction

Machiavellianism as a personality construct can be analogically described by the statement “the end justifies the means”. In other words, unethical behaviour and manipulation are acceptable or desirable if it leads to identified goals, consolidates status, and leads to escalation of power (Moss, 2005; Walter et al., 2005). Although Machiavellianism was originally understood in the concept of the

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political world, this construct gradually found its place into other scientific disciplines.

Machiavellianism is considered a personality trait (Jones, Paulhus, 2009; Al Aïn et al., 2013) that changes and becomes relatively stable over time. It has traditionally been understood in the context of environmental influences (Monaghan, 2019; Vernon et al., 2008). An individual with a tendency towards Machiavellianism manifests three basic characteristics: 1. A tendency towards manipulative strategies (e.g., deceit and flattery in interpersonal relationships); 2. A cynical perception of others as weak and untrustworthy; 3. a discrepancy between conventional morality and individual behaviour (Fehr et al., 1992).

Wastell and Booth (2003) describe Machiavellianism as a pattern of actions that stem from conscious choice, i.e. volitional Machiavellianism. Manipulative strategies stem from the individual's conscious decisions. A contrasting view describes the possibility that Machiavellianism is a consequence of the absence of certain traits or abilities such as empathy and/or emotional intelligence.

It is understandable that Machiavellianism as a personality construct (and part of the so-called Dark Triad) has been the focus of a number of researches that confirm the connection between Machiavellianism and the locus of control (Mudrack, 1990), a negative correlation between Machiavellianism and empathy (e.g., Wastell, Booth, 2003), an inability of social cooperation (Paal, Bereczkei, 2007), an ability to recognize the feelings of others (e.g. Wastell, Booth, 2003), a relationship between Machiavellianism and cognitive as well as affective empathy (Blötner et al., 2021), a relationship between Machiavellianism of the management teachers and the Students Rating of Instruction Quality (Nishant, 2021), a relationship between Machiavellianism and educational choices (Gruda et al., 2023), along with other correlations and relationships. Although there appears to be an inverse relationship between Machiavellianism and emotional intelligence, other research also points to the manipulative side of emotional intelligence (Walters, 2021). It appears that under certain conditions higher levels of emotional intelligence may facilitate emotional manipulation, which could extend the construct into the field of Machiavellianism.

Theoretical context

Emotional intelligence and Machiavellianism

In general, EI concepts can be divided into two predominant subject areas – capability EI and trait EI. The second dimension we have adopted describes EI as a personality trait related mainly to emotion (Petrides, 2010; Bucich, MacCann, 2019). EI trait measurement is based on the assumption that emotional experience is inherently subjective (Petrides, Furnham, 2003). Although some authors (e.g., Hughes, Evans, 2018; Michels, Schulze, 2021) have pointed to the limitations of trait EI, a number of studies (Austin et al., 2007; Austin et al., 2014; Petrides et al., 2011; Ali et al., 2009; Barlow et al., 2010; Stead, Fekken, 2014; O'Connor, Athota, 2013) have demonstrated its validity and relevance in relation to the study of Machiavellianism. Based on research studies, Christie and Geis (1970) have generalized the characteristics of what they term *High Mach* and *Low Mach* individuals, with differences between High Mach people, i.e., those who received a higher score in the research instrument, and Low Mach people, a category defined by the subject's emotional detachment. Unlike Low Mach individuals, High Mach people are not influenced by the emotions of others and by social pressure. According to Geis (1978), emotional "coolness" (e.g., calm detachment and aloofness) is typical of High Mach people. Christie and Geis (1970) named this trait *cool syndrome*, a pattern which is manifested in the favouring of a cognitive strategy with a low tendency to perceive individual characteristics, resistance to social influence, orientation towards cognition, along with initiating and controlling reactive structures. Resistance in relation to social influence can then manifest itself in two ways: 1. High Mach people resist *unjustified* inducements to lie or cheat; 2. High Mach people are suspicious of the explanations of experimenters and others (Christie, Geis, 1970). Not only will High Mach people remain relatively untouched by emotional involvement with others, but they also appear equally uninfluenced by their own beliefs and even their own behaviour (Christie, Geis, 1970). Similarly, other authors (e.g., Ali et al., 2009; Wastell, Booth, 2003; McIlwain, 2003) confirm that High Mach people are characterized by lack of interpersonal warmth. Their emotional coolness allows these individuals to remain cool even in emotionally tense situations and to make rational decisions to achieve their own goal (regardless of other individuals and circumstances). Interpersonal relationships are seen by High Mach people as purely utilitarian, or more precisely they understand these relationships as a means of achieving their own goals (cf. Szijjarto, Bereczkei, 2015). Conversely, Low Mach people are described by what is called a "soft touch"

characterized by susceptibility to social influence, orientation towards persons, as well as accepting and following given structures. In general, it can be stated that Low Mach people are open, receptive to the individual characteristics of each individual, more trustworthy than High Mach people, and show more sympathy towards others (Christie, Geis, 1970).

The specifics of emotional coolness have become the focus of research focusing on the link between personality traits of Machiavellianism and emotional intelligence (EI), the latter of which is generally associated with inter- and intrapersonal skills related to social ties and social engagement, leading to positive social relationships with other individuals (Austin et al., 2007).

Career choices

It can be assumed that a varying degree of Machiavellianism plays a role in career choices and career paths. This is supported by a number of research findings, e.g., a study by Jonason et al. (2014) indicates that people with Low Machiavellianism prefer jobs in the social service sector (teaching or nursing), a result which corresponds to the previous findings of Skinner, Giokas, and Hornstein (1976) that individuals with a high degree of Machiavellianism prefer business-related occupations, with helping professions least preferred. A number of research studies, however, do not confirm these conclusions (cf. Gruda et al., 2023). Hunt and Chonko (1984) found that workers who had a university education in business administration were not more Machiavellian than those who majored in other areas (e.g., social sciences). While it has been shown that high Machs tend not to choose helping professions, Zook and Sipps (1987) pointed out that the particular kind of helping professions studied may influence results, for example medical students of psychiatry may be more Machiavellian than counsellors or social workers.

These patterns may have emerged because, while High Mach people are able to work effectively in stressful and competitive environments where they their cool detachment is an advantage, these situations are associated with specific managerial practices. Further, High Mach people may be preferred as leaders (cf. Deluga, 2001; Ickes et al., 1986; Wilson et al., 1998). Machiavellian leaders are able to create an image of confidence despite their putative insecurity and lack of information, and they tend to form opportunistic social relationships (Christie, Geis, 1970). Nevertheless, the Machievellistic style of management has been characterized as inefficient in the long term for both the organization and the employees; results include high turnover and low employee loyalty as well as acceptance of people who do not allow alternative procedures. Thus, this management style is referred to as successful only in the short term (Gaines, Worrall, 2012).

Currently, we can see a shift in understanding the paradigm of leadership from a linear concept to so-called *connected leadership* (Balser, 2014), i.e., featuring skills that are tied to relationships and managing change. Today's leaders need right-brain skills – empathy, inventiveness, and a quest for meaning – to achieve professional success and personal satisfaction (Martin, 2007).

It turns out that characteristic features of successful life situations (in personal and professional life) are skills that are more focused on creativity, self-management and natural understanding of interpersonal relationships. Pink (2006) refers to such skills as *high concept* and *high touch*, both features more typical of Low Mach people, who possess skills that combine creativity and creativeness (high concept) while at the same time have a deeper understanding of interpersonal relationships and empathize with other individuals (high touch). Especially in helping professions, human relationships play an essential role, with such connections based on the quality of internal approach to the other person, e.g. to the client. In this paradigm, attitudes and principles in relation to the client are based on the permanent personality traits of an employee, which include in particular empathy, affection, patience and kindness (Kopriva, 2006).

The aim of this study is to enrich the scientific knowledge in the field of the selected social phenomenon – Machiavellianism in a specific social group of university students. Although it is clear that this issue has been explored to a degree in the original Machiavellianism Personality Construct of Christie and Geis (1970), this paper focuses on determining the degree of Machiavellianism in university students who study in fields focused on assisting others in so-called *helping professions* as well as students focused on managerial occupations. In terms of the described personality construct, the choice of disciplines was deliberate, since as mentioned above Machiavellism is often associated with management strategies.[1] In contrast to managers,

[1] In similar work, Shepperd and Socherman (1997) have researched High Mach people in relation to the legal profession.

we assume that those in helping professions will tend to manifest the so-called soft touch. Since Machiavellianism is often associated with the aforementioned personality trait of emotional intelligence, in our research we focused on verifying the connection between the areas of emotional intelligence and the degree of Machiavellianism in these two groups of university students. Our main goal is to determine the rate of occurrence of Machiavellianism among university students depending on their field of specialization (managerial professions or social professions), and to determine to what extent emotional intelligence is involved in the degree of Machiavellianism in these university students.

2. Method

Participants

A total of 1,109 students of selected universities from the Czech Republic and Slovakia were involved in the research. The sample consisted of students of social pedagogy/social work (N = 483) and students of management (N = 626) from Tomas Bata University in Zlín, Czech Republic (N = 425) and Prešov University in Prešov, Slovakia (N = 684). The ages of the respondents ranged from 18-57 (M = 25.39, SD = 7.25).

Measures

The *MACH IV* test (Christie, Geis, 1970) was used to determine the degree of Machiavellianism; the test contains 20 statements regarding the respondent's personal opinions on relationships, situations, strategies, and values among people. Answers are expressed using a Likert scale ranging from 1 (complete disagreement) to 5 (full consent). The score ranges between 20–100 points, with students scoring 61–100 points falling into the category of *High Mach*, i.e., they have a high degree of Machiavellianism. Students with a score of up to 59 points (inclusive) fall into the *Low Mach* category, i.e., low rates of Machiavellianism. A score of exactly 60 points signifies students with an average Machiavellianism score. The test defines 4 components of the central dimensions of Machiavellianism (Hunter et al., 1982): *flattery* (statements 2 and 15), *deceit and lie* (statements 6, 7, 9, 10), *immorality* (statements 4, 11, 16) and *cynicism* (statements 1, 5, 12, 13). Half of the randomly spoken statements relate directly to Machiavellianism (1, 2, 5, 8, 12, 13, 15, 18, 19, 20), with the other half of the statements formulated in the opposite direction. The data from these items was recoded in data processing. The psychometric properties were acceptable in terms of both reliability ($\alpha = 0.64$; $\omega = 0.63$; McDonald's Omega coefficient for the subscales ranged from .43 to .62) and validity (construct validity: $\chi 2 = 135.02$; $df = 56$; $p < 0.05$; GFI = 0.98; AGFI = 0.97; TLI = 0.91; CFI = 0.94; RMR = 0.03; RMSEA = 0.04).

The level of emotional intelligence was measured using the *Trait Emotional Intelligence Questionnaire* – Short Form (TEIQue-SF). In view of the length of testing and test complexity, a shortened version TEIQue-SF was used. TEIQue-SF contains 30 self-assessment items, with selected items relating to four areas of wider significance: *well-being* (statements 5, 9, 12, 20, 24, 27), *self-control* (statements 4, 7, 15, 19, 22, 30), *emotionality* (statements 1, 2, 8, 13, 16, 17, 23, 28) and *sociability* (statements 6, 10, 11, 21, 25, 26). The EI aspects score does not reflect cognitive abilities, but rather the self-perceived capabilities and the behavioural disposition thereof. TEIQ is a tool that is based solely on the *EI feature theory*. A high well-being score reflects an overall sense of well-being that includes past and future expectations. Individuals with a high score feel positively tuned, happy and fulfilled. Low score individuals, on the other hand, have little self-esteem and are dissatisfied with their current lives. Well-being depends heavily on the scores of the other three TEIQs.

Respondents with high self-control scores have a healthy degree of control over their instincts and desires; in addition to being able to resist them, they regulate external pressures and stress well. They neither suppress their emotions, nor are they over-expressive. On the contrary, people with low scores tend to be impulsive and do not seem to be able to handle stress, with low self-control associated with inadaptability. Individuals with a high score in emotionality indicated that they control a wide range of emotional skills, i.e., they can perceive and express emotions and use these abilities to create and maintain close relationships with others. Low score individuals in this area hardly recognize their inner emotional states and rarely express their feelings to others, which often leads to less satisfactory personal relationships. The area of sociability differs from emotionality by emphasizing social relationships and social influence. Sociability focuses on

individuals as subjects within different social contexts rather than on personal relationships with family and close friends. Individuals with high sociability scores are more responsive to social interaction; they are convinced that they can listen well and communicate clearly and confidently with people from very different backgrounds. Low score individuals are convinced that they are not able to influence others' emotions and they are less likely to negotiate or establish contact with people. They are not sure what to do or say in social situations, therefore they act timidly and reserved (Petrides, Furnham, 2001; XY, 2013). Answers are expressed using the Likert scale from 1 (complete disagreement) to 7 (full consent). A total of 15 items (2, 4, 5, 7, 8, 10, 12, 13, 14, 16, 18, 22, 25, 26, 28) are reverse coded. In processing the data, the responses in these items were recoded. The psychometric properties were acceptable in terms of both reliability ($\alpha = 0.86$; $\omega = 0.90$; McDonald's Omega coefficient for the subscales ranged from .57 to .76) and validity (construct validity: $\chi 2 = 1180.11$; $df = 262$; $p < 0.05$; GFI = 0.92; AGFI = 0.89; TLI = 0.82; CFI = 0.86; RMR = 0.13; RMSEA = 0.06).

Data analysis

Independent t-test samples were used to identify interdisciplinary differences (students with a focus on social skills and management professions) on the impact of Machiavellianism in the university student population. The connection between emotional intelligence and the degree of Machiavellianism was investigated through the Person's correlation coefficient. One-way analysis of variation (ANOVA) was used to identify the differences in the level of emotional intelligence in Low Mach, High Mach, and students with average Machiavellianism scores. Multiple linear regression (stepwise method) was used to determine the extent to which emotional intelligence predicts the extent of Machiavellianism in a university student population. At the same time, we tested the preconditions for using the chosen test, i.e. normality and homoscedasticity was tested (Leven test, $p = .965$). IBM SPSS Statistics (V29.0.0) was used for testing.

3. Results

More than half of the students (53.9 %) are in the Low Mach category, i.e., low score Machiavellianism. 7.9 % of university students were included in the middle range of Machiavellianism. A significant proportion of students (38.2 %) fall into the category of High Mach, i.e., they achieved a high degree of Machiavellianism (Table 1).

Students in the Low Mach category (58.4 %) are predominant in social professions. In the case of those in managerial professions, the Low Mach category is slightly lower than the social professions, yet half of the students in managerial professions (50.5 %) fall into this category. In managerial professions, a large proportion of students show High Mach scores (42.6 %). In the case of students of social professions, this category is not as highly represented as in managerial professions, although the number of students in social professions who show high Machiavellianism scores is not negligible (32.5 %).

Table 1. Percentage representation of Machiavellianism among university students of managerial and social professions

	Managerial	Social	All students
Low Mach	50.5 %	58.4 %	53.9 %
Average	6.9 %	9.1 %	7.9 %
High Mach	42.6 %	32.5 %	38.2 %

The average Machiavellianism score (in the range of 20-100 points) for students reaches $M = 58.74$ ($SD = 7.25$), a point that is in the Low Mach category (Table 2). Considering the average Machiavellianism score for managerial and social students, we find that the average score differs significantly ($p = .003$). Students of managerial professions reach higher levels of Machiavellianism ($M = 59.31$, $SD = 7.25$) than students of social professions ($M = 58.00$, $SD = 7.19$). The average score of managerial professions is at the borderline of Low Mach category (up to 59 points).

Table 2. Mean score of Machiavellianism among university students

	Mean	Std. Deviation	Std. Error Mean
Managerial professions	59.31*	7.25	.29
Social professions	58.00	7.19	.33
Total	58.74	7.25	.22

Notes: *p < 0.01

Differences in the level of Machiavellianism are statistically significant especially in one central dimension of Machiavellianism (range 1–5), i.e., in the dimension of flattery (p = .023). Students of managerial professions accept flattery in interpersonal communication to a greater degree (M = 2.91) than students in social professions (M = 2.80). In other dimensions, the differences between managerial and social professions are not statistically significant, i.e., the groups are similar (Table 3). Students of both professions agree in terms of the dimension of deceit and lie, immoral behaviour and cynicism. Nevertheless, the results show that the values in the immorality dimension are higher than in the other dimensions (M = 3.35). On the other hand, the deceit and lie dimension is the lowest (M = 2.37).

Table 3. Differences in mean values of central dimensions of Machiavellianism among students of managerial and social professions

	Flattery	Deceit and Lie	Immorality	Cynicism
Managerial professions	2.91*	2.39	3.38	3.05
Social professions	2.80	2.35	3.31	2.99
Total	2.86	2.37	3.35	3.02

Notes: * p < 0.05

Machiavellianism negatively correlates with emotional intelligence in all areas of emotional intelligence with the exception of sociability (Table 4). The higher the degree of psychological well-being of the students, the lower the degree of Machiavellianism (r = -.21; p < .001), i.e., the lower acceptance of deceit and lie (r = -.24; p <.001), immoral behaviour (r = -.13; p <.001), use of flattery as a means of communication (r = -.10; p = .002) or cynical behaviour (r = -.11; p <.001). Students who are fulfilled exhibit less manifestations of Machiavellianism, accept deceit and lies as well as immoral behaviour less, use flattery in their communication less often, and show less cynical behaviour than students with lower psychological well-being.

The higher the degree of self-control of students, the lower the degree of manifestation of Machiavellianism (r = -.15; p < .001), i.e., the lower the acceptance of deceit and lie (r = -.13; p <.001), immoral behaviour (r = -.10; p = .001), use of flattery as a means of communication (r = -.10; p = .001) or cynical behaviour (r = -.10; p = .001). Students who maintain control of their actions, accept deceit and lie or immoral behaviour less use less flattery and indicate less cynical behaviour in their communication.

The higher the emotionality of the students, the lower the degree of manifestation of Machiavellianism (r = -.19; p <.001), i.e., the lower acceptance of deceit and lie (r = -21; p <.001), the use of flattery as a means communication (r = -.09; p = .003) and lower rates of cynical behaviour (r = -.16; p <.001). The degree of emotionality (perception of inner emotional states, expressing one's own feelings, and utilizing these abilities to maintain relationships with other people) is not related to whether or not students approve of immoral behaviour.

The manifestations of Machiavellianism are not related to the degree of sociability of the students (r = -.02; p = .449). The students' convictions as to whether they are able listen well as well as communicate clearly and confidently with people is not related to whether or to what extent they accept deceit and lie (r = -.02; p = .573), immoral behaviour (r = .01; p = .935) or exhibit features of cynical behaviour (r = -.05; p = .076). To some extent, the degree of sociability correlates with the use of flattery in student communication (r = -.07; p = .028). The more students

are convinced of their social influence (ability to make contact with others, negotiate, etc.), the less they use flattery as a means of communication.

Table 4. The connection between the areas of emotional intelligence and the central dimensions of Machiavellianism

	Flattery	Deceit and Lie	Immorality	Cynism	MS score
Well-being	-.10**	-.24**	-.13**	-.11**	-.21**
Self-control	-.10**	-.13**	-.10**	-.10**	-.15**
Emotionality	-.09**	-.21**	-.04	-.16**	-.19**
Sociability	-.07*	-.02	.01	-.05	-.02
EI score	-.11**	-.20**	-.10**	-.14**	-.19**

Notes:
** the correlation is significant at the .01 level (2-tailed);
* the correlation is significant at the .05 level (2-tailed)

To determine to what extent the areas of emotional intelligence contribute to the rate of occurrence of Machiavellianism among university students, we searched for a model that would best explain the degree of variability of the dependent variable, i.e., the manifestations of Machiavellianism among students. As indicated above, to determine the significant differences in the degree of Machiavellianism between the fields studied (focusing on managerial professions and focusing on social professions), we created two models that would respect the different effects of Machiavellianism in these two professions.

The results (Table 5) show that emotional intelligence is a predictor of the Machiavellianism of university students of social professions and managerial professions.

The model was created with three independent variables for the managerial student population, which explains the 8.9 % variability of the dependent variable, i.e., Machiavellianism ($R^2 = .089$, $p < .001$). In the population of university students of social professions, a model was created with four independent variables, which explains 7.7 % of the variability of the dependent variable, i.e., Machiavellianism ($R^2 = .077$, $p < .001$).

Table 5. Predictors of Machiavellianism in Students of Managerial and Social Professions

		B	**SE_B**	**β**	**Sig.**	Partial correlation	Collinea rVIF	Corrected R^2 % scattering
Managerial professions	Well-being	-2.025	.361	-.257	.001	-.219	1.437	1. step 6 % 2. step 7 % 3. step 9 %
	Sociability	1.530	.398	.173	.001	.152	1.389	
	Emotionality	-1.291	.398	-.146	.001	-.129	1.383	
Social professions	Self-control	-1.279	.471	-.154	.007	-.123	1.672	1. step 4 % 2. step 6 % 3. step 7 % 4. step 8 %
	Emotionality	-1.355	.500	-.144	.007	-.123	1.459	
	Sociability	1.302	.464	.153	.005	.127	1.532	
	Well-being	-.857	.384	-.122	.026	-.101	1.540	

Well-being ($p = .001$), sociability ($p = .001$), and emotionality ($p = .001$) are relevant variables in explaining how Machiavellianism affects the student professions. Regarding the relative influence (the importance of each independent variable), psychological well-being ($\beta = -.257$) and emotionality ($\beta = -.146$) are the strongest variables, i.e., a higher level of mental well-being and emotionality predicts a lower degree of Machiavellianism. The amount of sociability (β =

.173) also affects the degree of Machiavellianism, for which the opposite tendency applies, i.e., a higher degree of sociability predicts a higher degree of Machiavellianism.

In particular, self-control (p = .007), emotionality (p = .007), sociability (p = .005), as well as psychological well-being (p = .026) all have a particular impact on the degree of Machiavellianism among students of social professions. Regarding relative influence, self-control (β = -.154) and emotionality (β = -.144) have the strongest effect, i.e., a higher level of self-control and emotionality predicts a lower degree of Machiavellianism. Sociability (β = .153) also affects the degree of Machiavellianism, for which the opposite tendency applies, i.e., a higher degree of sociability predicts a higher degree of Machiavellianism. Psychic well-being (β = -.122) also affects to a certain extent the degree of Machiavellianism, i.e., the higher the level of mental well-being, the lower the degree of Machiavellianism.

4. Discussion

Our research findings focusing on the degree of manifestation of Machiavellianism among students of social and managerial professions show that managerial students achieve a statistically significantly higher Machiavellianism score than social professions students, but the average for both groups falls into the Low Mach category and approaches the far pole, i.e., manifestations of Machiavellianism are somewhat more intense in students of managerial professions. Students in the Low Mach category (nearly 60 %) are predominant in social professions. 50 % of students in managerial professions are Low Mach. The High Mach category includes 40 % of students of managerial professions and 30 % of social professions (cf. Gruda et al., 2023).

Jonason et al. (2014) also confirmed their assumption that Machiavellianism was negatively associated with choosing a profession that involved caring for others. Similarly, an earlier study by Wertheim et al. (1978) found higher levels of Machiavellianism in law and management students than in teaching and social work students (cf. McLean, Jones, 1992).

Considering the components of the central dimensions of Machiavellianism, we find that students of both professions achieve similar manifestations in the deceit and lie dimension, immoral behaviour and cynicism, and they differ in the manifestations of the one central dimension of flattery. Students of both professions approve of deceit and lie the least, although they tend to believe that people are rather dishonest to promote their own interest. Students of managerial professions are more likely to accept flattery in interpersonal communication than those in social professions.

Similar to other studies (Ali et al., 2009; Austin et al., 2007; Austin et al., 2014; Petrides et al., 2011; Stead, Fekken, 2014), we have found that there is a negative relationship between the degree of Machiavellianism and emotional intelligence (cf. Szijjarto, Bereczkei, 2015). The negative correlation between Machiavellianism and trait EI is also supported by trait EI theory (Petrides et al., 2010). The manifestations of Machiavellianism are connected to the psychological well-being, self-control and emotionality of students. Students with a lower degree of Machiavellianism feel more fulfilled, maintain control over their actions, perceive inner emotional states more readily, express their feelings, and use these abilities to maintain relationships with other people.

It follows from the regression analysis that emotional intelligence participates in the manifestations of Machiavellianism in both researched groups (social and managerial professions). Among managerial students, mental well-being, sociability and emotionality are the main contributors to Machiavellianism. Among students of social professions, on the other hand, student self-control along with to a certain extent emotionality, sociability as well as to a lesser extent mental well-being contribute to the degree of Machiavellianism. Among students of managerial professions, a lower degree of mental well-being and emotionality as well as a higher degree of sociability contribute to increased Machiavellianism. Among students of social professions, a higher degree of self-control, emotionality, psychological well-being along with a higher degree of sociability contribute to higher Machiavellianism.

The manifestations of Machiavellianism are to some extent associated with all the areas of emotional intelligence researched. The results show that the different areas of emotional intelligence exert a different effect on manifestations of Machiavellianism in managerial professions and social professions.

Mental well-being plays an important role in the behaviour of students in managerial professions. Lower manifestations of Machiavellianism are associated primarily with a higher degree of psychological well-being in managerial students. Students of managerial professions who

feel satisfied are unlikely to feel the need to use Machiavellian strategies to achieve their own goals. Among students of social professions, psychological well-being is also involved in the manifestations of Machiavellianism, but to a lesser extent. Their self-control contributes mostly to the manifestations of Machiavellianism, with the increased level of self-control related to the reduced manifestations of Machiavellianism. If students are able to take advantage of a healthy degree of self-control, they are unlikely to have a Machiavellian tendency in their actions. Especially for students of social professions, it is crucial not to suppress their emotions, to manage impulsive behaviour, to maintain a healthy degree of control, to resist external pressures, and to cope with stressful situations.

Emotionality plays an important role in students in both the manager and social profession groups. The higher the emotionality of the students, the lower the manifestations of Machiavellianism. Students with a lower degree of Machiavellianism perceive and express emotions more readily, and they use these abilities to create and maintain close relationships with others. On the other hand, social interaction in the sense of social relations and social influence increases the manifestations of Machiavellian behaviour of both groups of students. As it turns out, the degree of the students' sociability in some situations is counterproductive and represents a risk element that may be reflected in the tendency of students to have Machiavellian behaviour. We assume that this connection is primarily due to the social influence component of emotionality. A higher conviction of students with regard to the ability to influence others' emotions and their certainty in social situations may be manifested to a higher degree among students with higher Machiavellianism manifestations.

All of this means that the lower level of manifestations of Machiavellianism is evident in students of social professions who maintain control over their behaviour (resist external pressures or stress), who more readily perceive inner emotional states, express their own feelings (in creating and maintaining close relationships with others), feel fulfilled, and at the same time who are less convinced of their social influence (the ability to make contact with others, to negotiate, etc.). On the other hand, students of managerial professions have a lower degree of Machiavellianism when students experience personal well-being (feel positive and fulfilled), are more receptive to inner emotional states, can more readily express their own feelings (in creating and maintaining close relationships with others) and, to a lesser extent, who are convinced of their social influence (ability to make contact with others, negotiate, etc.).

These results point to the possibility of working directly with students as part of their training. It is evident that emotional intelligence plays a key role in the preparation for managerial and social professions.

Emotionality (perception and expression of one's own feelings), as well as well-being, which proves to be key in managerial professions, play an important role in the professional training of students of both professions. In particular, self-control (emotion management, resistance to stress and external pressures) plays a key role among social professions students, yet proved to be less important in managerial professions. We assume that self-control is strongly associated with working in social professions, especially with regard to the specificity of this profession. Working with clients who find themselves in difficult life situations also brings difficult and stressful moments to workers who face these situations along with their clients. It is likely that self-control plays an essential role in communication with clients and manifestations of behaviour than in other types of professions.

As part of professional training of both professions, in addition to professional competencies, the development of students' social competences (Veteska et al., 2011) has also been found necessary, an approach which is also supported by our research. We consider as essential the application of socio-psychological training in the professional preparation of students who in the exercise of their profession will find themselves in daily interaction with other people, or who will act as "helping" workers in the relationship with the client. Such training of future practitioners will serve as a protective factor in their psychological resilience.

5. Conclusion

Our research supports the claim that the development of emotionality, self-control and well-being contributes to the reduction of Machiavellian behaviour among university students. The development of student sociability is aimed at promoting social interaction (empathy, developing communicative skills) rather than social influence (the ability to influence others'

emotions). In this context, we emphasize the specificity of the field (social and managerial) in the development of emotional intelligence among university students. In professions focused primarily on communication with clients or in the so-called helping professions, professional competence is very closely connected with the personal-social qualities of workers. Although the social intelligence (cf. Salovey, Mayer, 1990) construct carries a neutral characteristic, it can also be a predictor of ethical and unethical behaviour (XY et al., 2013). The practrical use of social techniques to manipulate others can be used both in a socially positive as well as socially negative sense.

6. Conflict of interest

We have no conflict of interest to disclose.

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The Experience of Using Digital Educational Content in the Psychological Training for Students in Psychology and Pedagogy-Oriented Classes

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Abstract

The modern stage of Russian education is characterized by the development of a system of specialized training for students. An important innovation is the introduction of specialized classes in Russian schools. This fact makes the presentation of the materials in this article particularly relevant. The aim of this publication is to present the results of an experimental study on the use of digital educational content in the psychological training of students in specialized profile classes in schools of the Tula region. The authors conclude that digital educational content for the elective course 'Basics of Psychology' contributes to the effective study, understanding and mastery of the educational material and makes the learning process interactive and engaging for schoolchildren.

The article presents the results of an empirical study conducted by the research team of Lev Tolstoy University as part of a government assignment. It introduces the authors' version of an online platform for the course 'Basics of Psychology' and provides an analysis of a survey conducted among school students (n = 84) studying this course. The questionnaires developed by the authors were used as diagnostic materials. Content analysis, descriptive statistics, and correlation analysis methods were applied for data processing.

The research results confirm the appropriateness of including digital educational content in the process of specialized training for school students.

Keywords: digitalization of education, psycho-pedagogical classes, digital technologies, digital educational content, fundamentals of psychology, pedagogical abilities, professional self-determination.

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1. Introduction

The modern stage of Russian education is characterized by the development of a system of specialized training for students and the active implementation of digital educational technologies in the learning process.

Let us turn to the analysis of scientific articles published in journals on the Elibrary and Scientific Research platforms for the period 2019–2025.

Considering digital technologies as one of the main components of education development, A. Haleema with co-authors argue that digital technologies should be considered not only as a modern source of knowledge but also entrusted with the functions of a mentor and even an expert (Haleema et al., 2022).

When considering issues of digital transformation in the educational process, foreign researchers approve that the main problem of modern education is the discrepancy in methodological approaches between traditional classical and modern education (Zhu, 2020; Wang, 2024).

For example, in an attempt to analyze the digital transformation of education in China, M. Liu and R. Su put forward proposals to optimize information platforms in order to improve the digital literacy of both students and teachers (Liu et al., 2023). Supporting the authors' position, H.P. Liang and L.G. Tian also express the view about of reform's necessity in teaching aimed at developing professional interests and realizing abilities in digital learning (Liang et al., 2024).

Taking into account the prospects of modern education, V.V. Gribanova and N.S. Ulanova identify a direct connection with the implementation of digital technologies in the educational process (Gribanova et al., 2022). As B.E. Starichenko points out, teaching and educational activities today should be viewed in the context of digital education which contributes to improving the quality of the entire educational process (Starichenko, 2020).

It is worth agreeing with I.V. Robert's opinion that modern high-tech society requires qualified specialists whose training largely depends on the introduction of digital technologies into the educational process (Robert, 2020). This point of view is shared by N.A. Sokolova and I.D. Gul who are convinced that "digital transformation affects not only social institutions but also the individual" (Sokolova et al., 2025). Earlier, V.D. Markova also pointed out the need for profound changes in the content, methodology, and forms of education in connection with the integration of digital technologies into the field of education (Markova, 2019). According to researchers from the Financial University under the Government of the Russian Federation, "the digital environment is becoming another space that sets professional guidelines, attitudes toward career building, ideas about professional future, and productive behavior strategies" (Brodovskaya et al., 2019).

Modern researchers focus on studying the methods and mechanisms of effectiveness in digital and online education. For example, the work of A.A. Leibina and G.A. Shukuryan addresses the issue of improving the effectiveness of online learning through the enhancement of methodological, psychological, and technical approaches (Leibina et al., 2020). In his time, A.Yu. Uvarov also spoke about the need for changes in the field of education, emphasizing the "comprehensive renewal of the main components of the educational process" (Uvarov, 2019).

When evaluating the digital educational environment, O.N. Shilova points to the need to take into account such characteristics as clarity, convenience, and attractiveness for students. The author emphasizes that the digital aspect of the educational environment should be enhanced through the inclusion of online platforms, digital educational content, and educational video materials (Shilova, 2020).

We agree with S.V. Pazukhina's view on the importance of incorporating modern digital technologies and tools to improve the quality of education (Pazukhina, 2024). As M.V. Rybakova asserts, the digital learning system should include a variety of information resources, such as media, video, audio, bibliographic materials, and so on. The author also highlights the importance of applying e-learning technology (Rybakova, 2021).

In our earlier publications we have already referred to the fact that "many government documents and programs of the Russian Federation point to the improvement of specialized education for schoolchildren, which is a key innovation in educational policy. Thus, based on the resolution of the Government of the Russian Federation No. 3273-r dated December 31, 2019, psychological and pedagogical classes were established" (Kulikova, 2025).

"The Concept of Specialized Psychological and Pedagogical Classes prepared by GAOU DPO "Academy for the Implementation of State Policy and Professional Development of Education Workers of the Ministry of Education of the Russian Federation," states that the goal of these classes

is to form in schoolchildren an understanding of the teaching profession, their attitude toward teachers as professionals, the development of self-awareness and professional interests, self-determination, and the alignment of their abilities with the teaching profession" (Kulikova, 2025).

Addressing the problem of developing interest in the teaching profession among school students S.V. Dementieva and V.I. Chumakov conclude that it is necessary to orient students towards pedagogy-related professions through the organization of elective courses and the stimulation of interest in the teaching profession (Dementieva et al., 2021).

Undoubtedly, the training of students in psycho-pedagogical classes aimed at identifying pedagogically gifted schoolchildren requires the use of modern educational technologies which include electronic educational resources, mobile applications, digital didactic materials, digital educational environment.

We share the positions of the cited authors on the development of digitalization as an inevitable process of reforming the system of pedagogical education which requires the development of appropriate didactic support. However, when considering the general problem of digitalization in education, attention should be paid to the digital tools used for creating digital educational content. As I.S. Yakimanskaya emphasizes, the content of educational material, both traditional and digital, should be clear and accessible for students to understand. An important aspect is addressing the personal experience of students, meaning that any content should correspond to the level of knowledge and the skills and competencies that students have already developed (Yakimanskaya, 2010).

Thus, the conducted analysis of scientific works allows us to state that solving the problems of informatization in education against the backdrop of the emergence of specialized classes, including pedagogical classes, is a relevant problem. It should be recognized that despite the importance of this problem, the number of developed digital educational resources is still insufficient which necessitates the creation and implementation of digital educational content in the curriculum for students of specialized psycho-pedagogical classes in "Basics of Psychology". Ownership of information resources in the field of practical psychology will allow students to see new aspects of their potential future professional self-realization.

All of the above defined the purpose of our article that is to describe the experience of using digital educational content in the psychological training of students in profile classes.

We put forward a working hypothesis that digital didactic materials, like digital educational content in general, contribute to the effective study, understanding, and mastery of the curriculum in the "Basics of Psychology" course and lay the foundation for improving the psychological training of school students in profile classes.

2. Methods

An empirical study on the use of digital educational content on the Basics of Psychology in specialized psychological and pedagogical classes was conducted throughout 2024 by the research team of Lev Tolstoy University under the state assignment of the Ministry of Education No. 073-00033-24-01 dated 09.02.2024 on the topic 'Scientific and Methodological Foundations for Creating Digital Educational Content for Psychological Training in Pedagogical Classes,' aimed at determining the conditions for improving and enhancing the quality of specialized education in psycho-pedagogical classes through the implementation of digital tools and resources" (Kulikova, 2025).

Description of the digital educational website

Guided by the goal and objectives of the project within the framework of the state assignment members of the research group developed an educational website for the course "Basics of Psychology". The structure of the digital educational website for the course "Basics of Psychology" is presented in Table 1.

Table 1. Structure of the digital educational website for the course "Basics of Psychology"

№	Sections	Description
1	Theoretical and methodological	This section includes a theoretical analysis of traditional conceptual approaches to the digitalization of modern education; an overview of foreign and domestic experience regarding the issue of digital transformation in education; the methodological foundations and

№	Sections	Description
		conditions for the development of students' pedagogical abilities in a digital educational environment; the psychological and pedagogical aspects of learning in a digital educational environment; an analysis of pedagogical technologies, models, and tools within the digital educational environment system.
2	Theoretical video section	This section includes several professionally oriented video lectures focused on the teaching profession, united by the common theme "Introduction to the Teaching Profession." The theoretical video section covers the following topics: the teaching profession: yesterday, today, tomorrow; the role of the teacher in the era of digitalization; the image of the modern teacher; pedagogical skills and how to become a teacher.
3	Didactic section	This section contains educational materials for students (multimedia presentations, video parables, video workshops) and methodological recommendations for teachers on organizing lessons using digital didactic materials.
4	Professionally-oriented section	This section contains an electronic bank of psychological tests for online career guidance diagnostics; identification of pedagogical abilities, professionally significant personal qualities and traits; career guidance games; a consulting platform with a schedule of webinars for the academic year.

The series of video lectures presented on the website is united by the common theme "Introduction to the Teaching Profession". In our view, video lectures have certain advantages in terms of material accessibility. Students have the opportunity to repeatedly return to rewatch the lectures asynchronously. Moreover, considering the characteristics of the 'clip-like perception' of modern students, the duration of a single video lecture does not exceed 15-20 minutes. The content of all video lectures is oriented towards the teaching profession.

Multimedia presentations converted into video format, video parables – specifically developed for each topic in accordance with the educational-thematic plan – help to develop reflective skills, to understand one's feelings and empathize with others, as well as how to express and defend one's opinion.

Multimedia workshops are designed to develop self-monitoring skills and are intended for independent student work. These video workshops are intended for students to work on independently.

The inclusion of psychological tests in the professionally-oriented section aims to identify the needs and interests of students, determine their inclinations and abilities, and also to "try on" their professional and personal qualities in relation to the teaching profession.

The didactic materials presented on the educational website create an effective and innovative educational space for the collaborative work of students and teachers. According to I. Darazha, R. Lyazzat et al., the creation and use of new models and forms of digital learning, as well as the gamification of the learning process and the possibility of self-organization in learning, contribute to increased learning motivation, the development of independence, and self-control in the learning process (Darazha et al., 2021).

Methodology of Empirical Research

The purpose of the empirical research was to identify the attitude of school students in psycho-pedagogical classes towards the content of digital educational material aimed at improving their psychological training. A questionnaire developed by the authors was used as diagnostic material, and the survey procedure was organized using the Google Forms online tool.

The reliability of the questionnaire was determined by measuring the distribution of students' responses to the given questions using α-Cronbach coefficient. Participation in the

questionnaire was voluntary and anonymous in accordance with the principle of confidentiality. No personal data was collected except for demographic information. All research results were analyzed in summarized form. The questionnaire procedure was conducted with the direct involvement of the psychology teacher at the educational organization. The study involved students from the 10th and 11th psychology-pedagogy classes of educational organizations in the Tula region. The total sample comprised 84 individuals aged 16-18. Of the total number of respondents 59.8 % were girls and 40.2 % were boys. All respondents were informed about the aim of the study before the questionnaire was administered. The wording of individual questions with result interpretation is presented in Section 3, "Results" of this article.

During the survey process the necessary ethical standards were observed. Firstly, taking into account the age of the subjects, when the consent to questioning or the collection of other data can be given by the teenager himself. Secondly, the safety (confidentiality) of the participation of schoolchildren in the questioning was guaranteed. Thirdly, the appeal in the introductory part of the questionnaire and its content focused students on obtaining a positive and useful experience, a feeling of their own contribution to a significant cause (Ipatova et al., 2023).

The analysis the results of the questionnaire, the following parametric statistical methods were used: the Pearson correlation coefficient r-test; the Student t-test for dependent samples. In particular, when analyzing the answers to questionnaire questions No. 1 (*Which source of information do you prefer to use when studying the basics of psychology – printed publications; notebook notes; online resources?*); No. 2 (*Choose the behavior typical for you while doing homework – only take notes in your notebook; watch a video lecture on the website; search for additional information on the Internet*?); No. 6 (*Identify the most interesting and useful didactic materials for learning the basics of psychology - multimedia lectures; video parables; multimedia practicum; psychological testing?*), it was interesting to identify the relationship between students' specific choice of response options. Each of these questions allowed multiple answer options.

Thus, by recording each student's choice of answers and using the Pearson correlation coefficient, the strength of the linear relationships was determined and patterns were identified in students' preferred choices (Table 2).

Table 2. Example of recording students' responses to question No. 1 of the questionnaire

Respondent's No	Question number 1		
	Answer option 1	Answer option 2	Answer option 3
1	0	0	1
2	0	1	1
3	0	1	1
4	0	1	1
5	1	0	1
n = 84	...	...	...

Notes: 0 – no answer selected; 1– answer selected

The analysis of responses to survey question No. 4 (*Can you say that the educational website increased your interest in psychology and pedagogy – yes; no; difficult to answer?*) the Student t-test for dependent samples was chosen, as the same students (n=84) participated in the survey at different stages of the study: before and after the execution of work on the project was implemented. For the purpose of quantitative statistical data processing, each student response was assigned a numerical number (point), as follows: *"yes" – 3 points, "no" – 2 points, "difficult to answer" – 1 point*. This allowed us to compare the two resulting dependent samples, before and after the project implementation, and draw conclusions about the changes that occurred and their statistical significance.

3. Results

In order to identify general trends and organize the data an initial descriptive analysis of the results for the entire sample (n = 84) was conducted (Table 3).

Table 3. Descriptive statistics of indicators characterizing the variability of data for the entire sample (n = 84) during the study

Descriptive statistics		Question 1	Question 2	Question 6
Average		1,7262	1,6071	2,5000
95 % confidence interval for the average	lower bound	1,6127	1,4288	2,2054
	upper bound	1,8397	1,7855	2,7946
Median		2,0000	2,0000	2,0000
Standard deviation		,52299	,82166	1,35771
Minimum		1,00	,00	,00
Maximum		3,00	3,00	4,00
Range		2,00	3,00	4,00
Inter-apartment range		1,00	1,00	2,00
Asymmetry		-,227	-,353	-,385
Exzess		-,439	-,322	-,532

Taking into account the mean and standard deviation values (Mean±SD), as well as the values of skewness (As) and kurtosis (Ek), we can conclude on the homogeneity of the group and understand how much the identified values differ from the average.

Analyzing students' responses regarding preferred sources of information we observe the following distribution: of the entire sample, 35.9 % chose printed materials, 43.8 % used their notes, and 87.5 % preferred digital content from the Basics of Psychology website.

Next, we conducted a correlation analysis of the obtained data which showed an inverse relationship, namely: students who prefer to use information from digital website content use less frequently information from printed publications (Pearson's coefficient was r = -0.689) (Table 4).

Table 4. Correlation indicators regarding the preferred sources of information

Variable	Printed publications	Notes	Electronic resources of the website
Printed publications	1		
Notes	-,361**	1	
Electronic resources of the website	-,689**	,453*	1

Notes: **correlation of significance at p < 0.01; *correlation of significance at p < 0.05

One of the survey questions aimed to gather information about the typical behavior of students while doing homework for the course "Basics of Psychology". Participants were asked to choose from several provided options (Figure 1).

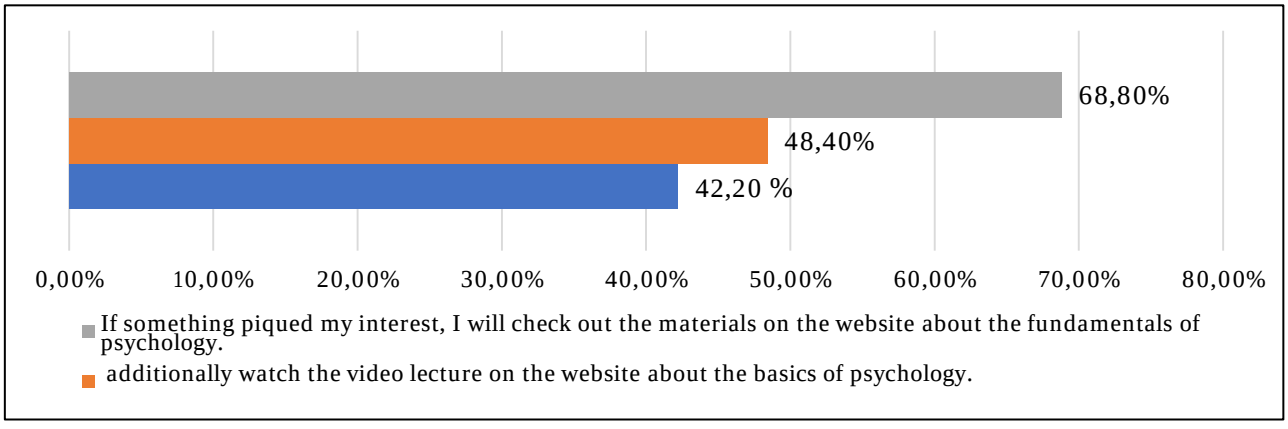

Fig. 1. Data on students' responses to the question about typical student behavior while completing homework for the course "Basics of Psychology".

As a result, out of the total sample, 68.8 % of respondents tend to view study materials on the Basics of Psychology website; 48.4 % use video materials on the same site, and 42.2 % of students reported that they limit themselves to only reading notes in their notebooks.

Correlation analysis revealed that students who prefer to use electronic resources on the Basics of Psychology website are more likely to watch video lectures on the same site (r = 0.602) than students who use only notebook notes (r = -0.364) (Table 5).

Table 5. Correlation results of responses regarding typical behavior when doing homework

Variable	Electronic resources of the website	Video lectures of the website	Notes
Electronic resources of the website	1		
N	84		
Video lectures of the website	,602**	1	
N	84	84	
Notes	-,305**	-,364*	1
N	84	84	84

Notes: **the correlation is significant at the level of p < 0.01

Next, we were interested in the question of how much the content of the online platform on the Basics of Psychology improved the learning process and made it more engaging. This is more a question of students' personal attitudes toward digital content. Analysis of the responses showed that 75.4 % of respondents found the website materials much more interesting and informative. Nevertheless, 23 % of the total sample believed that the provided digital content did not diversify their learning process, and another 1.6 % were unable to answer this question at all. The results obtained for this question were compared with the results of a survey conducted before the project trial. The survey aimed to identify students' preferences and expectations regarding the content of digital materials, the forms of information presentation, and possible interactivity.

Students were asked to evaluate whether digital multimedia educational content (videos, audio materials, interactive automated tests) could make the learning process more engaging and successful.

As a result, 45.2 % of respondents answered "yes," indicating that digital content on the Basics of Psychology would facilitate the learning process and material comprehension, 32.1 % of students answered "no," believing it would not affect the effectiveness of the learning process, and 22.7 % found it difficult to answer this question.

To calculate statistical significance the Student t-test for dependent samples was used to test the hypothesis that the mean value of the "before project implementation" sample differs significantly from the mean value of the "after project implementation" sample. The test statistic was tEmp = 6.3 > tCr = 2.63 (at p ≤ 0.01). The obtained empirical t value (6.3) falls within the significance zone.

Of greatest interest to us were the students' responses to the structured question about the most content-effective components of the educational website on the Basics of Psychology. To answer this question participants had to select one or more options from those provided (Figure 2).

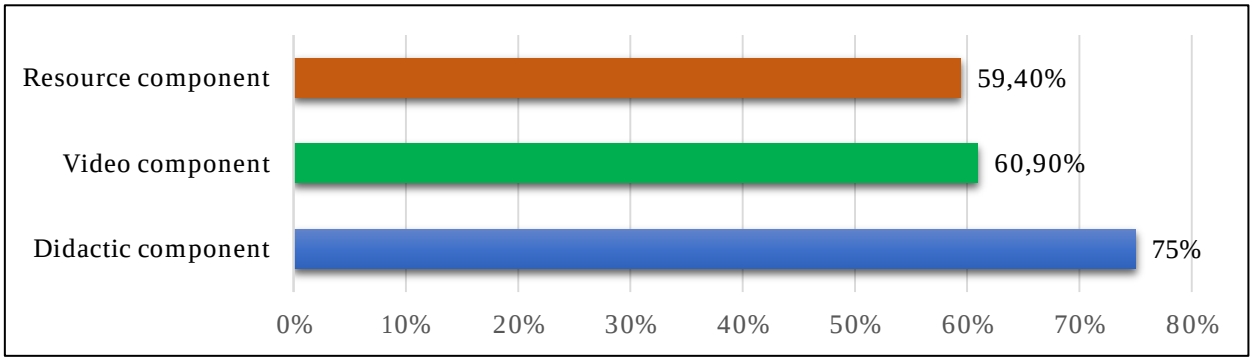

Fig. 2. Data on students' responses to the question about the most successful component of the educational website on the Basics of Psychology

The following results were obtained: 75 % of students definitely named the didactic component as the most successful, the video component holds the second position in terms of appeal, and the resource component was identified as the most useful.

Next, the participants were asked to highlight the most interesting and useful materials of the didactic component. It should be noted that students expressed interest in all didactic materials (Figure 3). Nevertheless, the most popular among students is the bank of psychological tests (73.4 % of respondents), the second position in terms of appeal is taken by multimedia lectures (64.1 % of respondents), followed by video parables (57.8 %) and the multimedia practicum (54.7 %).

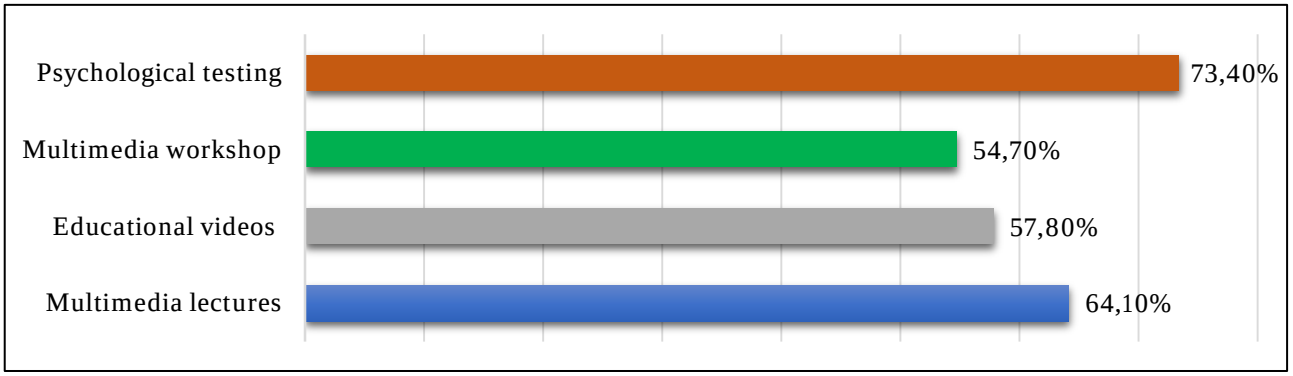

Fig. 3. Data on students' responses to the question about the most interesting and useful materials of the didactic component

Correlation analysis of the obtained data revealed several strong positive relationships, namely: students who were interested in psychological tests also preferred watching multimedia lectures (r = 0.657); and students who were interested in the multimedia practicum more often preferred watching video parables (r = 0.784) (Table 6).

Table 6. Results of the correlation of data on the question of preference for didactic materials

Variable	Psychological testing	Multimedia workshop	Video parables	Multimedia lectures
Psychological testing	1			
N	84			
Multimedia workshop	-,075	1		
N	84	84		
Video parables	,023	,784**	1	
N	84	84	84	
Multimedia lectures	,657**	,221*	,328**	1
N	84	84	84	84

Notes: ** correlation of significance at p < 0.01; * correlation of significance at p < 0.05

The questionnaire included two open-ended questions, where participants were asked to express their own opinions on the advantages and disadvantages of digital educational content on the Basics of Psychology. Let's present the students' responses in descending order:

– 70 % of respondents stated that they found no disadvantages;
– 40 % of students said they liked everything and that the website has many benefits;
– 23 % of students consider the digital content convenient and practical;
– 15 % of respondents did not find this digital content interesting;
– 12 % of students noted the attractiveness of psychological tests;
– 8 % of students found the video parables useful and only 2 % of the entire sample were unable to provide any answer.

4. Discussion

The methodological basis of the conducted study was formed by the scientific works of domestic and foreign authors: I.V. Robert, V.D. Markova, A.Yu. Uvarov, S.V. Pazukhina, O.N. Shilova, V.V. Gribanova, N.S. Ulanova, B.E. Starichenko, A. Haleema, W. Zhu, W. Wang, H.P. Liang, I. Darazha, R. Lyazzat, and others, who address the issue of creating, structuring, and applying digital educational content in the learning process.

The results of the empirical study on the inclusion of digital educational content in the psychological training of students in psycho-pedagogical classes are consistent with the views of the authors (Shilova, 2020; Uglova, 2024) that a digital educational environment involves the emergence and use of various digital technologies and digital educational resources as teaching tools in the educational process.

Digital educational resources are electronic materials designed to support and implement the learning process. They include e-textbooks, online courses, multimedia presentations, and other digital tools designed to optimize the learning process in a digital environment.

Considering the importance of organizing specialized pedagogical classes that promote the development of students' values and meaningful orientations, social competence, leadership skills, and communication abilities (Sergeeva, 2022) and developing in them the readiness for independent career choice makes the creation of an engaging and safe digital educational environment evident (Shilova, 2020; Pazukhina, 2024).

The theoretical aspects and basic structure of the online platform for the course "Basics of Psychology" presented in the article can serve as a reliable assistant for teachers in digital learning environments and, in particular, in psychology and pedagogy-oriented classes, taking into account the individual abilities, interests, and learning pace of each student. The distinction of the developed educational content from existing ones lies in the use of digital resources and the combination of didactic, educational, and career guidance orientations.

It is important to note that the empirical data obtained during the study indicate the demand for digital educational content for the "Basics of Psychology" course among students of specialized psychology and pedagogy classes.

However, this study has some limitations. Firstly, the sample was selected using a targeted method based on subjective criteria, which may not provide reliable insights into the quantitative distributions in the general population.

However, purposive sampling is used in exploratory designs to illustrate existing or generate new research hypotheses, which can later be tested by "rigorous" methods in a separate study. The second limitation is the lack of previous studies on this issue. Citing previous scientific works forms the basis of the literature review and helps to understand the subject of the research.

5. Conclusion

The development of digital education is impossible without understanding the accumulated global and domestic pedagogical experience and determining the main scientific approaches to using digital educational environment tools. Our research confirms that the use of digital educational tools and resources, including modern online educational platforms and digital didactic materials, contributes to the development of learning motivation, the formation of interest in the subjects studied, and overall improvement in the quality of education.

We believe that in order to increase students' satisfaction with the learning process, achieve high educational results for schoolchildren, and foster the readiness of today's senior students for independent career choices, integrating modern digital technologies into the educational process is a relevant and necessary task.

The experience presented in this article of using digital educational content in the psychological training of students in psycho-pedagogical classes demonstrates the effectiveness of using digital materials in the learning process and the advisability of incorporating digital educational content into the educational process as a necessary condition for the development of students' pedagogical abilities.

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Research on the Readiness of Future Teachers to Work with Children with Disabilities

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Abstract

The article highlights the results of an empirical study of barriers of future teachers in working with children with disabilities, determined by the degree of readiness of applicants to accept situations of uncertainty in professional activity, developed emotional intelligence, the ability to make effective decisions, developed empathy and a high level of stress resistance. The influence of emotional intelligence and stress resistance on the readiness of future teachers to work with children with disabilities is substantiated. The parameters of readiness to work with children with disabilities are determined using the method of diagnostics of communicative attitude.

The results of the correlation analysis of indicators of communicative attitudes and obstacles in establishing emotional contacts with indicators of emotional intelligence diagnostics (emotional awareness, management of one's own emotions, self-motivation, empathy, recognition of other people's emotions and levels of stress resistance (acceptance of helplessness and lack of self-efficacy) are presented. Positive correlations of stress resistance indicators with most indicators of barriers of future teachers were revealed. The reverse effect of emotional intelligence on the presence of barriers in future teachers in working with children with disabilities was confirmed.

The differences between applicants who are ready and not ready to work with children with disabilities according to the indicators of emotional intelligence (N. Hall) and the results of the test for determining the level of stress resistance are shown. Cluster profiles of indicators of (un)readiness in groups of students according to the method of diagnostics of communicative attitude according to V. Boyko are presented. Recommendations for developing a training program are proposed to prevent and minimize barriers of future teachers in working with children with disabilities.

Keywords: emotional intelligence, stress resistance, barriers, children with disabilities, communicative attitude, obstacles in established emotional contacts.

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1. Introduction

An analysis of the current state of education demonstrates an urgent need for highly qualified personnel capable of providing quality psycho-emotional support to children with disabilities. The state's inclusive policy of accessibility has laid the legislative and executive foundation for the implementation of inclusive services. However, putting these principles into practice requires training specialists who can overcome barriers when working with kids with disabilities. The existing system of training specialists in Ukraine can be characterized as insufficiently focused on developing skills for working with children with disabilities, which contributes to the formation of insecurity and internal barriers among students when interacting with this category of clients. Such barriers can significantly impair the quality of support provided to children with disabilities, which in turn will negatively affect their adaptation, development, and socialization.

Today, we can observe an increase in the number of children with injuries and developmental disorders, which exacerbates the need for effective training of future teachers to work with children with disabilities. At the same time, psychotraumatic circumstances can reinforce internal barriers in students, which manifest themselves in a lack of control over circumstances and reactions and an inability to manage their emotions.

In view of this, preparing future specialists to work with children with disabilities, overcoming existing barriers, and developing emotional awareness in students are pressing tasks for the modern approach to training specialists in the field of pedagogy at higher education institutions.

The purpose of this article is to highlight the results of an empirical study of the readiness of future teachers to work with children with disabilities, taking into account the emotional intelligence and stress resistance of higher education students. The task was to study the relationship between emotional intelligence and stress resistance with the readiness of future specialists to work with children with disabilities; to identify the parameters of their readiness to work with children with disabilities by diagnosing their communicative attitudes and existing barriers.

We assume that the readiness of future teachers to work with children with disabilities is determined by a high level of emotional intelligence and the ability to control circumstances and low stress perception.

2. Materials and methods

To study the existing barriers faced by future specialists in working with children with disabilities, we used: V. Boiko's method for diagnosing communicative attitudes (Shevenko, 2016), which reflects negative attitudes on a 9-point scale, and V. Boiko's methodology for diagnosing "barriers" to establishing emotional contact (adapted by A. Shevenko) with five scales (Shevenko, 2016). These methods allow us to study the emotional, cognitive, and behavioral manifestations of future specialists, which we consider to be barriers – obstacles in the interaction of future specialists with children with disabilities (rejection of the individuality of others, using oneself as a standard, conservatism in assessing people, intolerance to personal discomfort of communication partners, etc.).

The ability of future teachers to understand relationships manifested in emotions, manage their emotional sphere, and influence the emotional sphere of others was assessed using the emotional intelligence diagnostic methodology (Borh, 2019). To determine the level of stress resistance, a stress resistance test – Perceived Stress Scale, PSS-10 (Cohen, 1983) was used, which made it possible to measure the degree of control over circumstances and the level of perception of their inability to cope with problems, as well as the overall level of perceived stress in future specialists.

In order to identify the future psychologist's ability to understand relationships represented in emotions and manage their emotional sphere based on decision-making, N. Hall's emotional intelligence diagnostic method was used. The questionnaire consists of 30 statements reflecting different aspects of life. Respondents chose their level of agreement with the statements from “strongly disagree” (-3 points) to “strongly agree” (+3 points). For convenience in calculating the results of this methodology, we converted the degrees of agreement to a six-point scale, where the option “strongly disagree” equals 1 point, and “strongly agree” equals 6 points. The questionnaire contains five scales: 1) emotional awareness; 2) management of one's emotions (emotional detachment, emotional flexibility); 3) self-motivation (voluntary control of one's emotions); 4) empathy; 5) recognition of other people's emotions (ability to influence the emotional state of others).

The Perceived Stress Scale (PSS-10) test measures the degree of control over circumstances, one's own emotions and reactions, and the level of perception of one's inability to cope with

problems. The questionnaire contains 10 questions, the answers to which are graded from 0 to 4 points, where 0 means “never” and 4 means “very often.” The test can be used to determine the degree of perceived helplessness and lack of self-efficacy.

Based on the total score on the scales, the questionnaire also differentiates between levels of stress perception (stress levels): 0 to 13 points – mild stress perception (low stress), from 14 to 26 points – moderately perceived stress (moderate stress), from 27 to 40 points – strongly perceived stress (high stress).

To determine the list of psychological barriers in the context of interaction between a future specialist and a child with a disability, we used the method of diagnosing communicative attitudes according to V. Boiko (adapted by A. Shevenko). This methodology allows us to determine the overall level of communicative tolerance and levels of tolerance based on behavioral characteristics and mental attitudes – rejection of the individuality of others, using oneself as a benchmark, conservatism in assessing people, intolerance to the personal discomfort of a communication partner, etc.

The questionnaire contains nine sections with five statements in each, which are scales and allow us to conclude that the higher the number of points on each scale, the lower the level of communicative tolerance of the respondents and indicates the specialist's unwillingness to work with children with disabilities.

The method of diagnosing “barriers” to establishing emotional contact according to V. Boiko refers to methods of studying emotions and feelings of the personality. The text of the questionnaire contains 25 statements, to which respondents are asked to answer ‘yes’ or “no.” Based on the results of the diagnosis, we determine five scales: 1) inability to control emotions, to dose them; 2) inadequate emotional expression; 3) dominance of negative emotions; 4) inflexibility, underdevelopment, vagueness of emotions; 5) unwillingness to get close to people on an emotional basis. Accordingly, the higher the score on each scale, the more affected the psychological (emotional) barriers are in future specialists.

To check the quality of the questionnaires before using them in the study, we calculated Cronbach's alpha coefficient as a statistical indicator used to assess internal consistency and reliability of a set of questions in a questionnaire or scale. The reliability analysis showed a high level of internal consistency of the 30-item scale (Cronbach’s $\alpha = 0.914$; standardized $\alpha = 0.918$). The average inter-item correlation ($r = 0.28$) indicates an optimal balance between homogeneity and content diversity of statements. The asymmetry (-0.33) and excess (-0.28) indicators indicate that the distribution of total scores is close to normal. The results obtained allow us to conclude that the scale has high internal reliability.

To measure emotional intelligence, we used Hall's method, which consists of 30 statements grouped into 5 scales: “Emotional Awareness” (Cronbach's $\alpha = 0.77$), “Emotion Management” ($\alpha = 0.75$), “Self-Motivation” ($\alpha = 0.73$), “Empathy” ($\alpha = 0.81$), and “Recognition of Other People's Emotions” ($\alpha=0.82$). All indicators exceed the minimum threshold of internal consistency ($\alpha > 0.70$).

The Perceived Stress Scale (PSS-10) consists of 10 statements grouped into two subscales: perceived helplessness (6 items, $\alpha = 0.83$) and lack of self-efficacy (4 items, $\alpha = 0.65$). Both subscales demonstrated acceptable internal consistency.

V. Boiko's method for diagnosing communicative attitudes includes 9 scales of negative communicative attitudes with reliability coefficients ranging from 0.73 to 0.89, which corresponds to acceptable and good levels of internal consistency.

V. Boiko's methodology for diagnosing “barriers” to establishing emotional contact showed insufficient psychometric characteristics ($\alpha = 0.23$-0.65), which does not meet generally accepted reliability standards. However, individual scales of the methodology demonstrated statistically significant correlations with indicators of emotional intelligence and stress. The results of this methodology are interpreted with caution as preliminary data.

The empirical study was conducted in April-July 2025 at three higher education institutions: Kharkiv National Pedagogical University named after G.S. Skovoroda, Sumy State University, and Sumy State Pedagogical University named after A.S. Makarenko. The survey involved 87 respondents – students of bachelor's and master's programs. The respondents were aged 18 to 58, including 75 women and 12 men. The vast majority of respondents were young people (aged 18-23) and middle-aged people (aged 39-50). The sample is representative and adequately reflects the

characteristics of the general population of students in terms of structural and individual parameters, which guarantees the reliability of the research results.

The results were processed using correlation and cluster analysis, comparative analysis of mean values and standard deviations for the studied indicators for groups of future specialists – "ready" and "not ready" to work with children with disabilities using Student's t-test. Data processing and analysis were performed using TIBCO Statistica 13 software.

3. Discussion

The barriers faced by future specialists have been studied by researchers I. Glazkova, C. Dwek, O. Konstantinov, and N. Shelenkova. The influence of the emotional sphere on the readiness of future teachers to work with children with disabilities is the subject of study by domestic and foreign scientists, in particular J. Borg (Borh, 2019), R. Kapur (Kapur, 2020), A. Massanov (Massanov, 2024). The stressful impact on future teachers in the context of their professional activities with different categories of clients is reflected in the scientific works of A. Hirnyak (Hirnyak, 2019), V. Kravchenko (Kravchenko, 2025), Z. Onipko (Onipko, 2021), S. Isaevich, I. Kalinovska, T. Yaraya, and other researchers focus on the training of future specialists.

At the same time, the issue of the readiness of future teachers to work with children with disabilities in the context of increasing their stress resistance and developing emotional intelligence needs to be studied in more detail, which will contribute to the prevention of barriers in working with children with disabilities.

4. Results

Analysis of scientific sources allows us to conclude that the emotional component acts simultaneously as a barrier and as a component of the professional competence of future teachers in the context of their preparation for working with children with disabilities (Kapur, 2020; Borh, 2019). On the one hand, the emotional sphere is represented by a complex of experiences that provoke the activation of existing barriers (negative emotions – fear, anxiety, shame, guilt, helplessness in situations of uncertainty, inability to regulate emotions, inadequate emotional expression, underdeveloped and vague emotions, unwillingness to get close to people on an emotional level, inability to restrain oneself) (Onipko, 2021).

On the other hand, developed emotional intelligence, manifested in emotional awareness, the ability to manage one's own emotions, the ability to quickly "disengage" emotionally and flexibly adapt emotional reactions to the situation, voluntary control of one's emotions through emotional regulation strategies (cognitive reappraisal, suppression of expression, etc.), a moderate level of emotional empathy, and the ability to positively influence the emotional state of others, becomes an indicator of a future specialist's readiness to work with children with disabilities.

Scientific research confirms the influence of stress resistance on the readiness of future specialists to work with children with disabilities (Voronov, 2017; Hirnyak, 2019; Kravchenko, 2025; Massanov, 2024). Future teachers who do not experience exhaustion and chronic tension (low level of perceived stress), control circumstances, their own emotions and reactions well, and have the strength to cope with existing problems, are distinguished by their readiness to work with children with disabilities. On the other hand, a low level of stress resistance (high levels of perceived stress) hinders professional activity, causing stress in future specialists due to constant emotional involvement in the complex life situations of children, frustration from the inability to quickly solve problems or improve the condition of children, the accumulation of stress manifestations due to the need for constant concentration and responsibility, personal uncertainty, and confusion.

To determine the relationship between emotional intelligence and stress resistance indicators and psychological barrier indicators (using methods for diagnosing communicative attitudes and "barriers" to establishing emotional contact according to V. Boiko), correlation coefficients were calculated for the entire sample of respondents (n = 87). The results of the correlation analysis indicate the presence of significant correlations for most indicators of psychological barriers (Table 1).

Table 1. Interrelationships between indicators of existing barriers and indicators of emotional intelligence and stress resistance in the sample of respondents (n = 87)

Psychological barriers/communication attitudes and obstacles	Indicators of emotional intelligence (N. Hall)					Indicators of the PSS-10 stress resistance test		
	Emotional awareness	Emotion management	Self-motivation	Empathy	Recognizing and influencing the emotions of others	Perception of helplessness	Lack of self-efficacy	Stress level
V. Boiko's method for diagnosing communicative attitudes								
Rejection or misunderstanding of a person's individuality	-0,041 -	**-0,274 p<0,010**	**-0,293 p<0,006**	**-0,270 p<0,011**	**-0,367 p<0,000**	**0,344 p<0,001**	**0,335 p<0,002**	**0,391 p<0,000**
Using oneself as a benchmark when evaluating others	-0,092 -	**-0,231 p<0,032**	**-0,215 p<0,046**	**-0,326 p<0,002**	**-0,278 p<0,009**	0,132 -	0,180 p<0,095	0,170 p<0,116
Categoricality or conservatism in people's assessments	0,087 -	**-0,228 p<0,034**	-0,086 -	0,043 -	-0,016 -	**0,358 p<0,001**	**0,231 p<0,031**	**0,361 p<0,001**
Inability to restrain oneself , smooth over unpleasant feelings when encountering uncommunicativeness in others	0,018 -	-0,202 p<0,060	**-0,213 p<0,048**	-0,141 p<0,194	-0,184 p<0,088	**0,279 p<0,009**	0,171 p<0,112	**0,278 p<0,009**
Desire to change or re-educate partner	-0,072 -	-0,205 p<0,057	-0,202 p<0,061	-0,158 p<0,143	-0,203 p<0,060	0,106 -	0,183 p<0,090	0,151 p<0,162
Desire to adapt one's partner to oneself, to make him/her comfortable	-0,040 -	-0,134 -	-0,112 -	0,020 -	-0,102 -	**0,297 p<0,005**	0,209 p<0,052	**0,306 p<0,004**
Inability to forgive others for their mistakes, clumsiness, and inconveniences caused to them	-0,113 p<0,299	-0,188 p<0,080	**-0,228 p<0,034**	-0,186 p<0,085	**-0,225 p<0,036**	**0,259 p<0,018**	**0,277 p<0,009**	**0,299 p<0,005**
Intolerance to physical or psychological discomfort of a partner	-0,070 -	-0,174 p<0,107	-0,187 p<0,084	**-0,288 p<0,007**	**-0,238 p<0,026**	0,115 -	0,089 -	0,121 -
Inability to adapt to partner	-0,078 -	**-0,229 p<0,033**	-0,183 p<0,090	-0,1648 p<0,127	**-0,262 p<0,014**	**0,333 p<0,002**	**0,263 p<0,014**	**0,354 p<0,001**

V. Boiko's method for diagnosing "obstacles" to establishing emotional contact according								
Inability to control emotions, regulate them	0,083 -	**-0,359** **p<0,001**	**-0,303** **p<0,004**	**-0,225** **p<0,036**	**-0,260** **p<0,015**	**0,228** **p<0,034**	0,208 p<0,053	**0,253** **p<0,018**
Inadequate emotional expression	0,089 -	0,189 p<0,080	0,197 p<0,068	-0,012 -	-0,007 -	-0,103 p<0,342	**-0,256** **p<0,017**	-0,177 p<0,102
Dominance of negative emotions	0,070 -	**-0,213** **p<0,048**	-0,190 p<0,078	-0,061 -	-0,089 -	**0,372** **p<0,000**	**0,241** **p<0,025**	**0,375** **p<0,000**
Inflexibility, underdevelopment, lack of emotional expression	**-0,250** **p<0,020**	-0,118 -	-0,189 p<0,080	**-0,247** **p<0,021**	**-0,211** **p<0,050**	-0,064 -	0,074 -	-0,021 -
Reluctance to get close to people on an emotional level	-0,075 -	-0,148 p<0,171	-0,205 p<0,057	**-0,255** **p<0,017**	**-0,294** **p<0,006**	0,145 p<0,181	0,164 p<0,130	0,173 p<0,109

According to N. Hall's emotional intelligence diagnostic methodology and indicators of existing barriers, statistically significant negative correlations were found, which means that the higher the emotional intelligence, the lower the manifestations of emotional, cognitive, and behavioral barriers. In particular, we observe significant negative correlations between "rejection or misunderstanding of a person's individuality," "using oneself as a standard when evaluating others," and "inability to manage emotions and regulate them" with four scales of emotional intelligence: "managing one's emotions", "self-motivation", "empathy", and "recognizing and influencing the emotions of others". There are also negative correlations between "categorical and conservative judgments of people" and "emotion management" ($r = -0.228$, $p < 0.034$); "self-motivation" and "inability to restrain oneself" ($r = -0.213$, $p < 0.048$), as well as "inability to forgive others" ($r = -0.228$, $p < 0.034$); "inability to adapt to a partner" and "emotion management" ($r = -0.229$, $p < 0.033$) and "recognition and ability to influence the emotions of others" ($r = -0.262$, $p < 0.014$).

The negative correlation between the indicators of "dominance of negative emotions" and "emotion management" ($r = -0.213$, $p < 0.048$) confirms that the more negative emotions dominate in future specialists in relation to working with children with disabilities, the less they can manage them. A significant negative correlation is also observed between "empathy" and "ability to recognize and influence the emotions of others" with "intolerance to physical or psychological discomfort", "inflexibility, underdevelopment, and vagueness of emotions" and "unwillingness to get close to people on an emotional basis".

It should be emphasized that a qualitative analysis of correlations shows the closest negative correlation between "emotional awareness" and "inflexibility, underdevelopment, and vagueness of emotions" ($r = -0.25$; $p < 0.020$), while other indicators show very weak inverse correlations. Thus, we can conclude that the level of emotional awareness as a component of emotional intelligence is not capable of significantly reducing negative emotional and communicative barriers in future specialists.

Also, indicative is the result of very weak correlations in the absence of a level of significance between indicators of emotional intelligence according to N. Hall and the desire to change, re-educate, or adapt a partner to oneself, as well as inadequate emotional expression.

Thus, future teachers with a highly developed ability to recognize the emotions of children with disabilities have a low level of barriers to rejection/misunderstanding of a person's individuality, which gives an understanding of the specialist's readiness to work with this category of clients. Providing psychosocial services to children with disabilities requires future specialists to have a balance of emotional skills. A specialist who is ready to work with children with disabilities must, on the one hand, be able to empathize and understand the child's experiences, but at the same time, not lose objectivity and be able to separate themselves from the client's emotional state in a timely manner, dosing and separating their own emotions from the child's emotions during

professional interaction. Moreover, a teacher who is ready to provide services to children with disabilities is endowed with the ability to respond flexibly to the child's changing emotional manifestations, to be motivated and able to emotionally connect, adapt their behavior and approach to psychological intervention.

The readiness of future teachers to work with children with disabilities is indicated by the art of emotional regulation and voluntary control of emotions (as one of the indicators of developed emotional intelligence), which includes changing opinions about the situation of emotional reaction, reducing expression in relation to the client's emotions, shifting the focus of emotional tension to other objects, and modifying circumstances to influence one's own emotional experiences and those of the client. A high level of ability of a future specialist to manage their emotions, as one of the criteria for developed emotional intelligence, reduces the manifestation of psychological barriers (positioning oneself as a standard, categorical in assessing others, etc.) and confirms readiness to work with children with disabilities.

The reverse relationship between emotional intelligence and the ability to recognize other people's emotions and influence their emotions, along with most indicators of communicative and emotional-volitional qualities of personality that act as existing barriers, allows us to conclude that a high level of ability to influence the emotions of a child with disabilities on the part of a future specialist reduces intolerant emotional and communicative barriers of the personality. At the same time, a specialist who is ready to work with children with disabilities is endowed with the ability to adapt to their partner, is tolerant of psychophysical discomfort that may potentially manifest itself externally in a child with a disability, and is also able to forgive the child's imperfections and unsuccessful attempts at self-expression.

The results of the correlation analysis of the test to determine the level of stress resistance (Perceived Stress Scale, PSS-10) with indicators of emotional, volitional, and communicative barriers show moderate positive correlations with a high level of significance. The data in Table 1 confirm the relationship between stress levels and the rejection and misunderstanding of others' individuality ($r = 0.391$; $p < 0.000$), categoricalness, conservatism in assessing partners ($r = 0.361$; $p < 0.001$), the desire to adapt one's partner to oneself ($r = 0.306$; $p < 0.004$), the inability to adapt to one's partner ($r = 0.354$; $p < 0.001$), and the dominance of negative emotions ($r = 0.375$; $p < 0.000$).

Accordingly, high stress levels (highly perceived stress) in future teachers increase emotional and communication barriers and reduce their readiness to work with children with disabilities. This confirms the hypothesis that specialists with low stress levels (weakly perceived stress) experience minimal manifestations of existing barriers and are ready to work with children with disabilities.

The indicator of perceived helplessness correlates significantly with the rejection of individuality ($r = 0.344$; $p < 0.001$); categorical or conservative assessments of people ($r = 0.358$; $p < 0.001$); inability to adapt to partners ($r = 0.333$; $p < 0.002$); dominance of negative emotional manifestations ($r = 0.372$; $p < 0.000$).

Another indicator of stress resistance is a lack of self-efficacy, i.e., the level of an individual's perception of their inability to cope with problems, which is closely related to the rejection and misunderstanding of other people's personalities ($r = 0.335$; $p < 0.002$). In other words, a future teacher who is not ready to work with children with disabilities may transfer their own fears, weaknesses, and experiences to their clients and experience fatigue (overwork, burnout) that prevents them from deeply and adequately understanding the individuality of children with disabilities.

On the other hand, future specialists who are ready to work with children with disabilities and have their own experience of failures and difficulties with constructive processing deepen their understanding and acceptance of others, which may seem paradoxical. We observe an inverse correlation between lack of self-efficacy and inadequate emotional expression ($r = -0.256$; $p < 0.0017$), which confirms that the higher the level of adequate perception by the specialist of their inability to cope with the situation (assessment of the ability to cope with the problem), the lower the level of inadequate emotional expression.

Somewhat weaker correlations can be observed between: 1) categorical or conservative assessment of partners with a lack of self-efficacy ($r = 0.231$; $p < 0.0031$); 2) inability to restrain oneself, reconcile unpleasant feelings with uncommunicative personalities with a perception of helplessness ($r = 0.279$; $p < 0.009$) and stress level ($r = 0.278$; $p < 0.009$); 3) the desire to adapt one's partner to oneself with a perception of helplessness ($r = 0.297$; $p < 0.005$); 4) inability to adapt to one's partner with a lack of self-efficacy ($r = 0.263$; $p < 0.014$); 5) inability to manage and regulate emotions with a perception of helplessness ($r = 0.228$; $p < 0.034$) and a general level of

stress (r=0.253; p<0.018); 6) dominance of negative emotions with a lack of self-efficacy (r = 0.241; p < 0.025).

Indeed, belief in one's own professional abilities as a future teacher, from the perspective of readiness for work, implies an open-minded assessment of children with disabilities and a strong desire to adapt to their individual needs. A specialist who is not under stress better controls their emotional reactions, does not try to "normalize" complex manifestations of the behavior of a child with disabilities, does not imitate the negative emotions of a child with disabilities, but uses nonverbal means of communication and other ways of interaction.

It should be emphasized that there is a positive correlation between the inability to forgive others for their mistakes, clumsiness, and unintentional misdeeds with all indicators of stress resistance, namely: perception of helplessness (r = 0.259; p < 0.0018), lack of self-efficacy (r = 0.277; p < 0.009), and overall stress level (r = 0.299; p < 0.005). A stress-resistant specialist with a low level of helplessness and a high level of self-efficacy is characterized by moderate sensitivity to the imperfections of others, and does not interpret or project random mistakes or actions of a child with disabilities as a potential threat, but accepts and understands the nature of mistakes, their occurrence, and causes.

Very weak links were found between "using oneself as a benchmark when evaluating others", "the desire to change or re-educate one's partner", "intolerance to the psychophysical discomfort of a partner", "inflexibility, underdevelopment, and vagueness of emotions", and "unwillingness to get close to people on an emotional basis" with all indicators of stress resistance (r from 0.007 to 0.183). Therefore, there is reason to believe that the level of stress of future specialists does not significantly affect the indicated indicators of communicative attitudes and emotional barriers.

Based on a k-means cluster analysis using the results of V. Boiko's communicative attitude diagnostic methodology (Shevenko, 2016), using the Statistica program, future specialists at the bachelor's and master's levels were divided into groups – "ready" (n = 49) and "not ready" (n = 38) to work with children with disabilities, and their cluster profiles were formed (Figure 1).

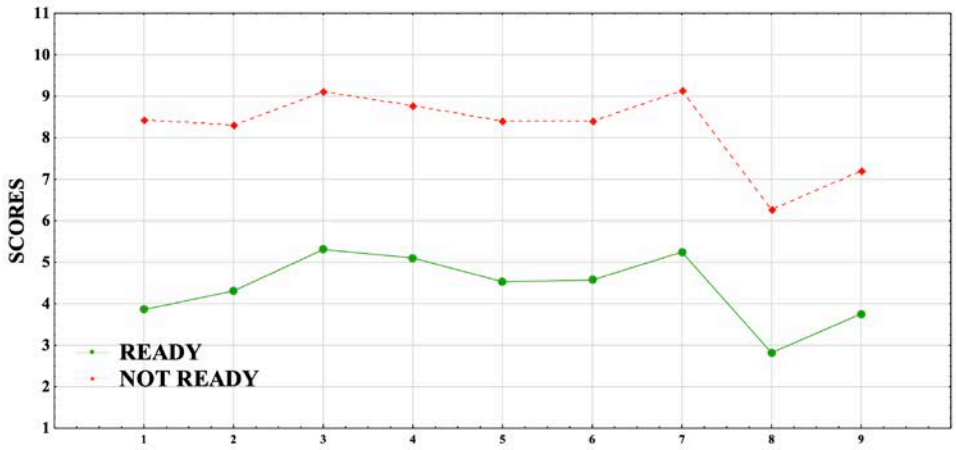

Fig. 1. Cluster profiles of the readiness parameters of future teachers to work with children with disabilities in groups of respondents – "Ready" (n = 49) and "Not ready" (n = 38)
Notes: 1 – rejection or misunderstanding of a person's individuality; 2 – using oneself as a standard when evaluating others; 3 – categorical or conservative in evaluating people; 4 – inability to hide or smooth over unpleasant feelings when confronted with uncommunicative qualities in a partner; 5 – desire to change or re-educate your partner; 6 – desire to mold your partner to suit yourself; 7 – inability to forgive others for mistakes, clumsiness, or inconveniences caused; 8 – intolerance of your partner's physical or mental discomfort; 9 – inability to adapt to your partner.

According to the methodology, range 1-3 corresponds to a low level of negative communication attitudes, range 4-6 to an average level, and range 7-11 to a high level of communication barriers.

An analysis of cluster profiles shows that the group of future teachers who are "not ready" to work with children with disabilities is characterized by high values for most indicators of communication barriers, with average values observed for the indicator "intolerance to physical or psychological discomfort of others". The highest values are observed for the indicators "categorical, conservative in evaluating others" and "unable to forgive others for mistakes".

In the group of respondents who are "ready" to work with children with disabilities, we observe the manifestation of most indicators at a low-medium level in the range of 4-3 points. We observe a low level of barriers (3 points) for the indicator "intolerance to physical or psychological discomfort of others". It should be noted that "categoricalness, conservatism in assessing others" and "inability to forgive others for their mistakes, clumsiness, and unintentional harm" in the "ready" cluster also have the highest values compared to other indicators. At the same time, future teachers who are ready to work with children with disabilities are distinguished by low levels of rejection, lack of understanding of individuality, and inability to adapt to a partner, demonstrating a high level of communicative and emotional tolerance towards children with disabilities. It should also be emphasized that the results of the cluster analysis demonstrate the absence of the highest manifestations of both readiness and unreadiness of future specialists to work with children with disabilities.

During the empirical study, average values were calculated for emotional intelligence and stress resistance for groups of students who were "ready" and "not ready" to work with children with disabilities, in particular, average values and standard deviations were determined using Student's t-test (Table 2).

Table 2. Differences between respondents who are ready and not ready to work with children with disabilities in terms of emotional intelligence and stress resistance levels

Emotional intelligence indicators and stress resistance levels	**Groups of respondents**		**t**	**p**
	Not ready (n = 38)	**Ready (n = 49)**		
Emotional intelligence diagnostic indicators (N. Hall)				
Emotional awareness	±	29.18	0	Not significant
Emotional self-regulation (emotional flexibility, emotional flexibility)	24.18	25.02±4.03	-0	Not significant
Self-motivation (voluntary control of emotions)	27.05	28.02	-1.02275	Not significant
Empathy	28.16	29.53±3.48	-1.54223	0
Recognition of other people's emotions (ability to influence the emotional state of others)	**27**	**29.53±3.79**	**-2.2144**	**0**
PSS-10 stress resistance test results				
Perceived helplessness	13.82±4.66	12.02±4.99	1.71	0
Lack of self-efficacy	5.82±2.52	5.18±2.41	1.187979	Not significant
Stress level	19.63±6.21	17.20±6.48	1.765097	0

Analysis of the data obtained shows that groups of applicants who are "unprepared" to work with children with disabilities in terms of emotional intelligence (with the maximum possible scores on all scales from 6 to 36 points) have: above-average and high levels of emotional awareness (29.21±4.56, in the range from 24.65 to 33.77); average level of emotional control (24.18± 5.3, in the range from 18.8 to 29.48); above-average self-motivation (27.05±4.7, ranging from 22.35 to 31.75) and empathy (28.16±4.82, ranging from 23.34 to 32.98).

With regard to stress resistance scales, we note a higher than average level of perceived helplessness (13.82±4.66, in the range from 9.16 to 18.48 with a maximum possible range from 0 to 24) and an average level of self-efficacy (5.82±2.52, in the range from 3.3 to 8.37 with a maximum possible range from 0 to 16). The stress level is characterized by mediocre values (19.63±6.21, in the range from 13.42 to 25.84 with a maximum possible range from 0 to 40).

At the same time, future specialists belonging to the "ready" group are distinguished by high manifestations of all indicators of emotional intelligence with possible values ranging from 6 to 36, namely: high level of emotional awareness (29.18±4.12, in the range from 25.06 to 33.3); above-

average level of emotional control (25.02±4.03, ranging from 20.99 to 29.05); high level of self-motivation (28.02±4.11, ranging from 23.91 to 32.13); high level of empathy (29.53±3.48, ranging from 26.05 to 33.01).

Applicants who are ready to work with children are also characterized by moderate manifestations on stress resistance scales: average levels of helplessness perception (12.02±4.99, in the range from 12.02 to 17.01 with a maximum possible range from 0 to 24) and general stress (17.20±6.48, in the range from 10.72 to 23.68 with a maximum possible range from 0 to 40). Lack of self-efficacy is characterized by low and below-average levels of manifestation (5.18±2.41, ranging from 2.77 to 7.59 with a maximum possible range of manifestation on the self-efficacy scale from 0 to 16).

At the same time, we observe significant differences in the indicator "recognize other people's emotions" ($t = -2.214$, $p < 0.0294$) between groups of respondents who are "ready" and "not ready" to work with children with disabilities. At the same time, "unprepared" applicants have a higher, than average level of ability to recognize emotions of others (27.5±4.8, ranging from 22.7 to 32.3 with a maximum possible range of 6 to 36). A tendency toward a high level of ability to recognize the emotions of others can be observed in the group of students who are "ready" (29.53±3.79, ranging from 25.74 to 33.32, with a maximum possible range of 6 to 36).

Accordingly, we can conclude that in the sample of respondents who are not ready to work with children with disabilities, most indicators have an average level of manifestation, except for a high level of emotional awareness, which gives grounds not to include emotional self-awareness and emotional interactivity among the criteria for distinguishing between groups of respondents.

Summarizing the statistical data of the average values of the group "ready" to work with children with disabilities, we can state a high level on the emotional intelligence scales and an average level on the stress resistance indicators. It has been found that the scales of helplessness perception and overall stress level in "ready" and "not ready" future specialists are equally marked by an average level of manifestation. There are grounds to believe that the level of feeling of lack of control over circumstances, one's own emotions and reactions, as well as the level of stress of future specialists is not related to and does not affect their readiness to work with children with disabilities. We assume that this phenomenon can be explained by the presence of stress factors caused by current socio-political events, which have a permanent impact on future teachers.

However, the level of self-efficacy among future teachers who are ready to work with children with disabilities is characterized by low levels of manifestation. Undoubtedly, a specialist who sees in himself the ability to cope with difficulties, perceives his inability to overcome challenges objectively and from the position of minor obstacles, is more open, ready, and motivated to work with children with disabilities. We also observe that in the sample of respondents, future teachers have statistically significant differences in the indicator of recognizing other people's emotions (the ability to influence the emotional state of others), in particular, the group that is not ready to work has an average level of this indicator, while those who are ready have a high level of manifestation.

The results of the data analysis confirm a slight difference in most indicators, as we do not observe a low level in the "not ready" cluster on the scales. Moreover, most applicants express readiness to work with children with disabilities (n = 49-56 % of the total number of respondents). It is evident that future teachers who are able to recognize, understand, accept, and effectively manage their own emotions, as well as recognize and respond appropriately to the emotions of others, are better prepared to provide educational services to children with disabilities.

There is confidence that a significant percentage of future specialists who, using the Statistica program, are classified as "ready" can be explained by the focus of the educational process and educational components of higher education institutions on the development of emotional intelligence and stress resistance of higher education seekers. At the same time, this focus in the training of future teachers may be partially achieved due to subjective or objective reasons, and therefore it is necessary to develop and implement a social and psychological training program with to minimize and prevent existing barriers and improve all indicators of the readiness of future teachers to work with children with disabilities.

5. Conclusion

Thus, emotional intelligence and stress resistance significantly influence the readiness of future teachers to work with children with disabilities, an important foundation of which is the ability to manage one's own emotions in difficult situations, the absence of difficulties in understanding and accepting the emotional state of a child with disabilities, the desire to help the child regulate their

emotional states, sufficient motivation to work, and a low level of perceived stress. The empirical study confirmed the hypothesis and allowed us to draw the following conclusions:

1. The closest negative correlations were found between emotional intelligence indicators and existing obstacles (the ability to recognize other people's emotions, the ability to influence the emotional state of others, rejection or misunderstanding of a person's individuality, etc.). The closest negative correlation between emotional awareness and inflexibility, underdevelopment, and vagueness of emotions, confirming that developed emotional intelligence largely determines the readiness of future teachers to work with children with disabilities.

2. Future specialists who see themselves as capable of coping with difficulties, perceive their inability to overcome challenges objectively, and have low stress tolerance are distinguished by their readiness to work with children with disabilities.

3. The parameters of readiness of future teachers who will provide educational services to children with disabilities also include the ability to adapt to a partner, tolerance of psychophysical discomfort, and the ability to forgive a child's imperfections and unsuccessful attempts at self-expression.

4. Groups of applicants who are "ready" and "not ready" to work with children with disabilities do not have statistically significant differences in emotional intelligence indicators such as "emotional awareness", "emotion management", "self-motivation, voluntary control of emotions" and "empathy" which are manifested at average and above-average levels, while statistically significant differences are observed in the indicator "recognition of emotions and ability to influence the emotional state of others".

5. An important task of professional training for future teachers is to increase stress resistance and reduce the manifestation of negative communicative attitudes and barriers to establishing emotional contact in the context of their interaction with children with disabilities.

The prospect for further research is the development and implementation of a psychological and pedagogical training program to reduce or prevent the manifestation of existing barriers and increase the level of all indicators of future teachers' readiness to work with children with disabilities.

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The Effectiveness of Vocal-Rhythmic Stimulation Methodology in the Development of Phonemic Awareness in Children Aged 5-6 years

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Abstract

The study presents the results of research aimed at verifying the effectiveness of an original method of vocal-rhythmic stimulation designed to develop phonemic awareness in children at the end of preschool education. Using a quantitative research design without a control group, the results of 22 children in a pre-test and post-test were analyzed using subtests from the D.B. Eľkonin test. The results showed improvement in most of the phonemic abilities assessed, especially in syllable analysis, sound isolation, synthesis, and rhyming. Only two children showed a slight decline in performance. The average results showed slightly better scores for girls, but without statistically significant differences between the sexes, confirming the universality of the methodology. Although the level of children's participation in activities did not show a direct correlation with performance, a positive effect of regular and playful stimulation was demonstrated. The research identified several limitations, including the small sample size, the absence of a control group, and organizational influences that may affect the validity of the results. Nevertheless, the research supports the use of the vocal-rhythmic methodology as an effective tool for developing pre-reading literacy and recommends its verification in a larger, longitudinal study focusing on the long-term impact on children's reading success.

Keywords: phonemic awareness, teaching methodology, pre-primary education, stimulation.

1. Introduction

Phonemic awareness is one of the basic components of phonological processing of speech. It is a key indicator of successful reading and writing acquisition (Kapalková et al., 2005). Preschool age is characterized by intensive language development, when children learn many skills, including the use of phonemes (the smallest units of sound in a language). The development of the ability to distinguish sounds, form rhymes, and divide words into syllables and sounds should be

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an integral part of the development of reading literacy (Lipnická, 2013). Sedlák and Váňová (2013) and Tichá (2014) agree that phonemic awareness should be developed through targeted pedagogical interventions with an emphasis on play, word manipulation, auditory differentiation and rhyming. Effective approaches to developing phonemic awareness also include rhythmic, musical, and movement activities (Shapiro, 2011; Kmentová, 2019), which stimulate perceptual and metalinguistic processes in a natural context.

As stated by Šedinová and Seidlová Málková (2021), the development of phonemic awareness and letter knowledge can be significantly supported by stimulating activities. Early intervention to support the development of phonological and other pre-reading skills in preschool children is an important topic in teacher professional development (Markussen-Brown et al., 2017). Caravolas et al. (2019) found that the development of early reading and writing in preschool and early school-age children is mainly influenced by three areas of ability: phonemic awareness, knowledge of letters of the alphabet, and rapid automated naming.

With this in mind, one of the authors of the study is conducting two ongoing scientific projects. One is called Children's Ideas about Reading Literacy (VEGA 1/0505/24) and the other is Games with Letters in Preschool Education. Creation of methodological material integrating educational areas (KEGA 001UMB-4/2025). This study complements the scientific findings of these projects with the issue of the development of phonemic awareness in children at the end of preschool education.

Research in this area

Phonemic awareness is part of a broader framework of pre-reading literacy, and its development in preschool age is considered one of the key prerequisites for a child's success in school. Research by Kantor (1969) and later by Lysáková, Kopinová annd Podhorná (1989) pointed to the importance of sensory experience, rhythm, and everyday language situations as means of developing phonological perception. Kodejška and Váňová (1989) emphasized planned pedagogical intervention in the area of linguistic thinking, as spontaneous verbal communication may not be sufficient for the development of phonological sensitivity. Deficits in this area may signal a risk of learning disorders, including dyslexia (Liberman, Shankweiler, 1985; Hulme, Snowling, 2013). From an international perspective, research by Lundberg, Frost, and Petersen (1988) confirmed the effectiveness of a hierarchical model of phonemic awareness development, which progresses from rhythm to rhyme to syllables and phonemes. Adams et al. (1998) showed that fun language activities (e.g., substituting sounds in songs) significantly contribute to metalinguistic abilities. Gillon (2000) and Eissa (2014) demonstrated that even short-term, targeted intervention programs can improve the phonological abilities of children with speech disorders.

Sedlák and Váňová (2013) analyzed phonemic awareness as a basic component of pre-reading skills. Their research confirmed that the ability to distinguish and use phonemes has a direct impact on successful reading. Therefore, they proposed forms of pedagogical work that integrate phonemic tasks into regular educational activities in kindergarten. In this process, they emphasized the importance of pedagogical diagnostics. Tichá (2014) also supported an inclusive approach to the development of phonemic abilities. She emphasized the importance of a differentiated approach to children with different needs and abilities. She proposed the creation of a language-stimulating environment so that each child could develop phonemic awareness at their own pace through interactive and playful activities. Research has also shown that phonemic awareness does not develop spontaneously in all children equally, but is influenced by biological, cognitive, and social factors (Kapalková, Palugyayová, 2016). The home environment, pedagogical intervention, and cooperation between professionals play an important role (Kutálková, 1996; Klenková, 2006). Eccles et al. (2020) also emphasized that active participation of children and an environment that supports autonomy have a fundamental impact on language and cognitive development.

Music and musical activities are an effective tool for developing phonemic awareness, as confirmed by several studies. According to Patel (2006), music and language share common neural and cognitive processes, particularly in the areas of rhythm, melody, and sound patterns. Bergeson and Trehub (2002) emphasized that children from an early age spontaneously respond to rhythm and melody, thereby creating conditions for the development of language skills. Kaplan and Berman (2010) and Tafuri (2008) found that musical activities – especially singing, rhythmic and musical movement games – increase children's phonological sensitivity and support their ability to work with phonemes. The significant influence of music education on phonemic

awareness is also confirmed by Anvari et al. (2002), Douglas and Willats (1994) and Moyeda, Gómez and Flores (2006), who point to a correlation between musical abilities and language skills. Research by Tierney and Kraus (2013), Moreno et al. (2009) and McPherson and Hallam (2012) shows that regular participation in musical activities improves speech processing, auditory perception and phonological processing, which are essential prerequisites for learning to read and write. Pramling and Wallerstedt (2009) found that integrating musical activities into the regular educational process contributes not only to children's emotional and social development, but also to the development of metalinguistic awareness. Feierabend (2001) showed in his programs First Steps in Music and Conversational Solfege that rhythmic singing and repetition of musical phrases significantly support the differentiation of sound units. Harms, Hyson, and Tomlinson (2014) add that systematic work with music improves attention, auditory perception, and memory, thereby creating a solid foundation for the development of reading skills.

These research findings suggest that phonemic awareness should be developed systematically, purposefully, and interactively, with musical activities providing an effective and natural way to stimulate it. This interdisciplinary perspective, combining language, cognitive, and musical domains, offers a solid framework for the development of stimulating methodologies in preschool education. Targeted and structured training in phonemic awareness significantly supports children's reading skills and their readiness for school (Torgesen et al., 1994; Share, 1995). The creation and verification of the effectiveness of programs and methodologies therefore has a firm place in pedagogical research. Our evaluation research is based on these findings.

The aim of the research was to develop a methodology for vocal-rhythmic stimulation and to evaluate its effectiveness in developing phonemic awareness in children at the end of preschool education. The study provides answers to selected research questions:

Does the vocal-rhythmic stimulation methodology increase children's phonemic awareness to a higher level? Are there differences between girls and boys in phonemic awareness?

Research methodology

The authors of the study conducted an evaluation study to assess the strengths and weaknesses of the vocal-rhythmic stimulation methodology. This study presents an evaluation of the effectiveness of the methodology using a quantitative strategy. The data were collected using D.B. Eľkonin's phonemic awareness test (Mikulajová, Ďujčíková, 2001). The data provided feedback to the authors of the methodology. Based on this, they formulated recommendations for its modification and application in pedagogical practice.

The research was conducted in three phases: pre-test, application of the vocal-rhythmic stimulation methodology, and post-test in a single-phase design comparing individual and group outputs and results (Žižlavský et al., 2014). The outputs are activities in educational activities that make up the methodology. The results are the effects of the methodology on the development of phonemic awareness in children in the research sample.

The research design was chosen for the following reasons. The methodology intensively stimulated the development of skills in a relatively short period of time. Children would not have learned these skills in free play. Learning was conducted in prepared conditions to minimize variables from the external environment. The aim was to verify and demonstrate how the stimulating effect on children in preschool education can be monitored and evaluated.

Method of collecting research data

A phonemic awareness test was used before applying the vocal-rhythmic stimulation method (pre-test) and after its application (post-test). The test was developed by Russian psychologist Professor Daniil Borisovich Eľkonin. It was published in Slovak translation by Mikulajová and Dujčíková (2001). The test consists of eleven subtests, each containing five items (a total of 55 items and points): first subtest: rhyming awareness; second subtest: rhyming production; third subtest: syllable analysis; fourth subtest: syllable synthesis into words; fifth subtest: isolation of the first syllable of a word; sixth subtest: omission of a syllable in a word; seventh subtest: isolation of the first sound in a word; eighth subtest: synthesis of sounds into words; ninth subtest: analysis of words into sounds; tenth subtest: omission of a sound in a word; eleventh subtest: substitution of sounds in words.

The testing took place in a separate room with each child individually. It was conducted by a researcher, one of the authors of this study. At the beginning of each subtest, the child was given

clear instructions. For the subtests rhyming words, isolating the first syllable, and analyzing words into syllables, the child also heard an example to better understand the task. She recorded the child's results in the subtests on a sheet taken from the standardized test. She circled the results achieved by the child. The testing was not limited by time. The average length of testing for one child was 12 minutes. The child could score a maximum of 55 points in the test.

Research data processing methods

The standardized test has a set evaluation of the child's performance. The scores of each child from the pre-test and post-test were transferred from the sheets to Excel, which enabled statistical description of the data for each child and for groups of children (girls, boys). Mean values (median, average, mode) were also used. The data were presented in tables and graphs.

Characteristics of the research sample

The research sample consisted of 22 children (N) – 8 girls and 14 boys aged 5-6 years. This was an accessible sample based on informed consent from the kindergarten director, two classroom teachers, and parents. Presissová Krejčí (2022) looked at the size of the research sample and found that in research where findings aren't generalized to the whole population, even a small sample of participants is enough. This was also true in our research.

Research organization

The research was conducted from January to March 2024 in a kindergarten in Zvolen. A preliminary test was conducted in the second week of January. From the third week of January to the second week of March, educational activities based on the vocal-rhythmic stimulation methodology were conducted with the children. A follow-up test was conducted in the third week of March. The data obtained were processed in April and May 2024.

The vocal-rhythmic stimulation methodology was implemented intensively, every working day from 8:00 to 9:00 a.m. From 7:00 a.m. to 8:00 a.m., the environment and aids for the implementation of specific educational activities were prepared. The presence of children at the beginning of each educational activity was recorded in an attendance sheet. The educational activity then took place. Short breaks were scheduled for personal hygiene and relaxation.

The educational activities were led by a researcher with a background in music. The class teacher also participated in each educational activity to make the children feel safe. The course of each educational activity was recorded on the researcher's mobile phone. Audio recordings were used for qualitative analysis of the children's statements, activities, and behavior during the educational activities. Due to the amount of data, we do not present them in this study.

Description of the vocal-rhythmic stimulation methodology

It is based on phonemic awareness training according to D.B. Eľkonin (Mikulajová, Dujčíková, 2001). It consists of introductory texts and plans for educational activities. The methodology has been assigned an ISBN and will be published in 2025 by Vydavateľstvo Písmenkové školičky pre malé detičky (Publishing House for Little Children). The introduction includes recommendations for using the methodology, explanations of musical symbols and terms, and an alphabetical list of words and names suitable for working with preschool children. There are also examples of auditory word discrimination after substitution of sounds and syllables in different positions in words, examples of work with the synthesis of syllables and sounds into words, as well as analysis of words into syllables and sounds. The second part of the methodology consists of 29 educational activities. They have themes whose initial letter (sound) guides the content of the children's learning. Each educational activity includes the musical notation of a children's song whose content supports learning in its theme.

Table 1. Themes of educational activities in the vocal-rhythmic stimulation methodology

A	Auto (Car)	**T**	Trúbka (Trumpet)	**Č**	Čmeliak (Bumblebee)
E	Električka (Tram)	**D**	Dúha (Rainbow)	**Š**	Škôlka (Kindergarten)
O	Otecko (Daddy)	**J**	Ježko (Hedgehog)	**Ž**	Žaba (Frog)
U	Užovka (Snake)	**K**	Kukučka (Cuckoo)	**L**	Lastovička (Swallow)
M	Mamička (Mommy)	**G**	Gaštany (Chestnuts)	**R**	Rodina (Family)
P	Pavúk (Spider)	**Ch**	Chrobáky (Beetles)	**Ň**	Nezábudka (Forget-me-

					not)
B	Bocian (Stork)	**H**	Hudobníci (Musicians)	**Ť**	Ťava (Camel)
F	Fialka (Violet)	**C**	Cesta (Journey)	**Ď**	Ďateľ (Woodpecker)
V	Vlak (Train)	**S**	Slimák (Snail)	**Ľ**	Lietadlo (Aircraft)
N	Nosorožec (Rhinoceros)	**Z**	Zebra (Zebra)		

The educational activities were designed to comprehensively develop phonemic awareness of each phoneme. Each educational activity has the following structure:

1. *Storytelling* begins with a riddle and continues with a discussion about the appearance, function, or occurrence of a particular phenomenon, as well as experiences and impressions of it.
2. *Breathing* takes the form of breathing exercises and games so that children become aware of and try out different ways of breathing with appropriate motivation or aids.
3. *Articulation* means playful preparation for the correct pronunciation of a particular Slovak sound by imitating the movements of the articulatory organs and the sounds using that sound.
4. *Rhythmization* is based on reciting short rhymes and expressing their content through movement (*awareness of rhymes – subtest no. 1*). It can be identical to the lyrics of a song in the activity. Children learn to analyze words into syllables (*subtest no. 3*), distinguish the first syllables in words (*subtest no. 5*), and form words from syllables (*subtest no. 6*).
5. *Discrimination* in children develops the ability to analyze and synthesize words from simple to more complex in terms of phonemes and syllables, up to the creation of rhymes (*subtests 4, 5, 6, 7, 8, 9, 10, 11*).
6. *Clarification* leads children to individually explain the meanings of abstract and foreign words used in songs and to discuss different concepts of meaning.
7. *Singing* takes place in the process of learning children's songs accompanied by a musical instrument and rhythm. The songs have a range of tones appropriate for the age of the children.
8. *Movement* is linked to the rhythm and content of the song, based on examples given by the teacher or the children themselves. Children can also improvise dance moves freely.
9. *Evaluation* means looking for answers to simple evaluation questions: *What did we do together? What did we learn? What did you like best? What else would you like to do?*

Research ethics

Work ethics and GDPR protection through informed consent were priorities in our research. We also worked ethically with children during the testing and implementation of educational activities. We respected not only standardized testing procedures, but also the rights and needs of children. We communicated empathetically and behaved according to the rules applicable in schools and kindergartens. We made sure that the children were not under time pressure during the testing and that they felt safe. The presence of the class teacher also contributed to the positive emotional atmosphere. Audio recordings of the testing, implementation, and reflection on the educational activities were made using a mobile phone. The device was quick to operate and worked quietly. The children were not informed that they were being recorded, nor could they see the recording device. Parents did not give their consent to the making of video recordings and photographs, but these were not necessary. The data were processed and presented using coded names for the children (boy 1 – boy 14, girl 1 – girl 8).

2. Results

Effectiveness of the vocal-rhythmic stimulation methodology

The effectiveness of the methodology was evaluated by comparing the results of children from the research sample in the pre-test and post-test in individual subtests. The data in Figure 1 and Table 1 answer the first research question: *Does the vocal-rhythmic stimulation methodology improve children's phonemic awareness skills?*

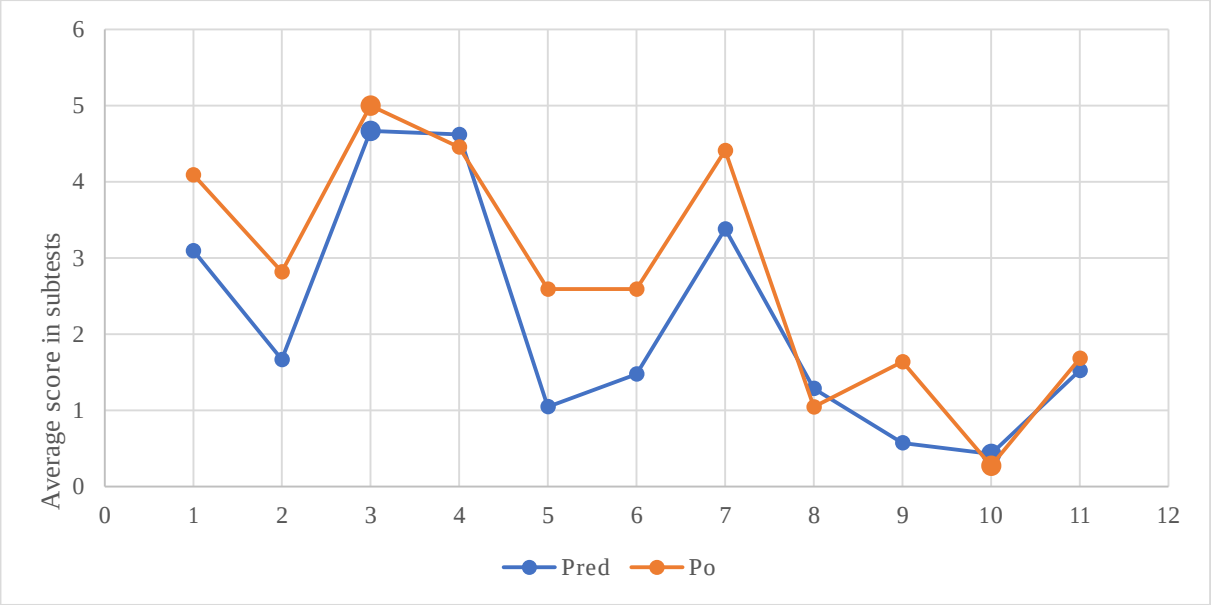

Fig. 1. Average point score (minimum 0 and maximum 5 points) in 11 subtests (pre-test and post-test) in the research sample

Table 2. Success rate of children from the research sample in 11 subtests (pre-test and post-test) from the highest to the lowest average result (minimum 0 and maximum 5 points in one subtest)

Subtest number	Points in the pre-test	Ranking	Points in the post-test	Ranking
1st subtest: *Awareness of rhymes*	3,09	4.	4,09	4.
Second subtest: *Rhyme production*	1,66	5.	2,82	5.
3rd subtest: *Analysis of words into syllables*	4,66	1.	5	1.
4th subtest: *Synthesis of syllables into words*	4,61	2.	4,45	2.
5th subtest: *Isolation of the first syllable of a word*	1,05	9.	2,59	6.
6th subtest: *Omitting syllables in words*	1,47	6.	2,59	6.
7th subtest: *Isolation of the first sound in a word*	3,38	3.	4,41	3.
8th subtest: *Synthesis of sounds into words*	1,28	8.	1,04	9.
9th subtest: *Analysis of words into sounds*	0,57	10.	1,64	8.
10th subtest: *Omitting sounds in words*	0,43	11.	0,27	10.
11th subtest: *Substitution of sounds in words*	1,52	7.	1,68	7.

A comparison of the results of children from the research sample in the pre-test and post-test showed that children achieved higher levels in almost all phonemic awareness skills. The exceptions were subtest 8, where they scored 0.24 points lower in the post-test, and subtest 10, where they scored 0.16 points lower in the post-test. In subtests 5 and 9, there was a change in the order of success. The results also showed which phonemic skills the children had most and least developed.

Comparison of test results for girls and boys

We also focused on comparing the results of girls and boys from the research sample in pre-test and post-test individual subtests in order to evaluate the effectiveness of the methodology.

The aim was to answer the second research question: Are there differences between girls and boys in phonemic awareness abilities? First, we compared the individual results of the children to determine the overall results.

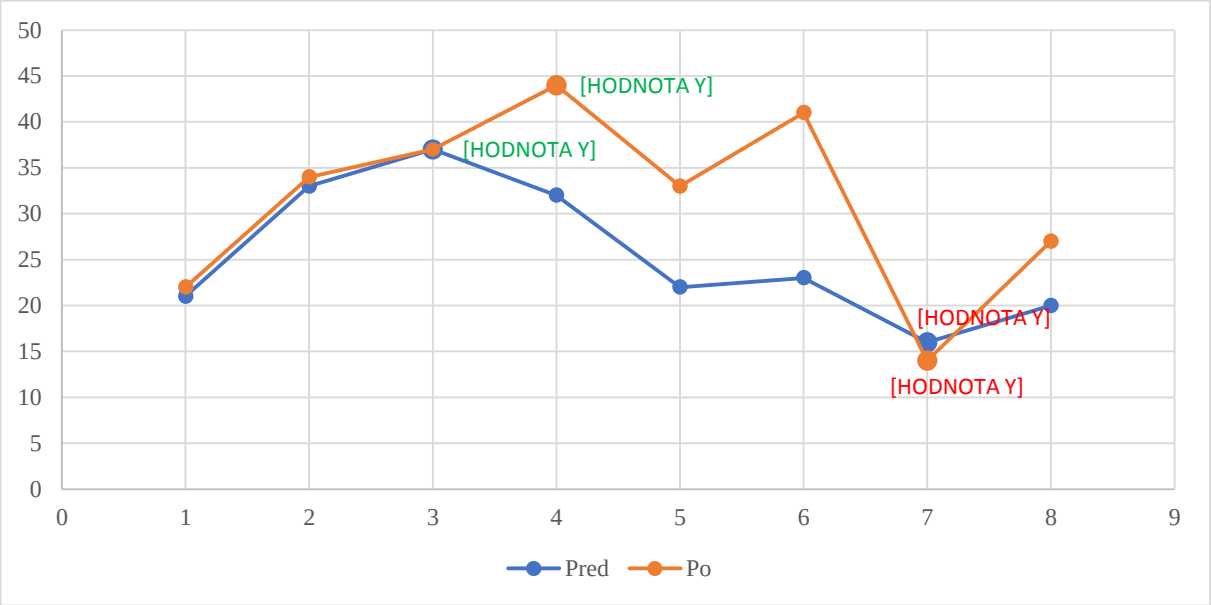

Fig. 2. Number of points scored by 8 girls from the research sample in the pre-test and post-test in a total of 11 subtests (minimum 0 and maximum 55 points)

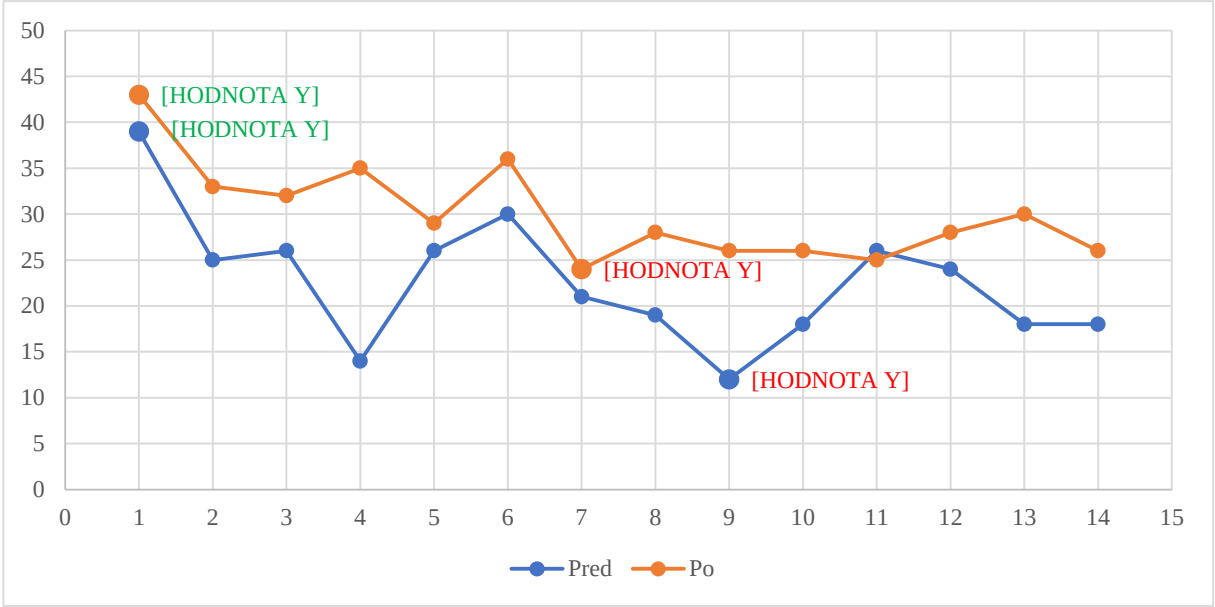

Fig. 3. Number of points scored by 14 boys from the research sample in the pre-test and post-test in a total of 11 subtests (minimum 0 and maximum 55 points)

Table 3. Success rate of girls and boys from the research sample in 11 subtests of the pretest and posttest (minimum 0 and maximum 55 points)

Girls	Points in the pre-test	Points in the post-test	Improvements in points	Boys	Points in the pre-test	Points in the post-test	Improvements in points
1	21	22	1	1	39	43	4
2	33	34	1	2	25	33	8

Girls	Points in the pre-test	Points in the post-test	Improvements in points	Boys	Points in the pre-test	Points in the post-test	Improvements in points
3	37	37	0	3	26	32	6
4	32	44	12	4	14	35	21
5	22	33	11	5	26	29	3
6	23	41	18	6	30	36	6
7	16	14	-2	7	21	24	3
8	20	27	7	8	19	28	9
Median	22,5	33,5		9	12	26	14
Average	25,5	31,5		10	18	26	8
Modus	--	--		11	26	25	-1
				12	24	28	4
				13	18	30	12
				14	18	26	8
				Median	22,5	28,5	
				Average	22,5	30	
				Modus	26	26	

Table 4. Improvement of girls and boys from the research sample in 11 subtests according to a comparison of pre-test and post-test results and depending on participation in educational activities from the methodology

Girls	Participation	Improvements in points	Boys	Participation	Improvements in points
1	79,91 %	1	1	58,62 %	4
2	55,17 %	1	2	55,17 %	8
3	44,83 %	0	3	48,27 %	6
4	96,55 %	12	4	72,41 %	21
5	48,27 %	11	5	41,38 %	3
6	75,86 %	18	6	68,97 %	6
7	62,07 %	-2	7	75,86 %	3
8	58,62 %	7	8	41,38 %	9
			9	86,21 %	14
			10	55,17 %	8
			11	68,97 %	-1
			12	65,52 %	4
			13	79,91 %	12
			14	72,41 %	8

Based on the results of testing girls and boys from the research sample, we can conclude that both groups showed improvement in phonemic awareness skills, with the exception of two children (girl 7 and boy 11). According to the median and average, girls achieved slightly better results.

Based on these data, we can conclude that the vocal-rhythmic stimulation methodology had positive effects on the development of phonemic awareness skills in children from the research sample. However, it needs to be verified on a larger sample of children from several kindergartens in different regions of Slovakia. This also applies to further verification of the assumption that the development of a child's phonemic awareness skills depends on the extent of their participation in educational activities from the methodology.

3. Discussion

The aim of the evaluation research was to create a vocal-rhythmic stimulation methodology and evaluate its effectiveness in developing phonemic awareness in children at the end of pre-primary education. In this study, we supported its achievement with a quantitative strategy. We compared the results of children from the research sample in the pre-test and post-test, also according to gender. A qualitative strategy was not presented here. It contains extensive data processed by methods of thematic analysis of children's statements and pedagogical reflection on their behavior and actions during the implementation of individual educational activities. This research study answered two questions selected from the research.

Does the vocal-rhythmic stimulation methodology advance children's phonemic awareness to a higher level? The results of the children in the pre-test and post-test showed that it has developmental effects. Most children in the research sample showed improvement in almost all phonemic awareness skills. Only two children out of a total of 22 showed a slight deterioration in their post-test scores. This may be related to their emotional insecurity in situations of controlled mental work. Similar phenomena have been reported in the literature by Share (1995) and Brady (1997). They pointed to the variability in the development of children's phonological abilities and the dependence of their manifestation on environmental conditions and current mental state. These and many other determinants of performance in preschool children are common (Horáková, 2009; Smolík, Seidlová Málková, 2015).

The children studied performed best at syllable analysis of words and isolation of the first sound in words. They were less able to identify sounds at the end of words and had problems identifying sounds within short words. Most of them are unable to analyze words into individual sounds. Phonemic analysis is one of the more difficult metalinguistic operations and is usually consolidated at the beginning of school attendance (Ehri, 2005; Seidlová Málková, 2016). These findings correspond to the recommendations of Gillon (2000), Adams et al. (1998) and Zavrazhina and Terentyevy (2021) on stimulating these abilities. Eccles et al. (2020) empirically confirmed the positive influence of musical-rhythmic activities on the development of phonological sensitivity in preschool children.

Lundberg, Frost and Petersen (1988) found that children who completed a phonological program focused on rhythm, rhyming, and word manipulation scored higher on reading skills later in school. Torgesen et al. (1994) pointed out that phonological intervention has the greatest effect when it is implemented regularly, purposefully, and playfully. We have fulfilled this condition through intensive daily implementation. Equally important is the transfer effect of musical and rhythmic elements on language skills, as demonstrated by research by authors such as Pramling and Wallerstedt (2009) and Tafuri (2008).

Our research has confirmed this. The tested vocal-rhythmic stimulation methodology is original and, in addition to phonemic awareness, it integrates the development of language, musical, cognitive, and motor skills. It respects the development of phonemic awareness in preschool children, from the perception of sound units (syllables, rhythm) to the differentiation of phonological elements of words (Gillon, 2004; Hulme, Snowling, 2013; Kapalková et al., 2005). Research data have confirmed that it is suitable for preschool children.

Are there differences between girls and boys in phonemic awareness abilities? No significant differences between boys and girls were found in the sample studied, which indicates the universality of the methodology in these groups. Despite the positive findings, it is important to mention the children who did not score higher in the post-test than in the pre-test (girl 3) and those who showed a slight deterioration in their post-test results (girl 7, boy 11). Girl 3 already achieved a relatively high score (37 points) in the pre-test, which indicates a possible ceiling effect, where the child had already reached an advanced level of phonemic awareness before the start of the research. In the case of girl 7 and boy 11, this may be a fluctuating performance, influenced by something or someone.

The research also showed that there is no direct correlation between the increase in phonemic ability and the child's level of participation in activities. Therefore, it is not true that the higher the participation, the better the results (e.g., girl 5 with 48 % participation improved by 11 points, versus girl 1 with 80 % participation improved by only 1 point). According to Allen (2011), it is not usually true that the more intensive the intervention, the more effective it is. There are reasons for this phenomenon, which we have not investigated. They will be the subject of

further research when verifying the effectiveness of the methodology on a broader research sample. This may be related to the quality of engagement, individual developmental level, and the ability to learn new things outside of stimulating activities (Gan, Chong, 2006; Eccles et al., 2020). The affective tone of the activities also appears to be an important factor, i.e., whether the child found the activities fun, meaningful, and personally significant, which influences their motivation and level of engagement (Stanovich, 1986; Winsler et al., 2011).

When comparing the results for the groups by gender, boys improved by an average of 7.5 points and girls by 6 points. However, girls had higher average scores than boys in both the pre-test and post-test. Therefore, it can be said that girls were slightly more successful in developing phonemic awareness skills, by an average of only 1.5 points (Table 3).

Limitations of the research

A serious limitation is the evaluative research focused on verifying the effectiveness of the methodology without a control group of children. This design made it possible to capture authentic expressions of children in a real educational context, but at the same time limited the possibility of formulating clear causal conclusions about the impact of the methodology on the observed abilities. Another limitation was the size and structure of the research sample. The small number of children and uneven gender representation make it impossible to generalize the results to a wider population or to make reliable comparisons between subgroups. The short-term nature of the intervention limited the possibility of verifying the sustainability of the changes achieved over time.

The data collection process was also affected by organizational and operational circumstances specific to the pre-primary education environment. During some activities, there were interruptions due to children arriving late, staff arrivals, or parallel activities, which could have disrupted the continuity and quality of the activities carried out. Variable attendance of children, mainly due to illness, was another disruptive factor.

Some children did not participate in all educational activities, which may have affected their post-test results. The epidemic situation in the kindergarten, the researcher's illness during February and March (a total of 2 days), and the flu holidays (1 week in February) led to repeated interruptions in the research process. For these reasons, the retesting of almost half of the sample was carried out three weeks after the end of the intervention, which may have affected the validity of the post-test data.

Another limitation was the fact that the person implementing the stimulation methodology was not a regular member of the class team. In the initial stages, this aspect manifested itself in increased shyness or, conversely, excessive activity on the part of some children, which may have temporarily distorted their authentic participation. The initial adaptation contact with the class, carried out a week before data collection, served to familiarize the children with the research aim and eliminate unfamiliar stimuli, but it was not possible to guarantee that the initial uncertainty would be completely overcome.

Taking these limitations into account is crucial for drawing conclusions from this study. At the same time, it provides a valuable starting point for optimizing the methodological framework in future research projects.

4. Conclusion

The results of the research confirmed the effectiveness of the vocal-rhythmic stimulation methodology in the development of phonemic awareness in children at the end of pre-primary education. A comparison of children's performance in the pre-test and post-test showed a clear improvement in several phonemic awareness skills. The most significant progress was observed in skills such as sound isolation, synthesis and analysis of words into sounds and syllables, as well as in rhyming. These findings are consistent with previous research confirming the importance of targeted intervention in pre-reading skills already in preschool age (Markussen-Brown et al., 2017; Caravolas et al., 2019; Šedinová, Seidlová Málková, 2021).

An important contribution of the research is the creation and verification of a methodology that combines musical and linguistic elements in a systematic approach with an emphasis on rhythm, articulation, breathing exercises, and analytical-synthetic language activities. This comprehensive support was positively reflected in the children's performance in the individual subtests of the D.B. Eľkonin test. In addition, the methodology respected the developmental needs of children, supported their natural interest, and enabled learning through play, music, and movement.

In terms of gender, no significant differences between boys and girls were found in the sample, which points to the universality of the methodology within diverse groups of children. Although the research sample was small and does not allow for generalisation of the results to the entire population, the data obtained through quantitative analysis provide valuable insights for further research and pedagogical practice. Given the positive results of the research, further application and development of the vocal-rhythmic stimulation methodology in kindergartens can be recommended, especially when working with children with risk factors in the area of literacy. At the same time, there is a need for further longitudinal studies to monitor the durability of the methodology's effects at a later age and its impact on children's school performance in reading and writing.

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Microlearning for Lasting Learning: Perspectives on Memory Retention in Language Education

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Abstract

Microlearning has gained increasing attention as an instructional approach that enhances memorisation and long-term retention in foreign language acquisition. Despite its growing use, empirical evidence on its effectiveness across educational contexts remains limited. This study aims to investigate the impact of microlearning on the memorisation and retention of focal grammar and vocabulary in foreign language learners from different cultural environments. Three methods were employed: (1) a systematic literature review of scholarly works on microlearning design and pedagogy; (2) practice-based case studies in real-world classroom settings; and (3) comparative experiments with control and experimental groups. The interventions were guided by neurodidactic principles of microlearning such as content minimisation, focused delivery, spaced repetition and retrieval practice. Case Study 1 involved English learners in Turkey, and Case Study 2 involved Turkish learners in Russia. Microlearning was implemented in the experimental groups, while the control groups followed the standard curriculum. In Case Study 1 (Turkey), the experimental group demonstrated consistently higher vocabulary retention across all three tests compared to the control group. The most significant difference was observed in Test 2, where the experimental group recalled 37.7 % of the target vocabulary versus 13.8 % in the control group. These results highlight microlearning's ability to reinforce memory and reduce forgetting shortly after exposure. In Case Study 2 (Russia), the experimental group also outperformed the control group, showing an average improvement of 20.24 %, with the final test score being 30 % higher. This outcome reflects the effectiveness of neurodidactic microlearning strategies in guiding student attention toward key elements, enhancing comprehension and long-term retention. Additionally, microlearning promoted attentional control by helping learners focus on essential information, recognise patterns, and form meaningful associations. This study demonstrates the effectiveness of neurodidactic microlearning in enhancing memorisation and attention in foreign language learning

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across diverse cultural contexts. The consistent improvements suggest flexible microlearning designs can meet varied learner needs. Further research is needed to optimise and expand its pedagogical use. The obtained results enrich the methodological foundation of microlearning and can be applied by language instructors to improve students' academic performance.

Keywords: microlearning, foreign language learning, memory retention, language instruction, neurodidactics, attention regulation, vocabulary acquisition, lesson design, pedagogical strategies.

1. Introduction

In recent years, international organisations such as UNESCO (1998) and the Council of Europe (Redecker, 2017) have emphasised the importance of innovative approaches to education that promote learner engagement, knowledge retention, and skill acquisition. One such approach that has gained increasing attention globally is microlearning – a pedagogical strategy that delivers instructional content in short, focused segments and aligns with how modern learners process information. While microlearning has been widely explored in corporate training and informal educational contexts, its integration into formal foreign language instruction remains under-researched.

A review of current literature highlights the cognitive and neuroscientific foundations of microlearning. Ebbinghaus's Forgetting Curve demonstrates the importance of periodic review for memory retention (1913), while Sweller's Cognitive Load Theory (1988) underscores the need to reduce cognitive overload by presenting material in manageable chunks. Spaced repetition, retrieval practice, and the activation of prior knowledge have all been shown to enhance learning outcomes, particularly in vocabulary acquisition. These principles suggest that microlearning may be especially effective in second language acquisition, where learners benefit from repeated and structured exposure to new language forms. However, despite the theoretical promise and growing popularity of microlearning tools – such as digital flashcards, low-stakes quizzes, and gamified exercises – there is a notable lack of research examining their use in formal classroom settings, particularly in EFL (English as a Foreign Language) and early-stage foreign language learning.

This gap in the literature signals a need for empirical studies that test the practical value of microlearning in structured educational environments. Our research responds to this need by exploring how microlearning strategies can be applied to vocabulary and grammar instruction in two formal language learning contexts: a B1-level EFL classroom using English-language materials in a Turkish university, and an A1-level Turkish language course for Russian-speaking students. Although microlearning is increasingly mentioned in education research, few methodological frameworks have been developed to guide its implementation in language classrooms.

Moreover, preliminary interviews with the language learners, who participated in the case studies, revealed several recurring difficulties related to the retention of new material during the language acquisition process. The most frequently reported challenge was the memorisation of new vocabulary. A number of students emphasised that a lack of interest in the content significantly hinders their ability to retain information. Other difficulties were associated with the presence of numerous unfamiliar words in a text and the extended duration of lessons. Furthermore, many participants noted that the absence of repetition and the overload of new information adversely affect the memorisation process.

The aim of this study is to determine whether microlearning techniques – particularly minimisation, focused delivery of learning material, spaced repetition, retrieval practice, and structured micro-sessions – can significantly enhance vocabulary and grammar retention in beginner-level and intermediate-level language learners. Thus, based on the hypothesis that microlearning improves students' ability to memorise and retain new material, we address the following research questions:

RQ1. What effects does microlearning have on memorisation and retention of new learning material in a foreign language classroom?

RQ2. How effective are the proposed microlearning lesson designs at enhancing students' memorisation and retention of new learning material?

To address the research questions, two case studies were conducted involving tailored microlearning scenarios and comparative vocabulary and grammar testing in both control and experimental groups. Our approach draws from established educational theory while also integrating neurodidactic principles that emphasise attention management and cognitive association.

By analysing the results of these interventions, we aim to contribute to the growing body of research on microlearning and offer practical insights for language educators seeking to implement this approach in formal classroom environments.

2. Literature review

The concept of microlearning has gained significant attention in recent years, especially in the fields of digital education, corporate training, and increasingly, formal language teaching. It refers to an instructional approach that delivers content in small, focused segments, often supported by digital platforms. Its design aligns well with how learners process, retain, and recall information. One of the theoretical cornerstones explaining microlearning's effectiveness is Ebbinghaus's Forgetting Curve, developed in 1885 and introduced to an English-speaking audience through a 1913 translation of his original German work (Ebbinghaus, 1913). Through a series of self-experiments, Hermann Ebbinghaus demonstrated that memory naturally deteriorates over time unless the information is revisited at strategically spaced intervals. His findings established that retention improves significantly when content is reviewed periodically, a principle that remains relevant in modern educational design.

Building on this foundation, Cognitive Load Theory (CLT) offers additional insight into the benefits of microlearning. According to Sweller (1988), working memory has limited capacity, and overloading it can hinder learning. Therefore, instructional approaches that reduce cognitive strain – such as delivering content in short, manageable units – are likely to be more effective. Activating prior knowledge before introducing new material further supports cognitive efficiency. This process, rooted in schema theory (Baddeley, 2003), allows learners to connect new concepts with familiar ones, easing the burden on working memory. Research by Marzano, Gaddy, and Dean (2000) also confirms that drawing on prior knowledge significantly boosts academic achievement. Furthermore, retrieval practice, such as quizzes and visual reviews, strengthens memory retention over time (Wenger et al., 1980).

A core feature of microlearning is its compatibility with spaced repetition, an evidence-based method that enhances long-term memory and conceptual understanding. Unlike simple rote memorisation, spaced repetition involves revisiting content at gradually increasing intervals, which strengthens the learner's ability to internalise and apply information. This method directly counters the forgetting curve by embedding knowledge more deeply in long-term memory. In one study, medical students who engaged with spaced repetition techniques demonstrated 16–25 % higher accuracy in recalling key terms compared to those who crammed shortly before exams (Mostrady, et al., 2025). Such findings highlight microlearning's potential not only for improving memory but also for encouraging deeper cognitive processing and transfer of knowledge.

Microlearning supports this process naturally through brief, revisitable modules – often delivered via apps or online platforms – that allow learners to review information as needed without cognitive overload. Tools such as digital flashcards, low-stakes quizzes, and bite-sized video lectures help learners understand complex material by reducing the information load and spacing learning sessions over time. This environment is particularly effective for EFL learners, who benefit from repeated exposure to new language forms without the fatigue of intensive study sessions. This method aligns with principles of lifelong learning and continuous skill development, which are increasingly emphasised in modern pedagogy.

Moreover, microlearning has been described as an efficient means of acquiring and retaining knowledge in a fast-paced learning environment. Rather than overwhelming learners with a large volume of content at once – as in traditional educational methods – microlearning enables the mastery of small, targeted knowledge chunks. This fosters a sense of progress and productivity, as learners can complete meaningful learning tasks in shorter periods.

Importantly, microlearning also increases student engagement. The interactive nature of its tools – such as quizzes, short videos, or gamified exercises – makes the learning process feel more participatory. Students report that microlearning resembles browsing social media: the content is short, engaging, and easy to return to. This resemblance to everyday technology use makes the learning experience feel intuitive and less intimidating, especially for digital-native learners. Furthermore, concise content structures make it easier for learners to revisit and reinforce unclear points, enhancing overall comprehension (Ghafar et al., 2023).

Despite the growing interest, scholars such as Ghasia (2021) have observed a gap in the literature regarding the use of microlearning in formal educational settings, such as EFL

classrooms. Much of the existing research centres on informal learning environments, including professional development and workplace training. However, the evidence suggests a promising future for microlearning in formal pedagogy as a teaching method, instructional model, and learning tool.

Furthermore, current literature predominantly focuses on microlearning through digital platforms and applications, with limited attention given to its application in classroom-based settings. This highlights a significant gap in both theory and practice regarding the integration of microlearning principles into formal education, thereby justifying the need for the present study.

3. Materials and methods

This section outlines the methodological foundation of the research, detailing the study design, practical cases, participant involvement, and the procedural sequence of the experimental work.

Study design

Systematic literature review. The first method we employ is a systematic literature review, delving into academic literature, previous research, and studies to deeply explore the concept of microlearning, define criteria for effective microlearning design, and highlight key pedagogical issues that microlearning is designed to address. Our study draws from a variety of sources, including periodicals dedicated to microlearning research in language education (Research in Learning Technology, Journal of Education and e-Learning Research, Journal of Learning for Development, Education and Information Technologies, Linguistics and Education, Innovation in Language Learning and Teaching etc.). This approach provides a well-rounded understanding of the current body of knowledge on the topic.

Practice-based case studies. In our study, we utilised the practice-based case study methodology. This methodology was chosen for the following reasons:

– Practice-based case studies are widely employed in pedagogical research, as teaching inherently involves practical, interactive experiences with students in diverse educational settings;

– Case studies involve the narration of activities and changes within a specific context or setting, accompanied by reflection on the learning process (De Leeuw et al., 2015; Zwald et al., 2013).

– Case studies are primarily based on personal experiences or tacit knowledge rather than a systematic investigation (Simpson et al., 2013);

– Multiple case studies can provide valuable insights into common mechanisms, outcomes, and influencing factors, enabling a comprehensive understanding of implementation complexities (Lee, Chavis, 2012; Morestin et al., 2010; Simos et al., 2015, South et al., 2004).

Comparative research. We chose the comparative experimentation methodology and created one control and one experimental group in both cases above. The method of comparative research allows us to clearly discern the effectiveness and impact of the pedagogical innovation or concept we propose. As the primary focus of our study was to assess the enhancement of students' lexical and grammar skills, the criterion for measuring improved learning effectiveness was the students' ability to better memorise and retain the newly learnt vocabulary and grammar concepts.

In our work with the experimental groups, we used microlearning as a teaching technique to enhance memorisation of learning material, assuming that microlearning fosters the ability to control one's attention and maintain it on certain educational objects for a given period. The control groups' work was carried out according to the set curriculum. The assessment tool chosen for control sessions consisted of tests focusing on key vocabulary and grammar knowledge from the lessons. During all tests, students were not allowed to use their phones or coursebooks.

Case Study 1 and Case Study 2 were conducted separately but had the same research objectives. Microlearning was used in both cases, utilising modern teaching methods such as the communicative method and lexical approach, which are widely accepted and commonly used in foreign language teaching.

Cases and participants

The experiment took place over a two-month period, spanning from mid-October to mid-December. It took place in two universities, one based in Turkey and the other in Russia.

Case 1 took place at Marmara University's School of Foreign Languages (Turkey, Istanbul). Students in the English department study both General and Academic English for two terms (8–9 months). Upon successfully passing their final exams, they transition to their respective departments – such as physics, engineering, and biology – where all courses are conducted in English.

For this case study, two groups of students aged 18–19 participated: an experimental group (B1.23) with 20 students and a control group (B1.22) with 18 students. Both groups followed the same curriculum and had four-hour English classes five days a week, including one day of online instruction. Due to the course schedule, the teacher taught each group only once a week – B1.23 in a face-to-face setting on Mondays and B1.22 online on Fridays.

Case 2 occurred at Ural Federal University (Ekaterinburg, Russia). The study involved students from the Linguistics Department. These students were learning Turkish as their third foreign language for two academic periods (8-9 months). The experimental and control groups included 13 and 12 students, respectively. Both groups adhered to the same curriculum and followed the A1 general course of Turkish program. According to the provided curriculum, the number of Turkish classes amounted to four hours per week.

All the groups involved in the research were informed about the experiment, and all data collected remained anonymous.

Despite physical and language differences between the two cases, general conclusions can be drawn and common patterns identified. This is possible due to several factors, including:

– The foreign languages studied are not the primary focus of the students' academic studies, despite being a required component of the curriculum;

– The educators used the same methodological framework for microlearning instruction in both cases;

– The time spent interacting with the groups was equivalent;

– Comparisons are made between students of the same level of foreign language proficiency, reducing disparities;

– Both languages studied are from different language groups to that of the students' native languages, ensuring consistency.

Procedures, data, and analysis

The field of microlearning offers ample opportunities for methodological research. Numerous studies have explored the concept of microlearning so far (e.g., Hug, 2007; Kapp, Defelice, 2019; Alias, Abdul Razak, 2023; Balasundaram et al., 2004; Monakhova et al., 2020; Zakharova, 2022). After assessing these research papers, our analysis allowed us to identify crucial parameters necessary for microlearning, and we utilised these guidelines when implementing this practice in our study. The key parameters are the following:

– Analysis, identification, and understanding of students' learning needs;

– Selecting and integrating appropriate micro-content into educational practice according to those needs;

– Segmenting and minimising educational content into manageable, focused micro-content; determining the optimal time frame for micro-practices;

– Integrating micro-practices into the overall lesson plans.

To conduct effective and efficient microlearning practices, it is essential to identify and use the correct methodological tools. For the purpose of this research, the main criterion for selecting the tools was their adaptability to the microformat. In addition, these tools were chosen while taking into account the fact that they should not involve complex activities related to information analysis and synthesis (see Kapp, Defelice, 2019).

4. Results

In order to address the research questions, we developed a methodological component specifically tailored to microlearning in foreign language teaching. Analysis of recent research revealed that there is currently no universally accepted or unified methodological framework for microlearning in this field. To construct our own framework, we undertook the following steps:

1. **Examination of existing foundations:** we analysed the methodological foundations of microlearning and identified its core principles and characteristics.
2. **Exploration of neurodidactic aspects:** we investigated the neurodidactic underpinnings of microlearning to better understand its mechanisms and pedagogical potential.
3. **Case analysis:** we reviewed several relevant cases of microlearning implementation across various educational contexts to inform the development of teaching strategies specifically suited to foreign language instruction.

Case Study 1 (Turkey)

In case study 1 the students used *National Geographic: Listening and Notetaking Skills, Level 1*, the coursebook selected by the university's curriculum committee. Each week, students worked on one chapter, practicing listening, note-taking, and speaking skills, while also learning new vocabulary related to the topic of the audio track.

Building on Wenger's theory (1980) that activities like quizzes and visual reviews enhance long-term memory, we selected ten words for weekly testing. To assess vocabulary retention, both groups took identical vocabulary tests every three weeks, with a total of three tests during the study. However, the experimental group had an additional weekly vocabulary review, which provided them with more exposure to the target words. Words and phrases from the abovementioned coursebook were chosen specifically because the students' knowledge of these words is tested in the first progress exam.

The review process included:

– *Definition Recall:* the teacher read English definitions of the new words, and students wrote down the corresponding words on small pieces of paper anonymously before submitting them. Then, the teacher repeated the definitions, and students responded orally.

– *Question-Based Practice:* the teacher incorporated the target words into questions and asked students to either answer them or create their own questions using the new vocabulary. They then practiced asking and answering in pairs.

In Table 1 we can see that the experimental group – which engaged in weekly vocabulary revision – consistently outperformed the control group across all three tests. While both groups were introduced to the same vocabulary items through the coursebook, the additional exposure and retrieval practice provided to the experimental group appear to have significantly enhanced their long-term retention.

The experimental group recalled a higher number of target words and expressions, particularly more abstract or less frequently used ones such as *expertise* (14 vs. 3), *formal language* (14 vs. 2), *to work efficiently* (8 vs. 3), and *eventually* (9 vs. 4). These differences suggest that regular, focused revision played a crucial role in reinforcing students' memory. Words that were more concrete or familiar (e.g. *volcanic eruption*, *ancient*, *ruins*) also showed higher recall in the experimental group, though with a smaller gap, indicating that revision benefits all types of vocabulary but is especially helpful for more complex or abstract items.

These findings support the idea that microlearning strategies such as spaced repetition and retrieval practice significantly improve vocabulary retention, echoing Ebbinghaus's Forgetting Curve and Wenger's research on memory reinforcement through repeated exposure.

Table 1. Vocabulary retention in two groups of students: comparison of three test results in Case 1 (Turkey)

Words in each test	Experimental group (had revisions every week)	Control group (no revisions between tests)
Test 1	*n = 19*	*n = 15*
fame	16	12
military campaign	3	2
deserted	9	6
volcanic eruption	14	9
ancient	12	11
ruins	7	3
electronic device	12	9
profitable	7	6
eventually	9	4
unbearable	11	4
Test 2	*n = 13*	*n = 16*
to gain speed	5	3
to consist of	3	2
to acquire a language	2	-
essential words	-	-
precise	3	1

Words in each test	Experimental group (had revisions every week)	Control group (no revisions between tests)
to work efficiently	8	3
to store information	4	3
the remotest island	5	-
devastating	5	5
off the grid	4	2
Test 3	*n = 16*	*n = 10*
to predict	4	1
to tremble	4	2
to interact	8	4
formal language	14	2
legitimate	4	2
expertise	14	3
to imitate	8	6
diversity	1	4
to originate	1	1
crops	3	2

As can be seen in Table 2, the experimental group demonstrated consistently higher vocabulary retention across all three tests compared to the control group, indicating a clear advantage of the microlearning approach. The most notable difference appeared in Test 2, where the experimental group recalled 37.7 % of the target vocabulary versus only 13.8 % in the control group. This result suggests that microlearning is particularly effective in reinforcing memory and preventing rapid forgetting shortly after initial exposure. Also, the overall trend across all three tests highlights microlearning's potential to support more durable retention over time, even with challenging or abstract vocabulary.

Table 2. Summary: percentage of students who remembered the words

Test	**Experimental group**	**Control group**
1	57.9 %	44 %
2	37.7 %	13.8 %
3	38.1 %	33.8 %

After the final test, we asked the students in both groups the following question: '*Was it easy to remember the words?*' Approximately 70 % of the students in the experimental group reported that it was easy to remember the words, whereas about 65–70 % of the students in the control group said they found it difficult to recall the words and phrases.

Additionally, we asked the experimental group: '*Did seeing the words from each chapter every week help you remember them now?*' Most students responded affirmatively, suggesting that regular revision contributed significantly to their confidence and success in recalling vocabulary.

Another important observation in the experimental group was that some students developed a habit of revising vocabulary on their own, either at home or just before class. Knowing that vocabulary revision would take place every week appeared to encourage them to take more responsibility for their learning. This is a positive sign, as it suggests that regular, structured revision not only improved vocabulary retention but also helped foster learner autonomy and engagement with the learning process.

Case Study 2 (Russia)

The work with microlearning in both cases involved a focused approach to key vocabulary and grammar topics from the course, with the aim of improving retention and memorisation. Since the experiment lasted two months, we identified which lexical and grammatical topics could be adapted to the microlearning format, taking into account the students' needs and the complexity of the material.

After analysing these factors, we determined that the most challenging grammatical aspects for learners at the A1 level in Turkish are related to possessive suffixes and possessive noun

phrases. These topics were therefore prioritised in the experiment. The selected topics share underlying principles, are closely interconnected, and are critical at the early stages of language acquisition, serving as a foundation for more advanced grammatical structures.

Furthermore, the analysis of the Russian-speaking students' educational needs in recent years has shown that these particular grammatical concepts are among the most difficult for them to master at the A1 level.

The lexical component of the microlearning practices focused on vocabulary related to the topic *Ailem (my family),* as presented in the textbook. Additionally, vocabulary from the previous two chapters was incorporated, along with lexical items identified as important for the experimental group, based on the teacher's observations during class. These items were included in the microlearning practices and assigned as homework.

In this study, we supplemented the standard *Istanbul A1* curriculum with tasks that had been specifically reformulated into the microlearning format. The experimental group engaged with the microlearning material through several microlearning scenarios proposed by Kapp and Defelice (2019):

1. *Preparatory microlearning*. The inclusion of this microlearning scenario was motivated by the complexity of the topic, which necessitated preparatory exercises leading up to it. In the two lessons preceding this topic, the teacher integrated short texts containing sentences with possessive suffixes. To ensure appropriate focus, the teacher highlighted new sentence structures related to the upcoming theme, drawing students' attention to these patterns. The goal of this practice was to cultivate students' awareness of the forthcoming grammatical concepts.

2. We employed *performance-based microlearning* to provide learning solutions at the point of need and to reinforce key vocabulary and grammar. This method utilised the *surprise short talk* technique, which involved a dialogue between the teacher and students. The teacher prepared a list of focal vocabulary and grammar questions in advance, and then dynamically generated additional questions during the microsession based on the students' responses. This approach enabled targeted reinforcement of focal vocabulary and grammar content. Below are examples of microcontent and dialogic inquiry questions, selected for their relevance to students, based on the teacher's observations during classes:

– Words of the same root *bilmek (to know), bilgi (knowledge/information), bilgisayar (computer); İngilizce iyi mi biliyorsunuz? (Do you know English well?); Hangi başka yabancı dilleri biliyorsunuz? (Which other foreign languages do you know?); Bu metinde yabancı diller hakkında bilgi var mı? (Is there any information about foreign languages in this text?); Bilgisayarınız var mı? (Do you have a computer?); Günde kaç saat bilgisayar karşısında geçiriyorsunuz? (How many hours a day do you spend in front of the computer?).*

– Pattern *"... olarak çalışmak" (to work as a ...)*: the students were asked by the teacher to answer questions about their family members' professions, with a requirement to use the specified grammar pattern. Example answers given by the students: *Babam müdür olarak çalışıyor (My father works as a manager). Annem öğretmen olarak çalışıyor (My mother works as a teacher).*

– Pattern *"ne zaman..., o zaman ..." (when ..., then ...)*. This construction is used as a simplified way of forming complex sentences with adverbial clauses of time, suitable for students at the A1 level of Turkish. The students responded to the teacher's questions, which incorporated the focal pattern as well as previously-learned vocabulary and grammar structures: *Ne zaman anneniz size telefon ediyor, o zaman ne hakkında konuşuyorsunuz? (When your mother calls you, what do you talk about?); Ne zaman ailenizin bir partisi var, o zaman kim yemek pişiriyor? (When your family has a party, who cooks the food?); Ne zaman annebabanızın evine gidiyorsunuz, o zaman orada ne yapıyorsunuz? (When you go to your parents' house, what do you do there?).*

3. *Persuasive microlearning* aimed to modify students' behaviour and foster new habits. The task was to develop students' ability to conduct interpersonal dialogues on a given topic and to overcome communication barriers. To achieve this goal, students were given a survey form containing previously learned focal microcontents at the beginning of each lesson. To enhance retention, students were required to fill in the gaps with focal grammar patterns (here, possessive suffixes and possessive noun phrases). These microsessions were conducted at the start of each class to encourage open communication and reinforce memorisation of the studied focal content. The examples of questions included in the questionnaires are as follows: *Senin aile...de kaç kişi var? (How many people are there in your family?); Bizim ülke...de deniz var mı? (Is there a sea in your country?); Senin ailen... kaç araba... var? (How many cars does your family have?); Senin*

annebaban... köpek... var mı? (Do your parents have a dog?); Annen... meslek... nedir? (What is your mother's profession?); Senin kardeşler... var mı? (Do you have any siblings?) etc.

4. *Post-instruction microlearning*. To reinforce key grammar and vocabulary after instruction, post-instruction microlearning was implemented. For this purpose, the teacher used an oral assessment approach. In addition to the standard course test, she conducted a targeted oral exam focused specifically on the core grammar and vocabulary items. Students were required to participate in dialogues, which encouraged them to review the material beforehand. During the assessment, the teacher engaged each pair of students in conversation, noting areas where recall was incomplete or uncertain. The results showed that most students were able to successfully recall approximately 80 % of the focal material during this stage.

Here are the examples of questions containing the focal contents, which were asked during the oral assessment practice: *Kardeşinin bilgisayar bilgisi ne kadar iyi? (How good is your sibling's computer knowledge?); Arkadaşın bilgisayar mühendisi olarak çalışmak istiyor mu? (Does your friend want to work as a computer engineer?); Kardeşinin adı ne? (What is your sibling's name?); Senin evin nerede? (Where is your house?); Kardeşinin okulda en sevdiği ders hangisi? (Which subject does your sibling like the most at school?); Kardeşinin odasında bilgisayar var mı? (Is there a computer in your sibling's room?); En iyi arkadaşının telefon numarası kaç? (What is your best friend's phone number?); Babanın arabası kaç yaşında? (How old is your father's car?); Ailenin tatil planları var mı? (Does your family have any vacation plans?); Annenin ve babanın doğum günleri ne zaman? (When are your mother's and father's birthdays?); Kardeşinin odasında kaç kitap var? (How many books are there in your sibling's room?*

A systematic monitoring of the assimilation of learned material was conducted through microtests, delivered via Google Forms to both the experimental and control groups at the start of each class. In the final class session, all students took a comprehensive test encompassing all focal themes covered in the course. In the control group, students studied the same material, but it was not explicitly highlighted as focal content. They addressed these topics solely through exercises provided in their textbook.

The test results revealed that, compared to the control group, the experimental group demonstrated superior retention of the target material in both the interim and final tests. This outcome substantiated our selection of appropriate methodological microlearning tools, which effectively supported the achievement of our research objectives. The superior performance of the experimental group can be attributed to the neurodidactic principles underlying microlearning. Specifically, the targeted emphasis on key microelements enabled students to sharpen their attention, guiding it towards essential components and subsequently facilitating a deeper understanding of the material. This is clearly reflected in the test results presented in Table 3, where the experimental group consistently outperformed the control group, showing an average improvement of 20.24 % across all tests, with the final test demonstrating a remarkable 30 % higher score.

Table 3. Test results in the control and experimental groups (case 2)

Test	Experimental Group (Avg./Max.)	Control Group (Avg./Max.)	Difference (%)
Test 1	8.77 / 12	8.00 / 12	+9.63%
Test 2	4.73 / 7	4.20 / 7	+12.62%
Test 3	4.18 / 8	4.10 / 8	+1.95%
Test 4	3.14 / 7	3.00 / 7	+4.67%
Test 5	7.00 / 9	5.70 / 9	+22.81%
Test 6	8.40 / 11	7.10 / 11	+18.31%
Test 7	8.00 / 11	6.90 / 11	+15.94%
Final Test	19.50 / 27	15.00 / 27	+30.00%
Average	**7.97**	**6.63**	**+20.24%**

Notes: Avg. = Average; Max. = Maximum.

Additionally, we found that one of the core strengths of microlearning lies in its capacity to foster the development of attentional control: helping learners to prioritise essential information, create meaningful connections between concepts, notice critical details, and form effective associations.

5. Discussion

The findings obtained in the course of work on both case studies highlight the encouraging potential of microlearning as an effective method to enhance students' ability to memorise and retain new material. It is important to underscore that the relevance of microlearning is determined by several interrelated factors.

Firstly, the process of learning a foreign language necessitates the continuous assimilation of substantial amounts of new information, thereby increasing the demand for instructional strategies that enhance memory and attention. Secondly, the digital environment in which contemporary learners operate is exerting an increasingly profound influence on cognitive processes, including memory retention and information processing. For instance, a study conducted by King's College London revealed that approximately half of the respondents reported diminished attention spans due to constant interaction with information flows across various media platforms (King's College London, 2022). Moreover, information is becoming progressively more chaotic, cross-disciplinary, and emergent in nature (Siemens, 2007: 53). An analysis of recent publications indexed in the Scopus database indicates a growing scholarly interest, beginning in the mid-2010s, in pedagogical approaches aimed at enhancing students' memory performance (Attygalle et al., 2025; Choo, Abdul Rahim, 2023; Grenfell, Harris, 2015; Hammrich, 2025; Iwata et al., 2025; Larchen Costuchen et al., 2021).

In line with these and other studies, our research further reinforces the necessity of paying particular attention to the cognitive mechanisms of memory and information engagement within foreign language instruction in the contemporary era. Thus, such instructional practices as microlearning have consistently been shown to facilitate the consolidation of new information in long-term memory and are poised to become an essential component of foreign language pedagogy.

With regard to the evolving nature of information interaction in modern educational settings, we concur with Siemens' assertion that classroom-centric learning models, coupled with instructional design models which function as if knowledge were an object, are becoming increasingly obsolete (Siemens, 2007: 53). Microlearning offers a means of engaging with information in a more flexible, diverse, interactive, open, and learner-centered manner.

In designing the instructional frameworks for the case studies, we reviewed existing literature on the ways in which contemporary microlearning strategies propose to navigate dense informational environments. These strategies are frequently associated with a broad spectrum of digital tools and platforms, including mobile applications, websites, blogs, video-sharing platforms , and micro-courses, among others (Al-Zahrani, 2024; ALshammari, 2024; Conde-Caballero et al., 2024; Gorham et al., 2023). It is evident that microlearning is extensively integrated with digital technologies and represents a significant trend in modern educational practice.

Despite the predominant association of microlearning with digital environments, both case studies presented in this research demonstrate that microlearning can function effectively as a stand-alone pedagogical strategy, even in the absence of extensive technological integration (Inker et al., 2021: 22). Our findings indicate that microlearning can be seamlessly embedded into the structure of foreign language instruction, becoming an integral part of classroom activities without relying heavily on digital tools. Various elements of instructional methodology can be adapted to a microlearning framework, provided that the neurodidactic foundation of the approach is preserved and that microlearning is not conflated with the mere reduction of instructional content.

Following the approaches of Ebbinghaus (1913), Wenger (1980), M. Seidl et al. (2007) and others, our case studies aimed to illustrate how microlearning fosters memorisation and retention of information as well as the creation and integration of meaningful connections between learning units, enabling students to combine discrete elements into coherent knowledge structures. By assigning focal value to specific learning units and deliberately guiding students' attention, we encouraged the development of accurate and durable associations between micro-units. This approach facilitates learners' ability to navigate information-dense environments and mitigates the risks of cognitive overload, which is particularly relevant in the contemporary educational context.

One notable challenge encountered during the study was the lack of standardised frameworks for implementing microlearning within foreign language instruction. While this absence of a unified model may be viewed as a limitation, as it requires greater effort in curriculum design, it simultaneously opens up opportunities for methodological creativity. This flexibility allowed us to design lesson plans grounded in both the theoretical principles of microlearning (Hug, 2007; Kapp, Defelice, 2019) and the practical insights of previous research (Alias, Abdul Razak, 2023; Balasundaram et al., 2024; Dixit et al., 2021 and etc.).

In each case study, we developed slightly different strategies for incorporating microlearning into foreign language lessons. Nevertheless, in order to ensure internal consistency and data validity, we operated within a shared conceptual framework. As Friesen asserts, "the actual or potential function and purpose of microlearning should be immediately recognisable" (2007, p. 93). Accordingly, we adopted the core microlearning principles of *spaced repetition, retrieval practice, minimisation, focus*, ensuring that each unit of content was both concise and targeted. Furthermore, in developing these focused micro-units, we paid particular attention to their relevance and meaningfulness for learners. As Scherer et al. note, "as long as the bits of content are considered meaningful, their size does not matter" (2007, p. 121).

Scherer et al. also emphasise that, in the context of microlearning, *as capacities are limited, priority should be given to the task of learning* (2007, p. 123). We extend this point by adding that it is essential to maintain a sufficient level of attentional activation; otherwise, focused content may be lost within the general informational background (Kostromina, 2019: 68). To prevent such outcomes, we selected microlearning content based on the principle of desirable difficulty, ensuring that it remained cognitively challenging without overwhelming learners. This approach helped maintain student engagement and sustained attention throughout the learning process.

Despite these promising results, several limitations should be acknowledged. One limitation of this experimental study lies in the relatively small sample size and the use of a non-probabilistic sampling method. Consequently, the findings cannot be considered representative of the entire population under investigation. Further studies with larger and more representative samples are recommended.

From an organisational perspective, another limitation was the unequal number of lessons across the experimental groups. This discrepancy resulted from the fact that the case studies were conducted in different universities and countries, each following its own academic curriculum.

From a methodological standpoint, one of the limitations was the use of oral assessment in the form of a teacher-student dialogue in Case Study 2. For the sake of research validity, this must be recognised as a potential limitation, as such a form of assessment may introduce subjectivity into the evaluation process. Teachers' judgments and interpretations of students' responses may vary, leading to inconsistencies in grading. Nevertheless, despite its subjective nature, this method remains a legitimate scientific approach known as *pedagogical observation*.

6. Conclusion

In summary, our case studies illustrate that microlearning possesses inherent pedagogical value and can be successfully integrated into foreign language education both with and without technological support. The neurodidactic underpinnings of microlearning further enhance its appeal, as they offer a means to mitigate the adverse cognitive effects of the digital information environment when applied judiciously. However, it is essential to acknowledge that microlearning is not a panacea. Its effectiveness relies on consistency, time investment, and the active involvement of learners, particularly in developing the metacognitive skills required for attention regulation and memory retention.

In foreign language education, effective approaches that enhance memorisation and retention are essential for improving learning outcomes across diverse contexts. This study extends existing research on microlearning by examining its application in two distinct settings – Russia and Turkey – with different lesson designs grounded in common neurodidactic principles. Our findings demonstrate that microlearning not only improves long-term retention but also supports learners' attentional control, a crucial factor for sustained language acquisition. Given the variability and lack of standardised microlearning methodologies, these results highlight the potential of flexible, principle-driven lesson designs tailored to specific learner populations. We encourage further experimental and classroom-based research to refine microlearning approaches and explore their pedagogical implications more broadly, especially in contexts where

traditional foreign language instruction struggles to engage learners effectively and promote durable learning.

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A Study of Digital Educational Resources in Higher Education using Vos Viewer and SWOT Analysis

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Abstract

With the rapid development of information technology, Digital Educational Resources (DER) have been widely used in higher education. This study takes SWOT analysis method as the core to explore the current practice of DER in higher education and its potential value. The study firstly sorted out the concept, characteristics and advantages of DER, and combined with relevant research results at home and abroad to clarify the theoretical basis and practical significance of the study. It also analyzes the keyword co-occurrence, clustering and time evolution of DER literature in the Web of Science (WOS) database in the past five years through VOS Viewer to reveal the research focus and development trend of digital resources in higher education. It is found that DER have a significant role in improving teaching quality and promoting educational equity, but they also face problems such as insufficient technical facilities, lack of teachers' skills and data security. Based on the results of SWOT analysis, this study puts forward a number of targeted recommendations, including strengthening the quality management of DER, improving the teacher training system, and optimizing the policy support environment. In addition, it also looks forward to the future development trend of DER, pointing out that it will play an important role in promoting the digital transformation of higher education. This study provides scientific decision-making references for university administrators, educators and relevant decision-makers, and helps to better utilize DER to realize the innovative development of higher education.

Keywords: digital educational resources, higher education, SWOT analysis, VOS viewer, teaching quality.

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1. Introduction

In recent years, global informatization has been advancing, digital technology continues to influence every corner of society, higher education shoulders the mission of cultivating talents, and traditional teaching methods are facing new challenges and opportunities (Xie, Zhang, 2024; Radmehr et al., 2024). DER are all kinds of teaching materials developed with modern information technology, presenting diverse content-rich, text, pictures, audio, video and other forms, the core of which lies in the sharing of high-quality educational resources by digital means (Akhmetshin et al., 2019).

As a product of the deep integration of information technology and education, the characteristics of DER have profoundly changed the traditional teaching mode. First of all, DER are interactive and dynamic. With the help of real-time discussion forums, collaboration tools and intelligent assessment systems, teachers and students can break through the time and space limitations to communicate instantly, while the addition of multimedia elements such as video and virtual reality makes abstract knowledge tangible and enhances students' immersion in learning (Siemens, 2013). Second, openness and sharing is one of the core advantages of DER. Through the Internet platform, high-quality courses and open-source teaching materials can be disseminated globally, effectively narrowing the education gap between regions. At the same time, the diversity of digital resources has also been fully realized, from e-books, microclasses to virtual experiments, rich forms to meet the needs of different learning scenarios. At the technical support level, digital education resources have demonstrated strong updatability and data-driven capability.

Digital education resources have made remarkable progress, but their high dependence on network infrastructure and digital devices may aggravate the “digital divide”. The imbalance of regional economic development is a serious challenge, and there are obvious gaps in the distribution of digital resources between urban and rural areas and between schools, and some teachers do not receive adequate technical support and professional guidance, and they face difficulties in using digital resources (Heine et al., 2023; Wang et al., 2023). Moreover, the issues of copyright protection and data privacy still need to be tackled by both technical means and policy norms (García et al., 2023; Cao et al., 2024; Zhao et al., 2024). Therefore, how to leverage the advantages of DER while avoiding their potential risks is an issue that needs to be continuously explored in the future digitization process of education.

This study systematically analyzes the application and potential value of digital resources in higher education using bibliometrics, SWOT analysis and the visualization tool VOS Viewer to reveal the research focus and development trend of digital resources in higher education. This study aims to (1) reveal the research focus and development trend of digital resources in higher education; (2) analyze in detail the advantages, disadvantages, opportunities and threats of the application of DER in higher education; (3) put forward targeted suggestions based on the results of the SWOT analysis.

This study discusses in depth the current status of the practice of DER in higher education and its potential value, enriches the theoretical system of DER in higher education, and also provides a solid theoretical foundation for subsequent research. Meanwhile, based on the results of SWOT analysis, practical suggestions are put forward, including strengthening the quality management of DER, improving the teacher training system, and optimizing the policy support environment. These suggestions provide scientific decision-making references for university administrators, educators and relevant decision-makers, and help to better utilize DER to realize the innovative development of higher education, which has important theoretical value and practical significance.

2. Literature review

The emergence and development of digital resources has changed the traditional teaching methods and become an integral part of higher education. With the advancement of technology, digital resources play a key role in innovating pedagogy, facilitating resource sharing and addressing sustainable development.

As the global level of technology continues to advance, digital resources are increasingly being used in modern education, especially in higher education. Since the outbreak of the Covid-19 pandemic, there has been a massive increase in research on online education, and digital resources have become an essential teaching tool for teachers (Tang, 2021). Some researchers have categorized digital educational resources to include online services, mobile applications, digital environments and interactive tools (Akhmetshin et al., 2019).

Digital technology has an important role in facilitating the sharing of resources in higher education (Xie, Zhang, 2024). Co-created digital resources in nursing education increase student engagement and knowledge retention by meeting specific pedagogical requirements (Laugaland et al., 2023). Similarly, digital collaborative writing platforms play an important role in facilitating active learning for multilingual students (Pennington et al., 2024). When using digital devices in the classroom, problems with asymmetric access can be effectively addressed through multimodal digital resources when they occur (Vänttinen, 2024).

3. Materials and methods

This study uses the visualization tool VOS Viewer to retrieve and analyze the relevant literature on digital educational resources and higher education in the past five years, and combines the SWOT analysis method to systematically analyze the application and potential value of digital resources in higher education, and to reveal the research focus and development trend of digital resources in higher education.

3.1. VOS viewer

This study searched the Web of Science core dataset for the last 5 years. The search terms are “digital educational resources” and “higher education”. Literature that meets the requirements is imported into VOS viewer software, and the year of publication, country and keywords are statistically analyzed, so as to analyze the research status and hotspots through visualization. After the literature was imported into VOS viewer software, the keyword threshold was set to 50 times, and the keywords that met the requirements were clustered and analyzed to generate a visual keyword co-occurrence network map to analyze the current research hotspots, trends and directions.

3.2. SWOT Analysis

SWOT analysis is a systematic strategic analysis tool that is commonly used by businesses, governments, non-profit organizations, and the education sector. This method helps to assess the strengths, weaknesses, external opportunities, and threats of an organization or project, and SWOT analysis is a systematic assessment framework that assists decision makers in planning reasonable and feasible strategic programs by integrating internal and external environmental factors. The theoretical basis of this approach comes from systems theory and management science, and its key element is the integration of qualitative and quantitative analysis, which provides a comprehensive understanding of the internal and external environments in which the organization operates, and based on this information, improvement plans can be developed.

In the field of higher education, SWOT analysis is more popular, it is applicable and flexible. SWOT analysis identifies the core issues and it lays the basis for improvement measures. As institutions of higher education embark on a new era of growth, so do possible threats to data security and intellectual property protection. SWOT analysis requires the intersection of four dimensions to form a complete strategy matrix. This matrix analysis methodology visualizes complex relationships, and it allows decision makers to analyze problems from multiple perspectives, avoiding the limitations of a single viewpoint.

Over time, the internal and external environments of an organization or project usually change, so the analysis needs to be updated regularly. In this study, we have compiled and analyzed the cutting-edge articles on the research on the application of DER in higher education from WOS in the past five years, and evaluated them from multiple perspectives by using SWOT analysis, so that the digital educational resources can better serve the innovation and development in the field of higher education.

4. Results

To further grasp the application of digital educational resources in higher education, this study uses VOS viewer and SWOT analysis. The results are as follows.

4.1. VOS viewer Result Analysis

Searching the Web of Science core dataset about digital resources and higher education published in the last five years, excluding duplicates and unqualified literature, and finally including 4388 documents in the analysis.

4.1.1. Trend and Annual Distribution of Published Literature

Figure 1 is the annual distribution chart of the number of publications published in the Web of Science core dataset about digital resources and higher education in the past five years, showing an increasing trend year by year.

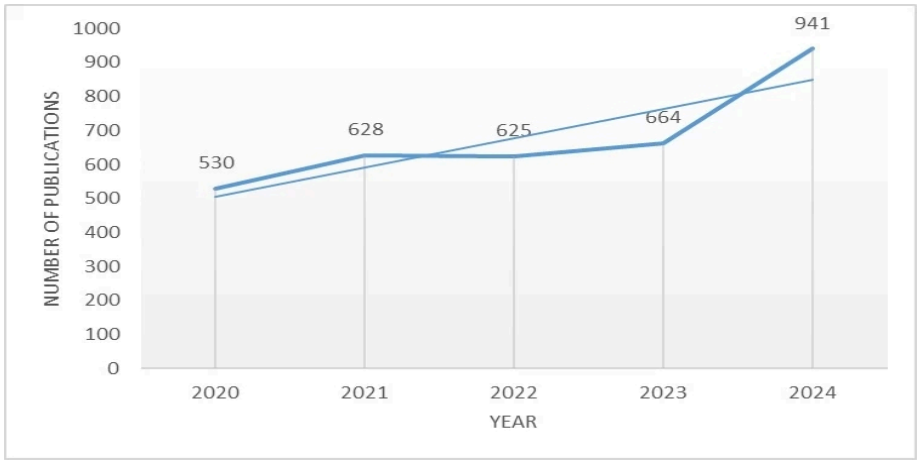

Fig. 1. Yearly distribution of literature on digital resources and higher education in the Web of Science core dataset (2020–2024)

4.1.2. Issuing Countries

As can be seen from Figures 2 and 3, the distribution of research on digital educational resources in the field of global higher education is characterized by significant geographical concentration. The United States, China, the United Kingdom and Spain are the countries that have published the most relevant literature, showing strong research capacity and discourse power in the field. Among them, the United States presents the strongest heat, highlighting its role as a major technology exporter and a pioneering country in education informatization. China follows closely behind, reflecting its comprehensive investment in policy promotion, platform construction and academic research in recent years. China and Russia are closely connected in the international cooperation network, especially China has formed denser cooperation clusters with India, Australia and other countries, reflecting its strategic expansion in the global layout of education digitization.

Meanwhile, Figure 4 shows that the research activities of China, India, Saudi Arabia and other countries will become more active after 2022, indicating the rapid growth of digital education resources construction in emerging countries in the “post epidemic era”, which indicates that Asian countries are still in the active development stage in this field. In contrast, research in Latin American and Southern European countries, such as Spain, Portugal and Brazil, has started relatively early, but the enthusiasm has declined, indicating that their research may have entered the stage of reflection and reconstruction. On the whole, the current research presents a pattern of “multi-center, multi-dimension and multi-country synergy”, which provides an international perspective and a comparative basis for the optimization of the practice of DER in higher education.

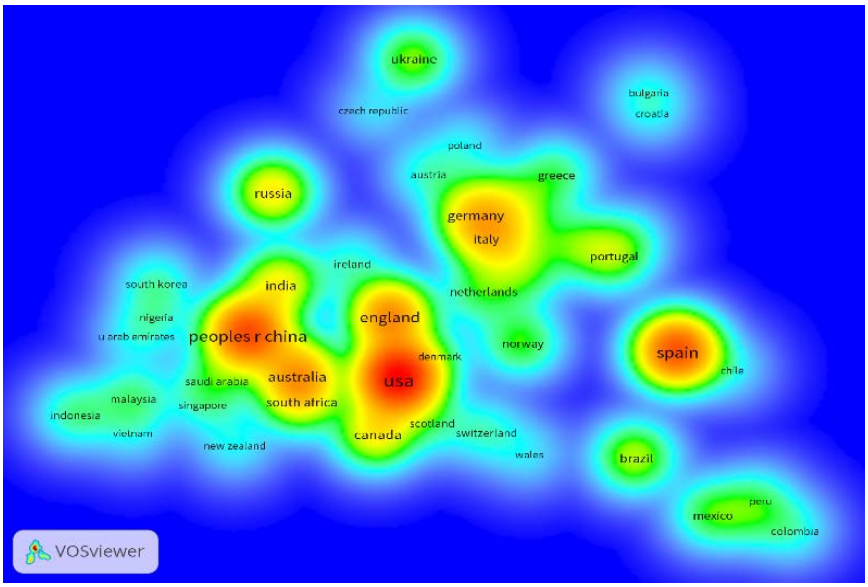

Fig. 2. Density Visualization of Issuing Countries

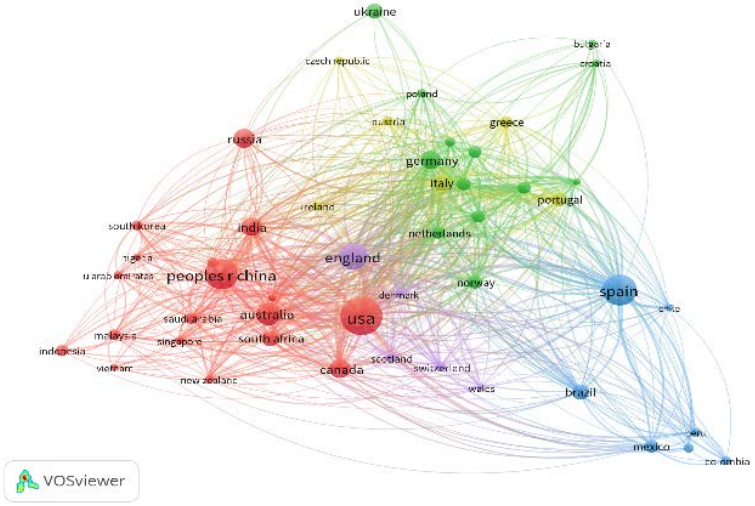

Fig. 3. Network Visualization of Issuing Countries

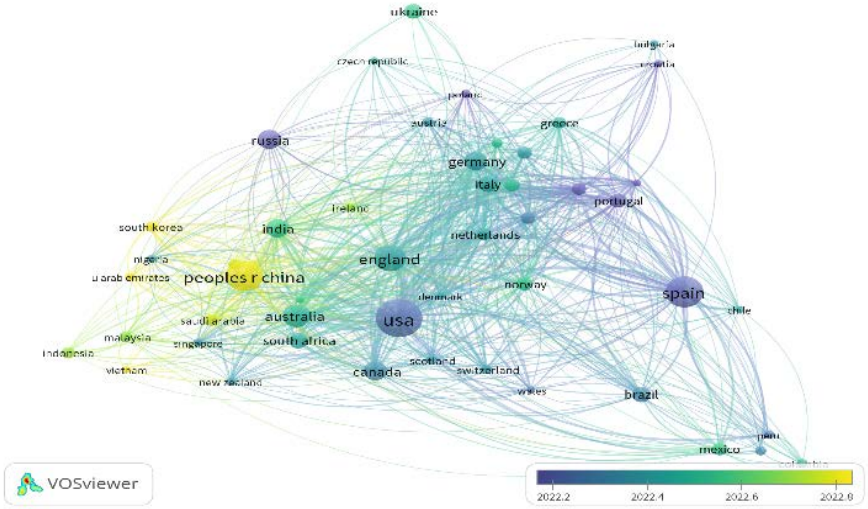

Fig. 4. Overlay Visualization of Issuing Countries

4.1.3. Keywords

In recent years, with the development of information technology and the influence of COVID-19 pandemic, the application of DER in higher education has gradually become an important direction of educational technology research. The visualization results show that “education”, “technology”, “students” and “higher education” are at the center of the research network, indicating that the academic community is particularly interested in the integration of digital technologies in education.

According to Figure 5, the research in the early 2022 is mainly focused on “online learning”, “covid-19” and “digital education” in the context of the epidemic. While over time, research will gradually shift to “artificial intelligence”, “digital literacy” and other topics. This suggests that, after the experience of emergency distance learning, educational research has entered a new phase oriented towards the long-term integration of digital resources and technologies.

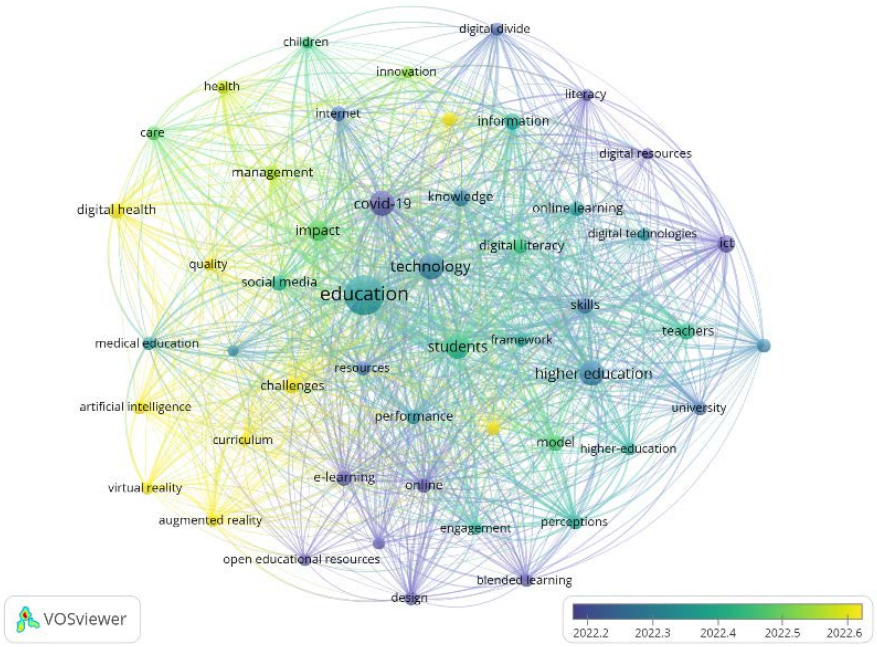

Fig. 5. Overlay Visualization of Keywords

Figure 6 reveals four major themes in digital education research: first, the red clusters are represented by “digital health”, “social media”, and “covid-19”, focus on social influences and educational environments; second, the green clusters are represented by “students”, “performance”, and “education environment”, focusing on the learning process and student behavior.; third, the blue cluster covers “ICT”, “teachers”, and “digital technologies”, pointing to the problem of adapting technology to teachers; fourth, the yellow cluster highlights “artificial intelligence”, “augmented reality”, representing new teaching tools and the expansion of specialized fields in higher education.

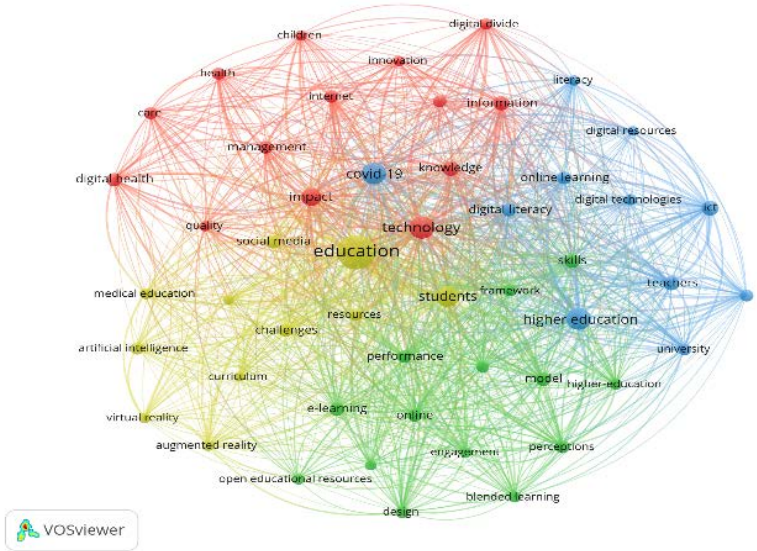

Fig. 6. Network Visualization of Keywords

The density map in Figure 7 further identifies the hot areas of research, i.e., the four core terms of “education”, “technology”, “students”, and “higher education” have the highest frequency of occurrence in the research, which is the central theme of the research on the application of digital education resources. Meanwhile, keywords such as “e-learning”, “digital literacy” and “management” also show a high density of occurrence, indicating that learner engagement, digital literacy, and digital education are the most important issues in the study, which indicate that

learner engagement and digital skill development have become hot research topics.

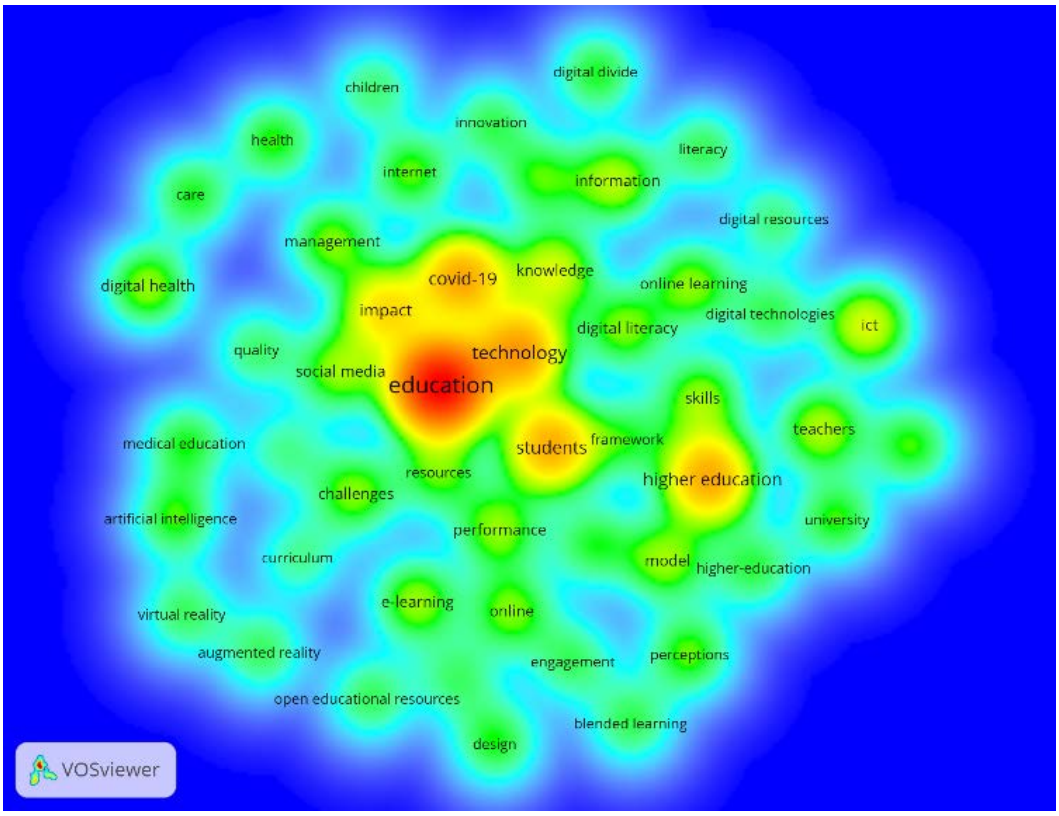

Fig. 7. Density Visualization of Keywords

In summary, the research on DER in higher education has formed a development pattern of interdisciplinary and cross-technology integration, with hotspots focusing on the online learning experience, educational technology innovation, and the improvement of teaching participation and assessment mechanisms.

3.1.4. Application of digital educational resources in higher education

With the rapid development of big data, artificial intelligence and other information technologies, DER are promoting the reform of higher education. In the higher education system, DER are not only limited to static resources such as electronic textbooks, multimedia courseware and online courses, but also include interactive simulation experiments, virtual laboratories, Open Educational Resources (OERs), and Massively Open Online Courses (MOOCs), which are dynamic and dynamic. These resources have enriched the content and form of teaching, and also made students' learning more diversified.

Digital educational resources are quite valuable in that they enhance teaching efficiency and the learning experience, and student engagement increases significantly (Pennington et al., 2024). Teachers use data analytics to keep track of students' progress and difficulties, and to better assist students with personalized instruction. DER have significant potential for innovation by expanding new ways of teaching and learning in higher education. DER are particularly suitable for highly practical disciplines such as medicine and engineering (Frøiland et al., 2023).

DER enable universities to respond more readily to the challenges of globalization, which has caused pressure of international competition for higher education, but also brought more opportunities for collaboration and exchange, and cross-regional platforms for sharing DER to promote international academic exchanges and cooperation.

DER have multiple application values in higher education. DER can improve teaching quality and learning effects, it promotes the fair distribution of educational resources, it promotes educational innovation, and it helps universities to maintain competitiveness in the wave of globalization, and it is of great significance to promote the sustainable development of higher education by deeply exploring the application value of DER (Rodríguez, Pulido-Montes, 2022).

4.2. SWOT Analysis

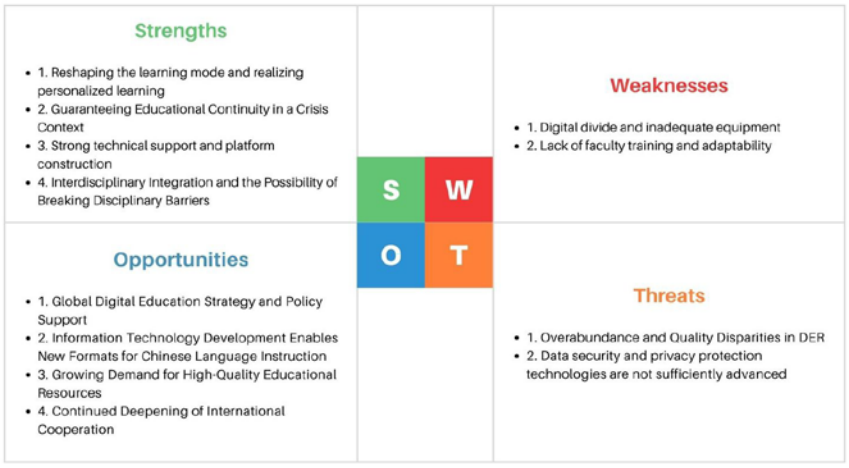

Fig. 8. The SWOT matrix

4.2.1. Advantages

(1) Reshaping the learning mode and realizing personalized learning

The most prominent advantage of DER lies in the profound reshaping of learning mode. It breaks through the limitations of traditional teaching in time and space, and provides learners with flexible and independent learning paths. In higher education, students often face problems such as heavy coursework and conflicting courses, while DER can provide learning resources accessible anytime and anywhere, so that students can arrange their learning progress according to their own pace and level of understanding, thus realizing personalized learning in the true sense of the word (Cook et al., 2024).

(2) Guaranteeing Educational Continuity in a Crisis Context

During the COVID-19 pandemic, the global higher education system was challenged like never before. In this context, DER demonstrated their critical role in crisis response (Rodríguez, Pulido-Montes, 2022; Mogas et al., 2023). In the case of school closure and suspension caused by the epidemic, DER ensured the continuity of teaching activities, and guaranteed the students' learning progress and the successful completion of teaching tasks. DER is not only a driving force for educational innovation, but also a core mechanism for coping with emergencies and guaranteeing the continuity of teaching and learning.

(3) Strong technical support and platform construction

The rapid development of information technology provides a technical foundation for the wide application of DER in higher education. From platform construction to content generation to user services, every aspect of DER is highly dependent on advanced information technology support. Cloud computing technology provides the DER platform with powerful elastic scalability and efficient storage space, so that teaching resources can be allocated on demand and run stably.

(4) Interdisciplinary Integration and the Possibility of Breaking Disciplinary Barriers

DER have the unique advantage of interdisciplinary integration. Traditional teaching is often restricted by the structure of the curriculum and the division of disciplines, and the integration and migration of knowledge is weak. The DER platform can integrate content from different fields to build a more open and three-dimensional knowledge system. Interdisciplinary collaboration and co-creation of digital resources can increase the relevance and effectiveness of digital resources (Laugaland et al., 2023; Barnes, Tour, 2023; Braßler, 2024). This type of pedagogical model not only broadens students' knowledge horizons, but also develops the cross-border thinking skills they will need to solve complex problems in their future work.

4.2.2. Disadvantages

(1) Digital divide and inadequate equipment.

Digital educational resources are widely used in higher education and it provides significant advantages and innovations. However, the challenges of digital divide and inadequate equipment still exist (Seleznev et al., 2022). The digital divide is reflected in the imbalance in the distribution of educational resources between urban and rural areas, as well as differences in IT penetration

rates. Students in rural areas often do not have stable internet access, while students in cities have easy access to online resources on the internet. The digital divide is equally significant in terms of hardware facilities, with problems such as interruptions and delays frequently occurring. Faculty and students' efficiency in using digital resources is compromised, and the use of infrastructure in some colleges and universities remains limited (Alenezi, 2023).

(2) Lack of faculty training and adaptability

The increasing popularity of DER has made the need for teacher training in the field of higher education more and more obvious, and some university teachers believe that they have encountered difficulties in the use of DER, especially in the production of multimedia courseware, the operation of online teaching platforms and data analysis. Therefore, HEIs need to take more specific measures to improve the effectiveness of teacher training (Seleznev et al., 2022). A flipped classroom training model can be implemented to integrate theoretical learning and practical operation. Or the practical skills of teachers can be enhanced through case studies and group discussions. At the same time, it is necessary to create a continuous tracking and coaching system, and organize regular experience sharing sessions, etc. Teacher training is not only limited to the scope of the technical level, the conceptual change is equally important.

4.2.3. Opportunities

The continued development of DER has been facilitated by a concerted global strategy to digitize higher education. Contingency programs during educational disruptions have contributed significantly to the development of flexible learning models and digital curriculum systems, and have provided an empirical basis for the diversification of future teaching and learning approaches (Mogas et al., 2023). The rapid development of information technology has led to the key position of DER in higher education, and the global demand for high-quality educational resources is growing rapidly, especially at the higher education level. Schools in remote and underdeveloped areas usually have difficulty in obtaining sufficient quality teaching materials and faculty, and the distribution of educational resources fails to be balanced. However, DER have the characteristics of convenience and flexibility, which can exactly improve this problem (Puiu et al., 2023).

4.2.4. Threats

At present, the most prominent threat facing the application of DER is the proliferation of resources and uneven quality. On the one hand, there is a lack of uniform standards for resource development and excessive differences between different platforms and courses; on the other hand, over-reliance on technology may make the teaching process lose its humanity and interactivity. In addition, data privacy and security issues are becoming increasingly serious. While heavily using platforms, applications and cloud services, colleges and universities are facing the potential risks of cyber-attacks and data leakage (Veletsianos, 2021).

Overall, the cyber environment is becoming more and more complex, and technological tools for data security and privacy protection need to be upgraded. Responding to these issues requires multi-sectoral collaboration in technology, management and law, data encryption can be used to enhance transmission security, data sharing protocols need to be optimized, the responsibilities of all parties need to be clarified, and strict privacy protection policies need to be formulated.

5. Discussion

Digital Educational Resources have become an important force in transforming the teaching and learning model of higher education, and their application has significant advantages in terms of flexibility, scalability, and policy promotion. However, its development still faces multiple challenges such as infrastructure, teacher training and data governance. Therefore, strengthening the integration of resources, improving the teacher training system, and establishing a diversified evaluation and guarantee mechanism are conducive to promoting the simultaneous improvement of educational equity and teaching quality.

(1) Strengthening Resource Integration and Optimizing Allocation

The rapid development of DER and the improvement of quality and efficiency have become important issues in higher education (Rodríguez, Pulido-Monte, 2022). Nowadays, the distribution of digital education resources in higher education is not very balanced, and the gap of resources between different schools in different regions is significant. Colleges and universities should build a unified DER sharing platform, which should integrate all kinds of high-quality educational resources, such as catechism, microclasses, virtual laboratories, etc., and realize efficient storage and rapid retrieval of resources with the help of cloud computing and big data technology (Puiu et al., 2023).

(2) Establishing a multi-level teacher training mechanism

Teachers are the core role of teaching and learning activities, and the level of teachers' informatization literacy and skills significantly affects the application effect of DER. Establishing a diversified teacher training mechanism has become the key to promoting the digital transformation of higher education (Puiu et al., 2023). Teachers in higher education have different levels and types, which require the development of differentiated training programs.

(3) Constructing a high-quality online course system

With the development of DER, building a high-quality online course system becomes the key to improve the quality of higher education teaching (Gumbi et al., 2024). High-quality course content needs to be scientific, systematic and innovative at the same time. The course content should be combined with the latest scientific research results and industry trends to maintain the cutting edge, and when designing the course content, pay attention to the hierarchy and progressivity, from basic knowledge to advanced applications, and gradually guide students to in-depth learning, so as to meet the needs of students at different stages of learning.

(4) Innovative Teaching Modes and Evaluation Methods

DER are commonly used in higher education, and innovative teaching models and evaluation methods have become the core of promoting the digital transformation of higher education (Seleznev et al., 2022). DER promote the change of teaching mode, and blended teaching is beginning to be popularized. This mode integrates online learning and offline classroom, making full use of the richness and flexibility of online resources, and enhancing the learning effect (Puiu et al., 2023).

In terms of evaluation methods, colleges and universities have begun to use more formative assessment and personalized assessment, which can more comprehensively assess students' comprehensive abilities. Formative assessment focuses on continuous observation during the learning process, and personalized assessment develops standards for each student that suit them and discovers each individual's potential more comprehensively.

(5) Optimizing the policy support environment

To improve teaching standards and learning efficiency, in addition to the practical actions that colleges and universities need to take to continue to deepen the reform of internal mechanisms, the government also needs to implement supportive policies (Rodríguez, Pulido-Montes, 2022). With the joint efforts of the whole society, the goal of digital transformation of higher education can be realized.

With the rapid development of information technology and the continuous updating of educational concepts, the strategic position of DER in higher education has become increasingly prominent. The field of higher education is undergoing an unprecedented technological change, and DER are an important part of this change, which has changed the traditional teaching methods and made education fairer and of higher quality.

Colleges and universities not only continue to introduce emerging technologies to optimize teaching tools and means, but also actively build interdisciplinary and cross-platform collaborative innovation mechanisms to promote the deep integration of teaching methods, curriculum design and resource allocation. This integrated development model helps to break the boundaries of traditional teaching and promote the evolution of the educational ecosystem in the direction of more intelligent, open and shared.

6. Conclusion

The sustainability of DER is a key issue. Although significant progress has been made in this area, challenges such as insufficient technical facilities and data privacy protection still exist, requiring the government, universities and the community to work together to make the application of DER in higher education evolve in a better direction.

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Learn with People You Can Learn From: Trust, Need for Achievement, and Sharing of Information and Knowledge among Remote Learning Students

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Abstract

In remote learning, students make use of social media and advanced technologies that help with learning, interactions among students, sharing of information, and replication of the face-to-face learning experience as much as possible. How each student experiences remote learning depends on different characteristics that affect different areas of learning. The present study explored how trust and need for achievement might explain information and knowledge sharing among students in remote learning. Three questionnaires were used – addressing trust, need for achievement, and information sharing – to examine levels of these characteristics among students. In addition, students were asked sociodemographic questions. Participants were 444 undergraduate students studying at various academic institutions who answered online questionnaires using a Google Docs file sent to their mobile phone. The findings show positive relationships between trust and sharing knowledge with others and between trust and receiving knowledge from others. In addition, a positive relationship was found between students' level of achievement and sharing knowledge and information with others, but no relationship was found between level of achievement and receiving knowledge and information from others. Hence, the research findings emphasize the importance of building trust in remote learning and its benefits regarding sharing information in remote learning.

Keywords: remote learning, trust, achievement, information and knowledge sharing, students.

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1. Introduction

Starting in 2018, the Higher Education Council (HEC) has promoted digital learning in higher education institutions in Israel, to the extent that 30 % of the courses in each department use this modality. The assumption underlying this decision is that digital teaching can improve the quality of teaching and learning, enhancing the learning experience and pedagogical abilities of the lecturer. The term "digital learning" refers to a learning process in which the construction of knowledge and skills takes place via teaching methods in online spaces using the medium of the internet and digital communication to make higher education accessible and improve and enhance the learning experience (HEC, 2018). The Covid-19 pandemic, which led to a complete lockdown in the state of Israel, accelerated the processes of digital learning, with studies at the academy suddenly transferred to remote (digital) learning. As a result, students were required to adopt remote learning skills, which led to a change in the frequency of information sharing and how students transferred and exchanged information. Sharing knowledge and information among students is related to many characteristics that can directly or indirectly explain the willingness, manner, and level of sharing (Raza et al., 2018).

Online learning has developed in the current era at the same time as technological developments and opened a window to a new type of learning that can replace or complement traditional learning styles. Today, all students and lecturers use these technologies to transmit and share messages, study information, create social relationships, complete assignments and tests, and more. In addition, phrases such as: "Meet on Zoom," "I have a Zoom meeting with the lecturer tomorrow," and "Send me the material on WhatsApp" have become common among students. Along with the technological progress in online learning, students face various problems, difficulties, and barriers that need to be considered, such as technological difficulties, high levels of anxiety, distractions as a result of remote learning, lack of interaction, lack of motivation, and more (Gillis, Krull, 2020). Difficulties of this kind may affect, among other things, how students study, their achievements, and their sharing of knowledge and information.

The theoretical lens on which the present study rests is Nonka and Takeuchi's (1995; 2021) knowledge creation theory for the context of distance learning during the COVID-19 pandemic. Specifically, the present study seeks to examine how the conversion processes between tacit and explicit knowledge sharing are explained in online learning environments where trust and errors play a significant role.

In other words, this study can be positioned as a contributor to an empirical understanding of the roles that trust and achievement motivation play in facilitating or inhibiting knowledge sharing behaviors among students in distance learning contexts. By bridging theories of interpersonal trust, achievement motivation, and bond strength, the study aims to shed light on the factors that enable effective knowledge conversion and transfer when traditional classroom social dynamics are disrupted.

Analyzing these relationships through the lens of Nonaka and Takauchi's (1995; 2021) knowledge creation processes can provide useful insights into the tensions surrounding knowledge socialization and externalization in distributed online learning communities. Positioning it as an empirical extension of this theory to newly emerging remote contexts can be a way to expand the meaning of the study.

Theoretical Background

Remote Learning

With the development of technology in general and the internet, remote learning has become defined as learning through online activity where students have no time and place limitations (Martinez, 2014). In recent years, the development of online technological environments for teaching and learning has accelerated (Hosen et al., 2021; Patel et al., 2013), using different remote learning means that require interpersonal and collaborative communication. Many students use social networks to share information and complete academic tasks. These social networks provide a quick way to communicate among students, and it seems that they have become their preferred way of sharing. Three main types of online learning, also known as remote learning, can be defined: synchronous, asynchronous, and integrated learning.

Synchronous learning is defined as the interaction of participants with an instructor via the internet in real time (Shahabadi, Uplane, 2015). In this environment, there are no physical meetings and tools such as discussions, instant messages, blogs, and more are used. These tools play an important role in personalizing online courses by replicating the classroom experience,

information exchange, and social structure. Synchronized online learning is live, in real time, and usually scheduled. The roots of synchronous online learning are derived from three main influences: the classroom, media, and plenary (participants; Tulaskar, Turunen, 2022). Online learning is not limited in place but only time and is done through classes held in real time through online technology platforms. Moreover, the student does not have the flexibility to decide when to study and must be present at the scheduled class times to complete the learning. Synchronous learning has great advantages related to interacting with other students and the lecturer and asking and responding to questions in real time.

Asynchronous learning, or learning "out of time," requires no commitment for the learners regarding time and place. Students can complete the course requirements without showing up at an educational institution or meeting their classmates and lecturers. The students complete assignments independently by using the educational institution's online learning system, which includes study materials, presentations, videos, and texts. Their schedule is flexible, and learning is based on computer and internet access. The advantages of this study method, among others, are time flexibility, the ability to work at the same time as studying, and the ability to live far from the place of study (Martinez, 2014). The notable disadvantage of this method is that it requires self-discipline, time management, and personal goal setting by the student.

Blended learning is a combination of synchronous and asynchronous teaching and learning components. Usually, most of the learning is asynchronous. Integrated learning environments contribute to higher interactions between students and combine benefits from both types of learning (synchronous and asynchronous; Baber, 2020; Martinez, 2014).

Remote learning has many advantages but also disadvantages. First, a disadvantage relates to interpersonal interaction. Remote learning may lead to social exclusion and perceived damage to traditional classroom teaching methods. Second, online learning can sometimes lead to burnout, lack of interest, and lack of motivation, which are main factors that hinder online learning and cause students to drop out of online courses (Baber, 2020). Third, Gillis and Krull (2020) found that most students who experienced online learning experienced common difficulties and barriers in their online studies, such as technological difficulties, high levels of anxiety, distractions, lack of motivation, and more. These barriers were found mainly, but not only, among students who were non-White, women, or first-generation students.

In the massive and rapid transition to online learning that took place worldwide during the Covid-19 pandemic, most students had to change from traditional face-to-face learning (on campuses) to remote learning (synchronous, asynchronous, or integrated) while using online technology systems. One of the most common and available learning platforms is the Zoom application. This platform is used in virtual conferences, lectures, and online meetings; provides audio, video, and document sharing; and creates an interactive environment, using tools such as small groups and surveys for student feedback recording meetings for future review, etc.

Despite the massive use of Zoom as the most common online learning platform, the means of online learning are diverse and have existed for many years among higher education institutions. Many studies (e.g., Baber, 2020; Maul et al., 2018; Serhan, 2020) examined the issue of online learning and related consequences compared to traditional learning, with the main concern being that remote teaching and learning is not equal in quality to face-to-face learning. Indeed, the results of the studies indicated a lower-quality learning experience. For example, in a study that examined the attitudes and perceptions of students regarding their learning and involvement through online learning via Zoom compared to face-to-face learning, not all students were satisfied with their learning experience during the current transition period and felt that educational institutions must improve and optimize learning practices based on the students' learning needs (Serhan, 2020). In contrast, Maul and colleagues (2018) examined the perceived value of using Zoom among students in doctoral programs and found that both the teaching staff and students indicated that Zoom allowed them to build a quality relationship and increase work efficiency. In addition, a recent study examined the learning outcomes and satisfaction of students from South Korea and India with reference to interaction, motivation, course structure, and how lecturers instruct and guide students, comparing online and traditional learning (Baber, 2020). The study did not find a significant difference in the learning outcomes between online and traditional learning but determined that interactions in online learning and the motivation of the learner are of great importance to students' perceived learning and satisfaction. The study also found that the guidance and knowledge of the lecturers and the structure of the course are important factors

related to the learning results and satisfaction of students. Indeed, lecturers faced a challenging reality that required them to provide students with expertise and technical skills while building a course structure that addressed obstacles in the rapid transition to online learning.

Information and Knowledge Sharing among Remote Learning Students

Information sharing is defined as an idea or process of mutual information sharing leading to the creation of a mix of experiences, values, contextual information, and insights (Raza et al., 2018). When students engage in information and knowledge sharing (IKS), communication channels are created that allow them to share and research, clarify things, and learn together with other students by exchanging information (Raza et al., 2018) – helping with learning and understanding the material and strengthening the relationships among participants. At the same time, information sharing depends on the individual's willingness to share or combine their ideas with others (Farahian et al., 2022; Raza et al., 2018). For example, a study on IKS found that most respondents agreed that sharing knowledge among students would benefit everyone. At least a third of the respondents agreed that information and knowledge should be shared only when approached by other students. Another third disagreed with this position. Nearly half of the respondents said that knowledge sharing should be done voluntarily and that students expect their friends to share important knowledge and information. In a study among students, final situational perceptions such as competitiveness, time pressure, and self-efficacy affected students' IKS behaviors. It also found that students who were under time pressure and feel "too busy" were less likely to share information and knowledge and that high self-efficacy was related to lower perceptions of time pressure and therefore, to sharing more information and knowledge (Connelly et al., 2014).

Social media is a technology that allows users to create and share information, ideas, and thoughts with other people through virtual networks (Baishya, Maheshwari, 2020). As far as the exchange of knowledge and information is concerned, it is possible to distinguish between information sharing carried out remotely versus face-to-face (at work, in studies, in meetings, and more). The means of sharing and transferring knowledge and information remotely include, among others, phone calls, emails, instant messaging apps, Facebook, Instagram, Telegram, Zoom, and a host of advanced social media software and apps that make use of new technologies via a computer, laptop, phone, mobile device, and more. During the coronavirus crisis, when all students switched to online learning, their sharing of information became based mainly on remote information sharing, and one of the main means of remote information sharing is the WhatsApp application.

WhatsApp is an independent application with a focus on building a fast and real-time messaging service around the world. Official data show that the number of WhatsApp users exceeds 2 billion people in more than 180 countries and 60 languages (https://www.whatsapp.com). The application is used to keep in touch with friends and family anytime and anywhere, is provided for free, and offers a simple, safe, and reliable service for transferring information and sending media items such as text, photos, videos, documents, location, and voice and video calls. In a study of student WhatsApp groups (Baishya, Maheshwari, 2020), the researchers found that in addition to academic uses such as sharing information related to classes, study materials, and exams, students use the application for greetings, and entertainment purposes and noted the importance of participating in these groups for social engagement. They also found that when lecturers or teachers are also present in WhatsApp student groups, there is a significant effect on the nature of the group conversation, making them much more formal and limited but with the advantages of direct assistance. Despite this, most students prefer their lecturer not be part of the group. In addition, the study examined why most WhatsApp student groups have some very active students and others who are not as active, finding that students who have information about and are active in classes are most active in the group and share information with the other students. The students' degree of sociability also affects their level of activity in the group. A student who connects easily with everyone tends to be more active in the group, whereas introverted students are less likely respond in the group unless someone mentions their name or addresses them. In fact, the virtual environment is used as a social environment, providing a substitute for interaction and social connection among students. It is possible to develop social and academic relationships that can influence IKS among students.

Nonaka and Takeuchi (2021), in the midst of the Covid-19 pandemic, reexamined their famous theoretical model from 1995, the knowledge-based theory model. The model describes the interactive spiral process of creating new knowledge by converting tacit knowledge into explicit and

vice versa. In their research, they adapted this model to today's new reality known as VUCA (volatile, uncertain, complex, and ambiguous). According to them, the emergence of the internet brought automation that makes data, information, and knowledge (especially explicit knowledge) abundant, open, unlimited, personalized, and shareable. They added to their famous model the concept of practical wisdom, which serves as a driving and directing force of society. Moreover, according to them, in the VUCA world, we need to rely on two areas: the creation of knowledge and strategy, or thinking about the future we want to create.

Importance of Trust among Students in Online Learning

One important characteristic that can explain the correctness of knowledge and information sharing in online learning and society in general is trust, which is defined as a sort of social contract between the giver and receiver (Kravitz, 2011). In general, there are three main types of trust: trust in strangers, people we know, and specific groups of people (Kravitz, 2011). According to Mayer and colleagues (1995), interpersonal trust in others' abilities, benevolence, and integrity increases the desire to give and receive information, resulting in improved performance of distributed groups, which creates and maintains an exchange relationship (p. 228). Another definition of trust refers to trust as a feeling of self-confidence and refuge that creates a caring response among partners and tightens their relationship (Raza et al., 2018).

Moghavvemi et al. (2018) explored the effect of trust and perceived mutual benefit on students' IKS through Facebook and found that trust and mutual benefit are perceived as predictors of information sharing among students. The researchers found that students who know each other and are involved in joint courses will share information and knowledge with each other easily. Also, online communities create an environment that encourages interactions and feelings of belonging and trust; thus, students trust their close friends and feel comfortable asking and answering questions and sharing new information related to the course. The study also showed that when the students know that IKS between them will result in mutual benefit, they are more willing to share knowledge and that a sense of belonging and reduced uncertainty among students will lead to the development of reciprocity and trust. Raza et al. (2018), who studied factors affecting information sharing among students, found that close relationships, trust, and subjective norms mainly affect information sharing, whereas motivation and rewards were found to be related to information sharing to the lowest extent among all factors. Other studies dealing with building trust in online learning environments found that trust is a prerequisite for revealing sensitive information by students, not only in face-to-face situations but also in online environments (Wang, 2014). In addition, trust-building strategies are related to effectiveness and improving student achievement in the online learning environment (Nam, 2014). Researchers also found that the use of video calls in synchronous online studies helps build trust and connection (Castelli, Sarvary, 2021).

In the virtual environment, unlike the traditional (face-to-face) environment, there are difficulties in building trust and sharing information. Alsharo and colleagues (2017) examined the role of information sharing and trust in the effectiveness of virtual teams compared to traditional teams. According to them, IKS affects cooperation, and cooperation affects team effectiveness. Because the assumption is that an effective team integrates and distributes knowledge, the sharing of knowledge depends on the willingness of team members to share; an effective team requires its members to place the success of the organization before their tendency to hoard knowledge. The main cost of sharing information is the loss of the team member's comparative advantage. When the team operates in a virtual space, it cannot observe physical behaviors that establish trust; therefore, a virtual team relies on different behaviors (unique to the virtual space) to assess reliability and compensate for the lack of observable physical behaviors. It is important to note at this point that building trust between virtual team members is a complex process based on cognitive trust because information technologies cannot successfully convey emotions that influence the establishment of trust. These findings are consistent with the concept of "ba" (Nonaka, Takeuchi, 1995). The Japanese word describes the place, space, or framework in which the management of knowledge is carried out in a constant and continuous manner of conversion. The knowledge goes from open to covert and vice versa. To process and manage it, hidden knowledge must become visible knowledge and personal knowledge must become shared and organizational knowledge. Therefore, among students in the current context, where "ba" is the virtual space in which they study, the conditions of the space must be known to find characteristics that can optimize their success in their studies and lead to maximum information sharing.

Cooperation is important to build trust, which will lead to success in the learning processes and increase IKS among students in remote learning.

Strength of Relationships among Students in Online Learning

The literature distinguishes between two main types of ties: weak and strong ties, as presented by Granovetter (1973), and redundant ties and nonredundant ties, as presented by Burt (1992). Relationship strength is defined as "a combination of the amount of time, emotional intensity, intimacy and intimacy and mutual services that characterize the relationship" (Granovetter, 1973: 1361). Hence, the strength of ties usually ranges from strong to weak, based on the closeness of the relationship and frequency of interaction (Evans et al., 2019; Granovetter, 1973; Hansen, 1999).

The research and theoretical literature present a complex picture of the relationship between the strength of ties and the willingness to share and transfer knowledge and information between individuals. For example, Constant et al. (1996) argued that in most cases, individuals use the weak ties they have accumulated to search for information that is not available among friends and coworkers. In other words, although the tendency is to use strong ties, which are created in part because of the physical proximity of two or more actors, when information is not available from these ties, people will tend to use weaker ties. This is because weak ties are preferred over strong ties for two main reasons: First, weak ties contain a greater number of potential helpers when some problem arises. Second, more advice can be received due to having more weak ties, because the wider the range of ties, the higher the chance of receiving an effective response (Constant et al., 1996). However, when there is a transfer of knowledge between employees from different organizations, through internet networks, a certain problem may arise. The information often comes from foreign sources who are sometimes geographically distant and the information depends mainly on their niceness – kindness and good will (Constant et al., 1996). In addition, the motivation of strangers to help other people may be weak and sometimes nonexistent. On the other hand, other studies have shown that it is precisely strong ties that explain the willingness to share knowledge and information. The argument is that when strong ties exist, there is also an established familiarity based on frequent interactions (Hansen, 1999). Therefore, the members of that strong social network develop shared expectations and conclusions related to common codes, language, and narratives (Uzzi, 1999) that contribute greatly to learning (Reagans, McEvily, 2003), innovation (Obstfeldt, 2005), and the ability and capabilities of transferring and sharing knowledge because this transfer is carried out in small and smooth steps. However, the network members are aware of the knowledge held by other network members and in this sense, they trade information that the searcher already knows about (d, p. 1478). Therefore, a dense network is inefficient, in that it returns less diverse information at the same cost as a sparse network (Nahapiet, Ghoshal, 1998).

Need for Achievement as a Factor Explaining IKS

The need for achievement, also called achievement motivation, also explains IKS among students. The need for achievement is a kind of drive that helps people reach their goals with distinction and is defined as the desire and effort to increase or maintain personal abilities as much as possible in all activities where standards of excellence apply (Heckhausen, 1967) and aspiration for success exist (Atkinson, 1966). In this context, motivations for achievement include automatic motivations and awareness that accumulate over the life course (Conroy, 2017; Turner et al., 2021). People with a high need for achievement have a strong desire to be at a more advanced level than their peers. They do not like to succeed by chance and prefer that their personal character led to their success.

Self-determination theory, developed by psychologists Richard Ryan and Edward Deci (see Deci, Ryan, 2000), provides an important and interesting explanation for the need for achievement. The theory deals with motivation to act based on a person's natural tendencies and needs. According to this theory, three motivational factors motivate a person to act: self-motivation, external motivation, and motivation arising from self-criticism. Self-motivation is motivation that comes from a person to do a certain action because they are interested in acting, choose to act, and want to act. Extrinsic motivation is a motivation for engaging in a certain activity resulting from an external goal such as a reward for the action or avoidance of punishment. Last is motivation arising from self-criticism such as avoiding feelings of guilt or shame. According to this theory, students' need for achievement and motivation to address this need can stem from self-motivation factors (innate need for excellence, satisfaction from success, etc.), external motivation factors (high

grades as a form of return or reward), or motivation arising from self-criticism (fear of disappointing others or failing).

The need for achievement is often associated with competitiveness. Researchers have identified a relationship between self-esteem and competitiveness and that high levels of self-esteem and competitiveness can (but do not necessarily) increase a person's achievement levels in all aspects of life (Janssen, Askari, 2019). The researchers tried to define the difference between competitiveness and need for achievement, citing previous studies that indicated that competitiveness is related in a certain aspect of the need for achievement. In fact, the motivation for achievement often involves competition with some standard of excellence that may be related to the task, self, or others (Smither, Houston 1992; Janssen, Askari, 2019). Furthermore, a connection exist between competitiveness and the desire to share knowledge, which is explained by the fact that among competitive people, competition for royalties may cause a reduction in IKS because it involves effort and causes the competitive person to move away from the task they are supposed to perform. That is, competitive people may perceive IKS as harming their performance. Therefore, people who try to be better than others and maximize performance (because of their high need for achievement and competitiveness) often avoid sharing knowledge with others with whom they compete (Bartol, Srivastava 2002; Connelly et al., 2014). Therefore, in the context of the current study, competitive students with a need for high achievement might be less willing to share academic knowledge with other students to maintain an advantage and be more successful. However, in the context of remote learning, these competitive dynamics may be intensified. As noted earlier, remote learning creates difficulties in building trust and social connections, mainly due to lack of face-to-face interaction (Alsharo et al., 2017). Unlike traditional classroom settings where social norms and collaborative behaviors are more visible and reinforced, remote learning environments emphasize individual performance and self-directed learning (Baber, 2020; Gillis, Krull, 2020). Furthermore, the asynchronous nature of much remote learning means that knowledge sharing requires additional intentional effort (Martinez, 2014). Students with high achievement motivation, who seek to maintain academic advantage and outperform their peers (Connelly et al., 2014), may be particularly reluctant to invest this extra effort when they perceive knowledge sharing as potentially diminishing their competitive edge in the less socially regulated remote environment. Therefore, we expect that in remote learning contexts, the negative relationship between achievement motivation and knowledge sharing will be more pronounced

This review of the literature indicates the multitude of existing studies on sharing, trust, achievement, and online learning among students and in general. Trust can affect the level of IKS. Trust is an important element that is built while getting to know others, understanding verbal and nonverbal cues, developing a sense of belonging and familiarity, engaging in social interactions, and more, and it seems that trust between people encourages IKS. However, remote learning creates difficulties in building trust, mainly due to the lack of interaction among students (Alsharo et al., 2017). Therefore, it is important to examine the strength of relationships, trust, and information sharing in remote learning.

The current study also focused on the need for achievement. This appear to depend on different motivations of each person and is subjective (Deci, Ryan, 2000). The research literature on the need for achievement and its relationship with information sharing is scarce. Achievement motives such as competitiveness, self-motivation, and drive for excellence were found to be indirectly related to the need for achievement and capable of influencing information sharing (Connelly et al., 2014). In remote learning, creating interactions between students is significant for sharing knowledge and helps them during their studies (Baishya, Maheshwari, 2020; Heusler et al., 2019). It is possible that for a student with a high need for achievement, interacting with fellow students and building trust and sharing information will be perceived as less important or necessary because they will tend to keep academic knowledge to themself and thus, reap high achievements and be more successful than their fellow students. To the best of our knowledge, attempts to combine all these factors in one coherent study are absent from the research and theoretical literature. Information sharing is an essential element in any organization that creates new knowledge and strengthens the organization. For students, the sharing of information is extremely important to learning outcomes and friendship processes (Lam, Ford, 2010; Raza et al., 2018). In online learning, IKS is mainly done with modern technological means that try to overcome the limitations of distance and represent a new challenge for both students and the

teaching staff. Therefore, this study explored how remote learning affects IKS students regarding trust and need for achievement. We derived the following hypotheses:

1. A positive relationship exists between the level of trust among students and level of IKS (receiving and giving). Hence, the higher the level of trust, the higher the level of IKS.

2. A negative relationship exists between students' level of achievement and level of IKS with their friends (receiving and giving). Hence, the higher the level of achievement, the lower the level of IKS.

3. Receiving knowledge and information from others makes a significant unique contribution to the strength of ties, trust, and success among students, with the highest unique contribution coming from the strength of ties.

4. Giving knowledge and information to others makes a clear unique contribution to the strength of ties, trust, and success among students, with the highest unique contribution coming from the strength of the ties.

2. Method

Sample

This study featured 444 undergraduate students studying in various academic institutions in Israel in fully online courses. The data in Table 1 show that 78.8 % were female students (n = 350) and 21.2 % were male students (n = 94). Their average age was 27.12 years (SD = 7.36). Regarding marital status, 73 % of the students were single. As for religion, 84.7 % of the students were Jewish, 8.8 % were Muslim, 2.7 % were Christian, and the rest were Druze or not religious.

Table 1. Students' Preferred Form of Study and Frequency of Information Sharing (N = 444)

Variable	*n*	%
Preferred form of study	**444**	
Face-to-face learning	206	46.4
Synchronous online learning only	71	16.0
Integrated online learning (synchronous, asynchronous)	1	0.2
Face-to-face learning in college combined with online learning	151	34.0
Frequency of sharing information with friends	**444**	
Never	26	5.90
Once every 2 or 3 weeks	49	11.0
Once a week	100	22.5
Every day	163	36.7
Several times a day	106	23.9

The questionnaire was sent to students from institutions recognized by HEC. Students from 21 academic institutions answered the questionnaires; 148 (33.3 %) were in their first year of studies, 133 (30.0 %) were in their second year, 125 (28.2 %) were in their third year, and the rest were in prep school or fourth year or higher (6.7 %).

Table 1 shows that the preferred form of studying for these students was face-to-face learning (46.6 %), whereas online learning was in last place by a significant margin (0.2 %). Most students shared information with each other, with a frequency ranging from once a day to several times a day (36.7 % and 23.9 %, respectively).

The extent to which the students used technological aids to share information with each other in remote learning were rated on a scale of 1 (*never*) to 5 (*several times a day*). Students seemed to prefer sharing knowledge through WhatsApp. It also appears that the students were more inclined to share knowledge (M = 5.20, SD = 6.73) than to receive knowledge from others (M = 3.53, SD = 3.78). It also appears that the number of friends to whom they provided help was relatively large and there was great variation in the number of students with whom they shared knowledge and information. However, there was relative heterogeneity in the number of people from whom they tended to receive information (see Table 2).

Table 2. Students' Average Use of Technological Aids to Share Information during Remote Learning[1]

	M	*SD*
Technology		
Desktop Computer	3.62	1.13
Laptop	4.02	0.99
Email	3.19	1.37
WhatsApp	4.72	0.68
Facebook	1.53	0.91
Zoom	3.06	1.36
Phone call	2.63	1.32
General average for IKS (receiving)	3.62	1.13
Average number of friends helped	5.20	6.73
Average number of friends asked for help	3.53	3.78

Measurement

Knowledge and Information Sharing

IKS among students was assessed using a sociometric questionnaire (Mesch, Talmud, 2006) adapted to test relationships between teenagers in a joint activity and updated by Shamir (2006). The questionnaire is designed to assess, among other things, joint activity, main topics of conversation, helping other students, and receiving help from other students.

Types of Joint Activities (Strength of Ties)

This index includes seven joint activities in which students usually engage. The index scores range from 1 (*often*) to 5 (*never*). An example item is "to exchange material for chores and work." The internal consistency obtained for this measure was α = .78.

IKS to Others

This measure tests the sharing of educational information from the focal student to other students. The index included five items with response options ranging from 1 (*often*) to 5 (*never*) and one open-ended question. An example item is "helping your friends prepare for tests and exams." The internal consistency obtained for this measure was α = .89.

IKS from Others

This index tests educational information that the focal student received from other students. The index included five items with scores ranging from 1 (*often*) to 5 (*never*) and one open-ended question. An example item is "taking pictures of lesson summaries agreed by your friends." The internal consistency obtained for this measure was α = .88.

This instrument was originally developed in Hebrew for Hebrew-speaking populations and was administered to Hebrew-speaking students in the current study. The questionnaire demonstrated adequate validity and reliability in previous research (Shamir, 2006)

Trust

The level of trust between students was assessed using the Interpersonal Trust at Work questionnaire (Cook, Wall, 1980), which was translated into Hebrew by Heller (2016). The original questionnaire contains 12 items, but this study used only five items because the other items measure employees' trust in management. The students expressed their agreement with the items on a 7-point Likert scale, ranging from 1 (*do not agree at all*) to 7 (*completely agree*). A sample item is "If I run into difficulties in my studies, I know that my fellow students will try to help me." The internal reliability obtained for this measure was α = .92.

Achievement

This variable was assessed using the Need for Achievement questionnaire (Elliot, 1999; Elliot, McGregor, 2001). The questionnaire was translated by Sheaf (2009) with the assistance of bilingual experts using the repeated translation method. The questionnaire measures the need for achievement, control, and execution with reference to avoidance (fear of failure) and approach (need for achievement and success). The questionnaire has 12 items on a scale from 1 (*not at all true for me*) to 7 (*very true for me*). An example item is "My goal is to get a better grade than most of the other students." The internal consistency obtained for this measure was α = .80.

[1] Measurement scale: 1–5.

Research Process

The interviewees were recruited using nonprobability snowball convenience sampling. The questionnaires were sent to the students using a Google Docs file to their mobile phone via WhatsApp. In addition, the questionnaire was distributed on Facebook in various student groups. According to research ethics, at the beginning of the online questionnaire, a mandatory question was provided and all respondents were required to answer: "I express my informed consent to participate in the research and am aware of my right to leave at any time without explaining." The study received the approval of the Ethics Committee of Emek Yezreel Academic College (2021–37).

3. Results

First, descriptive findings are presented, providing a picture of the students' attitudes regarding the research variables. The data (Table 3) show that the students tended to provide information moderately frequently (M = 3.53, SD = 1.04[1]), but they received knowledge less frequently (M = 2.97, SD = 1.03). The data also show moderate trust relationships[2] between the students (M = 4.72, SD = 1.46), but they did not often take part in various joint activities (M = 2.74, SD = 0.78). Finally, the students reported that they have a high level of achievement[3] (M = 5.28, SD = 0.91).

Table 3. Descriptive Statistics for Information Sharing, Trust, and Need for Achievement (N = 444)

Variable	*M*	*SD*
Gives information	3.53	1.0
Receives information	2.97	1.03
Trust level	4.72	1.46
Strength of ties (joint activities)	2.74	0.78
Achievement level	5.28	0.91

IKS, Trust, and Achievement

To test statistical relationships, Pearson correlations were calculated between trust, need for achievement, and IKS (receiving and giving). The findings show a positive relationship between receiving knowledge and information from others and sharing knowledge and information with others (r = .572, p < .001; Table 4). There was also a positive relationship between trust and sharing knowledge with others (giving; r = .345, p < .001). According to Cohen's (1988) guidelines for interpreting correlation coefficients, the relationship between receiving and giving knowledge (r = .572) represents a large effect size, while the relationship between trust and giving knowledge (r = .345) represents a medium effect size. Finally, a positive relationship was found between sharing knowledge with others (giving) and the student's level of achievement (r = .101, p < .05), but no significant relationship was found between the level of achievement and receiving knowledge from others (p > .05). These findings provide support for Hypothesis 1, indicating a positive relationship between trust and IKS. However, Hypothesis 2 was only partially supported: while a positive (rather than negative) relationship was found between achievement level and giving knowledge (r = .101, p < .05), no significant relationship was found between achievement level and receiving knowledge.

Table 4. Relationships between IKS, Trust, and Need for Achievement (N = 444)

Variable	1	2	3	4
1. IKS (receiving)				
2. IKS (giving)	.572**			

[1] Measurement scale: 1–5.
[2] Measurement scale: 1–7.
[3] Measurement scale: 1–7.

Variable	1	2	3	4
3. Trust	.416**	.345**		
4. Strength of ties	.543**	.524**	.429**	
5. Achievement	.057	.101*	.150	.102*

Notes: *p < .05. **p < .001.

The regression findings, which are presented in Table 5, show a significant regression result, $F(3,443) = 61.222$, $p < .001$), with a multiple correlation of .54 and explained variance of .29. This R^2 value of .29 indicates that trust and strength of ties together explain approximately 29 % of the variance in receiving knowledge and information, representing a medium to large effect size (Cohen, 1988). The standardized regression values indicate trust and strength of ties significantly contributed to predicting the receipt of knowledge and information. The strength of ties had the strongest effect on the tendency to receive knowledge and information. Therefore, the hypothesis was confirmed, indicating that receiving knowledge and information from others is significantly predicted by strength of ties and trust, with strength of ties making the strongest unique contribution (β = .454, p < .001).

Table 5. Regression Analysis of Research Variables that Predict Receiving Knowledge and Information from Others (N = 444)

Variable	*b*	*SE*	β
Trust	0.106	0.310	.149*
Achievement	0.059	0.460	.052
The strength of ties	0.603	0.590	.454**
R	.543		
R^2	.294		
Δ*F*	61.222**		

Notes: *p < .01. **p < .001.

The regression findings, which are presented in Table 6, show a significant regression result, $F(3,443) = 74.141$, $p < .001$), with a multiple correlation of .58 and explained variance of .33. This R^2 value of .33 indicates that the model explains approximately 33 % of the variance in giving knowledge and information, representing a large effect size (Cohen, 1988). The standardized regression values indicate that the contribution of trust and strength of ties to the prediction of receiving knowledge and information from others is significant. The strength of ties had the strongest effect on the tendency to transfer knowledge and information.

Table 6. Regression Analysis of Research Variables Predicting Transfer of Knowledge and Information from Others (N = 444)

Variable	*b*	*SE*	β
Trust	0.160	0.310	.225*
Achievement	0.009	0.044	.008
The strength of ties	0.591	0.057	.445**
R	.579		
R^2	.336		
Δ*F*	74.141**		

Notes: *p < .01. **p < .001.

Therefore, the hypothesis was confirmed, indicating that giving knowledge and information to others is significantly predicted by strength of ties and trust, with strength of ties making the strongest unique contribution (β = .445, p < .001).

4. Discussion

Sharing of knowledge among students is immeasurably important and depends on many characteristics. In light of HEC (2018) requirements for online courses to accont for 30 % of courses in each department, students are required to adopt remote learning skills. Remote learning students

may experience difficulties and barriers that depend on many characteristics that explain their willingness to share knowledge. Therefore, the present study focused on the strength of ties, trust, and need for achievement as possible factors that could explain IKS among remote learning students.

Similar to the findings of previous studies (Moghavvemi et al., 2018; Raza, 2018; Wang, 2014), the first hypothesis regarding the relationship between the level of trust and degree of IKS among students (receiving and giving) was confirmed. That is, positive relationships were found between trust and giving knowledge to others and between trust and receiving knowledge from others. Trust is built step by step at different rates, depending on the type and nature of the relationship between people, and is influenced by attitudes and ways of acting. When trust between people matures, the ground is ready for learning and working together. The findings of the current study are consistent with the findings of Mayer and colleagues (1995), who showed that knowledge sharing is based on trust, which is perceived as a characteristic that increases the desire to give and receive knowledge and information, and as a result, creates and maintains exchange relationships. This finding is particularly significant in the context of remote learning, where trust-building processes face unique challenges. According to Nonaka and Takeuchi's (1995) knowledge creation theory, the virtual learning environment serves as the 'ba' – the shared space where knowledge conversion occurs. In remote learning contexts, trust becomes even more critical because students must rely on cognitive trust rather than affective trust that develops through physical presence and face-to-face interaction (Alsharo et al., 2017). The current findings suggest that despite these challenges, students were able to develop sufficient trust through digital means to facilitate knowledge sharing, supporting the notion that technological platforms can serve as effective 'ba' for knowledge creation when trust is established.

In addition, this finding is consistent with a previous study that showed that despite the transition to remote learning and difficulties in building trust at a distance, students managed to build trust in their friends and share knowledge and information using technological means (such as social networks and instant messaging programs), which are a kind of substitute for face-to-face socializing processes (Alsharo et al., 2017).

The second hypothesis, which tested a negative relationship between achievement level and knowledge and information sharing (receiving and giving), was partially confirmed. That is, a positive relationship was found between the student's level of achievement and IKS (giving), but no relationship was found between the level of achievement and receiving knowledge and information from others. This finding has been reinforced in studies that also found no connection between the desire to achieve a better result than others and willingness to share knowledge and information (Lam, Lambermont-Ford, 2010; Connelly et al., 2014; Raza et al., 2018). It is possible that a student characterized by high levels of achievement also has high self-esteem and therefore, will not usually feel threatened to share knowledge and information with friends. Also, they will feel self-confident enough in their achievements and knowledge and will not perceive sharing knowledge and information with others as a threat to their academic success. This finding suggests that in remote learning environments, where the emphasis on individual performance is more pronounced (Baber, 2020; Gillis, Krull, 2020), students with high achievement motivation do not fear sharing knowledge with others. This may indicate that in the virtual space, where knowledge sharing requires intentional effort (Martinez, 2014), students with high academic self-confidence perceive knowledge sharing as an opportunity to strengthen their social and academic standing within the student network, rather than as a threat to their advantage. This finding aligns with the conception of knowledge as a social force that is strengthened through sharing rather than hoarding (Nonaka, Takeuchi, 1995).

Furthermore, they will not be asked for and therefore, knowledge and information will be received easily (Ghaziri, Awad, 2015; Ismail, Yusof, 2010). Therefore, it can be assumed that the lack of connection between level of achievement and receiving knowledge from others lies in the fact that a student with a high need for achievement wants to maintain an academic advantage and higher achievement than others and will carefully clarify the source and nature of the knowledge they receive from others.

5. Conclusion

Finally, the third and fourth hypotheses posited a distinct unique contribution to the strength of the ties between students in relation to IKS (receiving and giving); these hypotheses were confirmed. These findings are consistent with previous studies (Hansen, 1999; Obstfeldt, 2005;

Uzzi, 1999) that found that strong ties explained willingness to share knowledge and information. Based on these studies, frequent interactions help create strong bonds. Hence, students who study in the same department and the same course might create a strong social network in which codes of conduct, language, and shared norms develop throughout their studies, helping them learn what information and knowledge is allowed or acceptable to ask for or receive and from whom it can be requested or received (Uzzi, 1999). Moreover, because IKS occurs in small steps (Obstfeldt, 2005), throughout the learning process (that is, a semester or degree program), the process of IKS and the norms of behavior expected from members of the network are gradually established. Because IKS is carried out in parts, each time a small part of the learned material is shared. This situation allows both parties to examine the scope of the sharing and also the quality of the knowledge and information that passes through the network. As sharing processes with higher frequency and quality, they contribute to the tightening of relations among members of the network, increase the level of trust, and contribute to the strengthening of ties. These findings are particularly meaningful in the remote learning context, where the development of strong ties faces significant challenges due to lack of physical proximity and reduced opportunities for spontaneous interaction (Alsharo et al., 2017). The strong contribution of tie strength to IKS suggests that even in virtual environments, students who invest in building relationships through repeated interactions create the shared codes, language, and norms necessary for effective knowledge transfer (Uzzi, 1999). This supports Nonaka and Takeuchi's (1995) concept of socialization in knowledge creation – the conversion of tacit knowledge through shared experiences. In remote learning, this socialization process occurs through digital platforms, but the underlying mechanism of relationship building through repeated, quality interactions remains critical for knowledge sharing

Study Limitations and Recommendations for Future Studies

First and foremost, this study used nonprobability convenience and snowball sampling through social media platforms. This sampling method limits the generalizability of the findings to the broader student population. The sample may be biased toward students who are more digitally active, more socially connected, or have specific characteristics that led to their inclusion in the study through referral networks. Therefore, caution must be exercised when attempting to generalize these findings beyond the specific sample studied, and the results should be interpreted as exploratory rather than definitive.

Despite the uniqueness of the current study, one limitation is the minority of men in social science circles in general and hence, also in the current study. It is possible that in programs characterized by a higher percentage of men (engineering, economics, computers, etc.), they discover other patterns of IKS. Therefore, researchers should carry out research in a wide variety of fields with a wider representation of men, which will make it possible to make comparisons and examine differences between women and men regarding the research hypotheses. Second, the data were collected through self-report questionnaires, so the research findings may suffer from social bias. Researchers should use qualitative methods such as in-depth interviews that can provide a deeper understanding of the subject. Third, the study was conducted at a certain point in time, so no conclusions can be drawn regarding changes over time. Longitudinal studies can provide more robust data on how these relationships change over time. Finally, in addition, we could not obtain data regarding what knowledge they shared and their degree of success in the course.

Research Contributions and Implications

The field of online learning is still developing, and these findings suggest that it may be important to build educational and social support programs for students that will help them in this complex situation and continue their studies. According to the current study, most students still prefer face-to-face learning. Students who had to switch to remote learning faced quite a few difficulties and challenges. Nonetheless, it seems that remote learning is quite a worthy competitor and with giant strides, has managed to overcome the gaps to face-to-face learning. The current study contributes to our understanding of the importance of the interaction between remote learning students, as noted repeatedly in the literature review, and emphasizes the need for connections between students to build a social infrastructure that will help them collaborate. Furthermore, within the context of this sample, the research findings suggest the importance of building trust in remote learning and its potential contribution to IKS in remote learning. However, given the study's methodological limitations, these findings should be interpreted cautiously and require further validation with more representative samples.

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Methodological and Procedural Aspects of Student's Research Skills Formation by Artificial Intelligence Using

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Abstract

The symbiosis of conceptual, mathematical and computer modeling in natural science study of practice-oriented problems is becoming a leading trend in the effective development of students' thinking intellectual operations. Research problem: what are methodological, substantive and procedural aspects of students' research skills formation in natural science course of practice-oriented problems solving by an artificial intelligence using? Research objective: to identify the substantive and procedural aspects for students' research skills formation in natural science process of practice-oriented complex problems solving of artificial intelligence using by means of conceptual, mathematical and computer modeling. Materials and methods: environmental and synergetic approaches, historiogenesis and technology of mastering complex systems and knowledge, methods of visual modeling and personal experiences founding during of natural science processes adaptation of practice-oriented tasks mastering, symbiosis of conceptual, mathematical and computer modeling in an architectures and functionality construction of neural networks and deep learning methods using. Results: criteria and characteristics of "problem areas" in natural science aimed at subject and digital resources integration with potential of student's research skills development are identified; requirements for organization of student's search and research activities in digital educational environment are defined; didactic stages, principles and methods of multi-stage mathematical and information practice-oriented tasks implementation at natural science using generative and convolutional neural networks are identified.

Keywords: practice-oriented tasks of natural science, artificial neural networks, research skills, mathematical and computer modeling.

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1. Introduction

Student's research skills as a personal phenomenon are considered by educational scientists, as a rule at an operational component of cognitive activity methods (Wessels, 2021; Kumar, 2024). However, some of psychologists as V.P. Zaporozhets, A.N. Leontiev, N.G. Salmina, V.D. Shadrikov and others (Zvonova, 2018; Salmina, 1994; Shadrikov, 2022) have shown that operationality in thinking does not always lead to the effective development of intellectual operations, personal abilities and creative thinking of students. At the same time, the formation of research skills as part of the implementation of an individual's scientific potential can become the basis for the formation of creativity phenomenon in the context of student's self-organization in search and research activities.

Recent advances in educational theory demonstrate that implementing the post-non-classical paradigm in teaching mathematics can significantly enhance the quality of school-level mathematical education. This is achieved through a technology-driven approach to learners' self-organisation and self-development during research activities. The paradigm shift enables: revealing mechanisms and factors underlying the philosophical phenomenon of fundamentality (persistent manifestation of virtual essence); realising synergy via complex adaptive constructs in modern natural science knowledge; elevating the mathematical fundamentality of school education (Dvoryatkina, 2021; Smirnov i dr., 2016; Sekovanov, 2016). This approach to mastering complex systems and knowledge operates through the interplay of three interconnected aspects: substantive aspect – engagement with practice-oriented tasks that reflect real-world complexity; an exploration of complex systems and knowledge domains such as: fractals; nonlinear dynamics; cryptographic problems; integration of self-organisation mechanisms (drawing on Stepin's theoretical framework); procedural aspect – founding of personal experience by building knowledge through iterative, experiential learning; fostering dialogue between cultures by connecting mathematical, scientific, and humanities perspectives; promoting effective communication in research contexts; an implementing conceptual, mathematical, and computer modelling techniques (Ostashkov i dr., 2016; Smirnov, 2012); person-adaptive aspect by developing creativity and critical thinking skills; an enhancing research competencies from hypothesis formulation to data analysis; an applying visual modelling to make abstract concepts tangible; strengthening the motivational sphere as fostering intrinsic interest in mathematical inquiry.This tripartite framework: bridges abstract mathematical theory with real-world applications; supports differentiated instruction by addressing individual learners' cognitive and motivational profiles; cultivates adaptive expertise as an ability to transfer knowledge across novel contexts; an aligns with contemporary demands for STEM literacy and innovation-driven economies. This approach not only deepens conceptual understanding but also prepares students for the complexities of 21st-century scientific and technological challenges.

The opportunities for student's self-organization in search and research activities are significantly increased through the digital environments using (in particular, artificial intelligence systems and artificial neural networks) due to the multiplicity of goal-setting, optimization of routine operations, generation of cognitive and an ancillary product, interdisciplinary interaction, dialogue of cultures, and interpretation of research results. The technology for an identifying and an exploring of «problem areas» in mathematics education enables to interdisciplinary knowledge integration by using of merging insights from multiple scientific fields when addressing practice-oriented natural science tasks; AI-driven investigation by leveraging artificial intelligence tools to analyse and solve complex problems; an activation of student research with stimulating independent inquiry and exploratory activities; synergistic learning effects with enhancing knowledge acquisition through combined cognitive and technological approaches. A «problem area» emerges through an uncovering contradiction by an identifying inconsistencies or gaps in current understanding; revealing cognitive deficits by detecting weaknesses in students' thinking processes; an investigating complex element by an examining intricate aspect of educational content that resist conventional approaches. Successful implementation leads to: enhanced mathematical literacy as deeper grasp of abstract concepts; improved problem-solving skills for ability to tackle complex, interdisciplinary challenges; an increased student autonomy by confidence in independent research and inquiry; strengthened cognitive flexibility with capacity to adapt the strategies across different contexts. The technological nature of research into "problem areas" is based on the determination of criteria for their identification.

The methodology for identifying and examining «problem areas» in mathematics education offers a powerful framework for integrating of an interdisciplinary knowledge when tackling

practice-oriented natural science tasks particularly through the use of artificial intelligence (AI). This approach: creates conditions for activating students' search and research activities; reveals synergistic effects in mastering complex knowledge; fosters deeper engagement with multifaceted educational content. A «problem area» represents an integrated complex comprising three core components: substantial as the body of knowledge, concepts, and theories relevant to a specific mathematical domain; procedural as the methods, algorithms, and operations used to process and apply this knowledge; personal-adaptive as the learner's individual cognitive strategies, motivational factors, and adaptive mechanisms in knowledge acquisition. This complex emerges through: an uncovering internal contradictions and unresolved issues within a defined educational domain; an identifying cognitive deficit as gaps or inefficiencies in students' thinking processes; an investigating the essence of complex educational elements that challenge conventional learning approaches.

The research process is grounded in a systematic methodology for identifying and analysing these areas, which hinges on defining clear criteria for detection. Key technological aspects include: data-driven analysis as leveraging AI to process educational datasets (student performance, error patterns, cognitive load metrics); pattern recognition by using machine learning to detect recurring challenges or knowledge gaps; dynamic modelling as simulating how students interact with complex concepts to pinpoint friction points; criterion development as an establishing measurable indicators (e.g., frequency of errors, time to mastery, conceptual coherence) to define what constitutes a «problem area». By applying this technology, educators can achieve: enhanced interdisciplinarity as the bridging mathematics with natural sciences, computer science, and cognitive psychology; personalised learning pathways as an adapting instruction to address individual students' cognitive bottlenecks; proactive intervention as an anticipating and mitigating knowledge gaps before they hinder progress; research skill development as an empowering students to become active investigators of mathematical phenomena.

Characteristics of criteria manifestation research in «problem area»

The analysis of «problem areas» in mathematics education reveals several defining characteristics that shape both the challenges and methodologies involved. Below are the key manifestations:

1. Inadequacy of perception and transfer limitations. A core issue is the systemic insufficiency in how learners: perceive the dynamic nature of mathematical knowledge acquisition; master procedural components of learning; transfer of specific connections and operations (from concrete educational elements) to higher-order conceptual structures. This limitation manifests as: fragmented understanding of interrelated concepts; difficulty generalising of problem-solving strategies; an inability to see the overarching patterns across mathematical domains.

2. Essence identification through multi-goal modelling. The process of uncovering the essence of educational elements within «problem areas» relies on: multiplicity of goal setting by exploring multiple objectives and pathways simultaneously; mathematical modelling of generalised constructs on creating abstract representations that capture core principles; finite adaptation stages by structuring progressive steps to align new knowledge with existing cognitive frameworks.

3. Exploratory trials via information technologies. Effective investigation requires technology-mediated experimentation, including: experimental slices as segmented analysis of problem components; parameter variation as testing different conditions within the «problem area»; comparative analysis as contrasting specific manifestations across contexts; computer modelling as simulating complex interactions; analogical reasoning by drawing parallels with known systems; analysis through synthesis by building understanding by reconstructing systems from parts.

4. Unpredictability and multiplicity of outcomes. Interactions with «problem areas» are inherently non-linear and characterised by: unpredictable results so an outcome cannot be fully anticipated due to system complexity; multiple potential pathways as diverse solutions may emerge from the same initial conditions; side effects as an unexpected cognitive or conceptual shifts may occur during exploration.

The formation of student's research skills by artificial intelligence using also implies the basic requirements for organizing search and research activities (in extracurricular activities or in the system of an additional mathematics education):

– This section outlines two interconnected strategies for enhancing mathematics and computer science instruction through the artificial intelligence (AI) and cognitive profiling: to create a structured resource bank that bridges theoretical knowledge with real-world applications in natural sciences and technologies as repository of practice-oriented tasks and

modelling tools curated collection of interdisciplinary problems (physics, biology, engineering) solvable via mathematical and computational methods; AI-enhanced problem formulations (e.g., data-driven scenarios, simulation-based tasks). Modelling methodologies: conceptual modelling as frameworks for abstracting real-world phenomena; mathematical modelling as equations, functions, and algorithms for problem representation; computer modelling as a software implementation (Python, MATLAB, Wolfram Mathematica). Delivery formats: multimedia presentations; research essays; lecture series; computer-aided design projects (Hyunsuk, 2022; Sekovanova, 2025);

– To assess students' cognitive preferences and tailor AI-supported research activities accordingly to diagnosis of modal perception in digital Learning environments. Perception modalities analysed: sign-symbolic preference for algebraic notation, formal logic, and symbolic reasoning; strengths in equation manipulation and abstract pattern recognition; an image-geometric and visual-spatial reasoning (graphs, diagrams, 3D models), aptitude for geometric proofs and data visualisation; verbal (historical-genetic context) narrative understanding of concept development; interest in the history of mathematics and science; concrete-activity (computational and algorithmic) hands-on problem-solving via coding and simulations, procedural thinking (step-by-step execution); an informational (computer modelling and design) proficiency in programming and digital tool use, data analysis and system design skills (Wei Pan, 2024; Morgacheva, 2023);

– To adaptive the design of practice-oriented tasks (differentiated selection of practice-oriented tasks based on learners' proficiency levels; pedagogical scaffolding by structured support in designing learning stages, forms, and tools; AI-integrated adaptation by customising artificial intelligence libraries for small learner groups; an experiential grounding by anchoring knowledge in personal experience through visual modelling (Maaliw, 2020; Dvoryatkina, 2017);

– To define of multi-goal research framework on flexible methodology for investigating complex educational phenomena: multi-dimensional goal setting with simultaneous pursuit of complementary research objectives; an essence identification on uncovering core principles in research procedures and task solutions; modality activation by engaging diverse perception channels; conceptual integration by synthesising visual, conceptual, mathematical, and computational modelling approaches (Smirnov, 2017; Kuznetsova, 2020);

– To enhance of mathematical inquiry by digital transformation of research activities of modern technologies leveraging: informatization by integrating digital tools into research workflows; neural network support by mastering AI libraries for data analysis and pattern recognition; experimental mathematics by an applying computational methods in «problem zones»; modelling symbiosis by combining mathematical and computer-based approaches for result interpretation (Smirnov i dr., 2021; Lei Qin, 2025);

– To develop of cultivating critical thinking and creativity by using higher-order cognitive skills through: pattern identification with recognising structural regularities in mathematical phenomena; laboratory-calculation exercises on hands-on exploration of mathematical concepts; multi-stage tasks as progressive problem-solving challenges integrating mathematics and informatics; dynamic systems analysis as studying mechanism: basins of attraction; attractors and iterative procedures; bifurcation transitions; fluctuation dynamics. This framework aligns with contemporary demands for: STEM education; 21st-century skill development; lifelong learning competencies.

The purpose of the study is to identify the substantive and procedural aspects of student's research skills forming through the solving of practice-oriented complex natural science tasks by an artificial intelligence using and means of conceptual, mathematical, and computer modeling. The research materials are based on the self-organization and self-determination of students in research activities within the digital educational environment, historigenesis, and the processes actualization of complex mathematical knowledge mastering, as well as the synergy manifestation in mathematics teaching mastering as effective mechanisms for personal development and enhancing of mathematical education quality. Environmental and synergetic approaches are implemented, along with methods of visual modeling and founding of personal experiences during the process's adaptation of practice-oriented natural science tasks mastering by artificial intelligence using in school mathematics.

2. Materials and methods

The introduction of digital technologies into the process of mathematical education is a leading trend in the modernization of school education worldwide, including in Russia. According to the regulatory documents of UNESCO (UNESCO Science Report, 2015) and Strategy for Development of Information Society in Russian Federation for 2017–2030, dynamic development and dissemination of artificial intelligence (AI) technologies for specific methodological and educational tasks solving are anticipated. For example, the study by V. Singh and S. Ram (Sysoyev, 2025) describes the didactic potential of generative AI tools for personalized learning enhancing. A number of researchers (William Villegas-Ch, 2025) propose an intelligent educational system based on artificial intelligence that provides personalized and adaptive learning in real-time. The system combines advanced models of deep learning and natural language processing, allowing for targeted feedback and dynamic adjustments the education triectories. The issues of AI using in the implementation of research projects are analyzed by V.V. Menshikov and N.M. Savin in (Menshikov i dr., 2024). The work (Tereschenko, 2021) employed a deep learning methods based on convolutional neural networks, as well as the concept of “transfer learning”. A neural network was trained on the ResNet 50 architecture, allowing for the accurate an identification of disease presence in the cassava plant from an image with an F1-score of 0.93.

An innovation implementation in AI-Enhanced natural sciences: A Hegelian framework

We propose a methodology for integrating artificial intelligence into natural science education through conceptual, mathematical, and computational modelling. This approach is grounded in the Hegelian dialectical triad (thesis-antithesis-synthesis), which structures the innovation process into three interdependent phases.

1. *Thesis: Establishing Foundational Complexity*

The initial phase emphasises: complexity and coherence principles as an ensuring harmonised interaction between diverse aspects of knowledge acquisition; feedback mechanisms as an implementing dynamic, responsive evaluation loops in research processes; systemic integrity as maintaining holistic procedures for investigating of practice-oriented natural science tasks; structural connectivity as mapping both the internal and external relationships within complex systems or objects in digital learning environments.

This stage creates a stable framework where learners engage with multifaceted scientific concepts while developing systematic analytical skills.

2. *Antithesis: challenging and deconstructing assumptions*

The second phase introduces critical examination through: funding and fractality principles as dissecting knowledge into scalable, self-similar components; historigenesis analysis as tracing the evolutionary development of research objects and methodologies; problem-area focus as an identifying local attractors (key focal points) within complex knowledge systems; visual modelling and critical rationalism as an evaluating research quality via representational tools and logical scrutiny.

Here, learners confront contradictions and ambiguities in scientific knowledge, fostering deeper critical thinking and methodological flexibility.

3. *Synthesis: creative integration and validation*

The final phase achieves: creative self-organisation as an empowering students to design and implement innovative research approaches; an inversive integrity reflection as an examining complex systems from multiple perspectives to reveal hidden patterns; an innovative context application as deploying AI tools to assess and enhance research quality; holistic mastery as synthesising knowledge across conceptual, mathematical, and computational domains.

This culmination transforms by fragmented understanding into a cohesive, an adaptable knowledge framework, where students demonstrate both analytical rigour and creative problem-solving. Based on the specifics of extracurricular activities organizing (or additional education courses), project-based activities of students in practice-oriented tasks researching in natural sciences by AI using become a relevant means for research skills forming. Based on the studies by I.V. Kuznetsova, S.V. Napalkov, E.I. Smirnov, S.A. Tikhomirov, we can identify the following distinctive features of project activities that have a positive effect on research skills formation: focus of the activity on a final goal achieving; coordinated execution of interrelated actions by project participants; limited duration of time; outcome of the activity being a socially significant product. Thus, project activities include components such as: analysis of an existing problem; goal setting; determining the means to achieve it; searching, analyzing, and processing

information; developing and implementing the project; individual and collective evaluation of the results obtained.

Historiogenesis, complex systems, and AI-driven knowledge mastery in education

The integration of artificial intelligence (AI) into applied research necessitates two foundational components: historiogenesis (evolutionary analysis of knowledge development); technologies for complex systems mastering (Sysoyev et al., 2025; Dvoryatkina et al., 2023)); nature of complex knowledge (complex knowledge emerges from intricate systems, generating multilayered hierarchies and challenges). These can be addressed through: development of generalised mathematical and computational constructs; analysis of semiotic and informational linkages in nonlinear systems (real and virtual); integration of descriptive and computational diversity within knowledge frameworks (Uvarov i dr., 2017). A synergistic paradigm plays a pivotal role by enabling: creation of personalised learning environments; integration of educational elements across multiple levels; fostering self-organisation among learners.

This approach, advanced by scholars like S.P. Kurdyumov, G.G. Malinetsky, I.R. Prigozhin, E.I. Smirnov, and G. Haken, relies on interdisciplinary collaboration to generate novel, higher-order structures with emergent properties (Dvoryatkina et al., 2021). Intelligent management systems by including hybrid neural networks transform mathematics education by introducing adaptive, data-driven of pedagogical frameworks. Their impact is realised through three foundational principles: openness to external influences the integration of real-world data and interdisciplinary knowledge; responsiveness to evolving of educational needs and technological advancements; flexibility in adapting instructional strategies to contextual variables. Synthesis of mathematical and computational modelling bridging abstract mathematical theory with algorithmic implementation; an enabling simulation of complex systems for deeper of conceptual understanding; supporting of an evidence-based decision-making in instruction. *Key characteristics and their educational implications* include: dynamic cognitive processes these reflect the non-linear nature of learning: stochastic transitions with random fluctuations in attention and comprehension that require adaptive scaffolding; threshold effects on critical points where incremental input triggers of qualitative understanding shifts; bifurcation transitions with moments when learners diverge into distinct cognitive pathways (e.g., visual vs. algebraic reasoning); fluctuation-driven creativity by an emergent problem-solving strategies arising from cognitive variability. Also an adaptive goal-setting a multi-layered approach to learning objectives: multi-objective computer modelling by simultaneous pursuit of conceptual mastery, procedural fluency, and metacognitive development; personalised data processing as tailored analysis of diverse input types: visual (graphs, diagrams); textual (problem statements, explanations); signal-based (interactive simulations); tabular (structured datasets); feedback loops by continuous adjustment of tasks based on performance metrics. Intelligent management in mathematics education represents a paradigm shift from static instruction to dynamic, adaptive systems. This approach does not replace human pedagogy but augments it with precision tools for understanding and supporting the intricate processes of mathematical cognition (Dvoryatkina et al., 2023).

The theory of founding: phenomenological foundation (German: Fundierung) denotes an ontological justification by using the principle that complex entities derive from simpler foundational elements. In pedagogy, V.D. Shadrikov and E.I. Smirnov (2002) introduced personal experience founding as a process enabling: gradual deepening of scientific knowledge; expansion of cognitive actions; formation of a holistic knowledge cluster (founding spiral). In this study, founding manifests through: symbiosis of conceptual, mathematical, and computational modelling; AI-supported architectures (e.g., neural networks) (Smirnov, 2012); visual modelling: an innovative construct serves as a triadic interactive system (personality-model-understanding) aimed at: elucidating object/action essences; structuring of cognitive procedures; an enhancing comprehension through staged representation.

Core elements include: student centring: integration of perceptual, cognitive, reflective, emotional-volitional, motivational, and creative substructures; model adequacy: an alignment between a priori models and cognitive outcomes; sign system interplay: verbal, symbolic, graphic, digital, and concrete-activity modalities; knowledge stability: coherence of mathematical, scientific, and informational domains; perceptual sensitivity: responsiveness to diverse of input modalities; cognitive activation: engagement of higher-order thinking processes (Smirnov, 2012).

An environmental and synergetic approaches in project development are the most important component of students' cognitive activity content in supporting context of an artificial intelligence systems. It is essential to master and identify the essence and synergy of complex integration processes, applied scenarios, and procedures in the context of building stages and hierarchies, multiple goal-setting and analysis of side solutions, finding bifurcational transitions and basins of attraction in studied processes, and coordinating information flows in the creation of new product. The term "synergy" (synergeia (Greek) – joint action, cooperation) was proposed in the late 1960s by German chemist and theoretical physicist from Stuttgart (Germany) G. Haken. The subject of synergetics is complex self-organizing open systems that are far from equilibrium conditions (when there is a nonlinear exchange of matter, energy, and information). Synergy of processes of complex multi-stage practice-oriented tasks solving (Sekovanova i dr., 2025):

– Adaptation of modern achievements in science based on a dialogue of mathematical, informational, and natural science cultures;

– Actualization of synergistic effects in the deployment of educational content;

– Multiple goal-setting, stochastic planning, and emergent results of problem-solving;

– Visual modeling of bifurcation transitions of studied solutions to generalized hierarchical levels of order and organization.

– Identifying attractors and basins of attraction for basic constructs of mathematical knowledge, scenarios, and procedures.

Thus, we can conclude about the possibility of effective development of research skills through project activities with methodological and procedural aspects of student's research skills formation by AI using (training in planning of conceptual, mathematical and computer modeling symbiosis in an architectures and functionality construction of neural networks, development of visual modeling and personal experience founding skills in collecting and processing information, materials, ability to navigate the modern information space, development of analytical skills, training in independent knowledge construction, development of environmental and synergetic approaches in project development and presentation skills in historiogenesis and technology of mastering complex systems and knowledge adapting for fostering a free, creative personality of the learner).

3. Results

The choice of research object is a key stage in research process and can significantly influence on development of research skills among learners in a digital environment. One of most important modern tasks of personal development is mastering the content of mathematics as a complex knowledge, which involves the process of phenomenon actualizing for transitioning from development processes to self-development processes among learners.

Ontological engineering of learner development: motivation and cognitive autonomy in Vygotsky's framework

The cultivation of educational motivation, cognitive independence, and creative autonomy within learners are particularly lie in L.S. Vygotsky's «zones of proximal development» which requires deliberate strategies to help students overcome challenges inherent in mastering complex knowledge. This approach aligns with contemporary pedagogical paradigms and leverages advanced educational technologies. A pivotal component of this framework is the strategic use of information environments, including an artificial intelligence (AI), in practice-oriented research within natural sciences. Such disciplines often involve an intricate knowledge system that necessitate: development of an advanced intellectual operations (e.g., modelling, comprehension, idea generation, abstraction); minimisation of routine cognitive tasks through specialised computational tools (e.g., Python libraries and frameworks). Complex mathematical and scientific concepts can be effectively explored through a synergistic blend of mathematical and computational modelling. Notable examples include: function limits and Riemann hypothesis as foundational elements in advanced mathematical analysis; surface area calculations (as studied by G. Schwartz, V.A. Dubrovsky, E.I. Smirnov, S.N. Dvoryatkina, et al. (Dubrovsky, 1978; Uvarov, 2017); fuzzy set theory (pioneered by L. Zadeh and A. Kofman (Zadeh, 1988)) as a framework for handling uncertainty and imprecision; chaos and catastrophe theories (developed by A. N. Kolmogorov, R. Thom, and colleagues) as tools for analysing nonlinear dynamic systems; fractal geometry (explored by B. Mandelbrot, M. Barnsley, V.S. Sekovanov, et al. (Mandelbrot, 2002; Dvoryatkina, 2023) as a method for describing self-similar structures across scales; cellular automata for discrete models used to simulate complex systems.

The inherent unpredictability of contemporary reality marked by sensitivity to minor fluctuations and potential for bifurcation transitions to new developmental stages which generates a novel pedagogical challenges. These conditions demand an innovative approach to knowledge construction and transfer, emphasising adaptability and foresight. Rather than focusing solely on linear development, the educational process should prioritise self-development through deep engagement with complex knowledge. Critical objectives include: an individualisation processes as cultivating personal experience and an agency in learning (as discussed in (Xian, 2021)); an enhanced motivation as fostering an emotional and practical investment in learning for each student; personalised understanding as leveraging visual modelling techniques to facilitate comprehension of advanced scientific constructs and contemporary research achievements (as outlined in (Mingxing, 2021)).

Let's list the main principles that should be taken into account when choosing the object of research:

– *The principle of complexity in digital context*. The object of research should be relevant for modern digital space. To achieve this, you can explore a complex natural science construct related to conceptual and mathematical modeling, social media, data collection, and analysis, which helps to understand the current trends. For example, you can use an artificial intelligence or virtual reality as digital technologies;

– *The principle of data and resource accessibility*. It is necessary to choose the objects for which there is a sufficient amount of open data and resources. The object should allow of various digital tools and technologies using, such as statistical programs, analytical platforms, and data visualization tools;

– *The principle of an emotional and applied effect and involvement*. The research object should arouse the interest of students with the trends of practical orientation and symbiosis of conceptual, mathematical and computer modeling. The possibility of choosing of an individual research trajectory and taking into account the preferences of an individual can increase the motivation and creativity in research process, which is important for the formation of research skills;

– *The principle of interdisciplinarity and holomorphic*. The choice of research objects that involve the integration of content and methods of several disciplines (for example, chemistry, biology, psychology, physics, mathematics, computer science).

Let's consider the methodology for implementing of multi-stage mathematical and information-based practical tasks for three thematic groups of students in order to carry out relevant research: an artificial intelligence, virtual reality, and geoinformation technologies. When implementing the artificial intelligence models, we used the TensorFlow and Keras libraries of Python programming language, which facilitate the description, training, and operation of generative and convolutional neural networks.

Didactic stages of student's search and research activities in small groups

Stage 1. Preliminary Preparation. This foundational phase establishes the cognitive and procedural groundwork for investigating of complex mathematical challenges. It combines systemic analysis, historical insight, and pedagogical scaffolding to prepare learners for in-depth inquiry: contradiction and functionality analysis by revisiting repositories of practice-oriented natural science tasks enhanced with AI; uncovering core contradictions (e.g., theory-practice gaps, cognitive barriers); mapping functional aspects (input-output relationships, constraints, variables); generative AI and historiogenesis review by an analysing how generative AI tools can support the subtask exploration; tracing the historical development (historiogenesis) of the subtask: an evolution of methods and concepts; key breakthroughs and persistent challenges; anticipating potential hurdles and milestone steps in research trajectory; multidimensional objective formulation: setting interconnected goals as mathematical and conceptual understanding, proof construction; informational as data processing, algorithmic thinking; illustrative-graphic as visual modelling, diagrammatic reasoning; historical-genetic as contextualising knowledge within its developmental trajectory.

By the end of this phase, learners will: possess a clear understanding of subtask's thematic boundaries and challenges; demonstrate familiarity with historical and contemporary approaches to the problem; articulate multifaceted research objectives; exhibit enhanced cognitive flexibility through an exposure to diverse the solution pathways; an engage collaboratively in small-group inquiry; an apply visual and computational tools to model aspects of the problem. This phase lays

the groundwork for subsequent stages of hypothesis testing, experimental validation, and knowledge synthesis within the «problem zone».

Stage 2. Content and Technological Implementation. This phase shifts from exploration to structured problem-solving, leveraging advanced tools and methodologies to transform an initial insights into actionable research pathways. Anticipation and efficacy evaluation for forecasting of potential solution trajectories; an assessing strategy effectiveness through: risk-benefit analysis; resource allocation projections; time-efficiency estimates; using generative AI to: simulate alternative approaches; optimise multi-layered goal structures; generate scenario variations. Creating a comprehensive action plan for addressing the research query; an integrating diverse information of presentation formats: textual narratives; visualisations (graphs, flowcharts); computational outputs; multimedia components. Process evolution tracking by monitoring dynamic changes in: studied processes and phenomena; an influencing factor (internal/external); emergent patterns and anomalies; documenting developmental stages through: iterative logs; version control systems; comparative analysis frameworks. Building multi-layered representations: conceptual models as an abstract framework for understanding; domain-specific models by tailored to subtask's context; informational models by data structures and processing protocols; mathematical models by formal equations and algorithms. ICT Tool Exploration by leveraging technology for research support: data analysis platforms (e.g., Python libraries, R); visualisation software (e.g., Tableau, Matplotlib); collaboration tools (e.g., shared workspaces, version control).

By the end of this phase, researchers will have: a detailed action plan with milestones and deliverables; refined multi‑layered goals aligned with research objectives; an evolving process documentation tracking key development; strategies for managing uncertainty and risk; an enhanced disciplinary dimension (mathematical, historical, etc.); functional conceptual and computational models; proficiency in ICT research tools relevant to the subtask; a founding for empirical testing in subsequent phases.

This stage bridges theoretical exploration and practical implementation, setting the stage for hypothesis validation and knowledge synthesis in later research phases. Initial actions include: refreshing subject-specific and informational competencies; boosting student motivation and goal alignment through: mind mapping exercises; discussions on mathematical concepts, historiographical contexts, and AI tool integration for problem resolution.

Stage 3. Assessment and Refinement. This phase aims to: measure interim subject-specific, meta‑subject, and personal outcomes; monitor progress indicators for both educators and learners (e.g., reflective abilities, creativity, critical thinking, synergistic effects, and self-actualisation); adjust innovation mechanisms, research stages, and generative AI tools, emphasising: individual experiential learning; contextual education; intercultural dialogue; synthesise knowledge theoretically and empirically; document, validate, and refine procedures/algorithms; prepare findings for presentation.

Stage 4. Synthesis and Application. This final stage focuses on: transferring innovative constructs and procedures from the research context to routine classroom practice; aligning students' cognitive preferences with group achievements; exchanging information and validating project outcomes; identifying key parameters that gauge the success of students' cognitive growth in generative AI usage; interpreting results to generate a novel creative outputs; forecasting of future research directions; reinforcing motivation for self-actualisation and continued inquiry.

Example 1. Some of student's research activity directions:

– *Titanium sorting*. Automation of sponge titanium sorting by artificial neural networks using with an integration algorithm for production.

– *Save Tomato*. A Telegram bot for diagnosing tomato diseases by artificial neural networks using.

– *Spectacles*. A software tool for automated typhlo translation by using of artificial neural networks.

During the development of these and other products, students' research skills were formed both by solving a global research problem directly related to the project's goal and by solving on pre-prepared universal and applied mathematical problems from the field of an artificial neural network development (Figure 1).

Preparatory stage. In the process of an enterprise with specialists, the task was set to optimize the process of sorting titanium sponge by using of artificial neural networks. Sorting titanium sponge, or more precisely, removing of defective samples from the conveyor belt, is an

important stage of production. At this stage, about 100 employees are involved. On each belt, sorting is performed manually by 5 specialists.

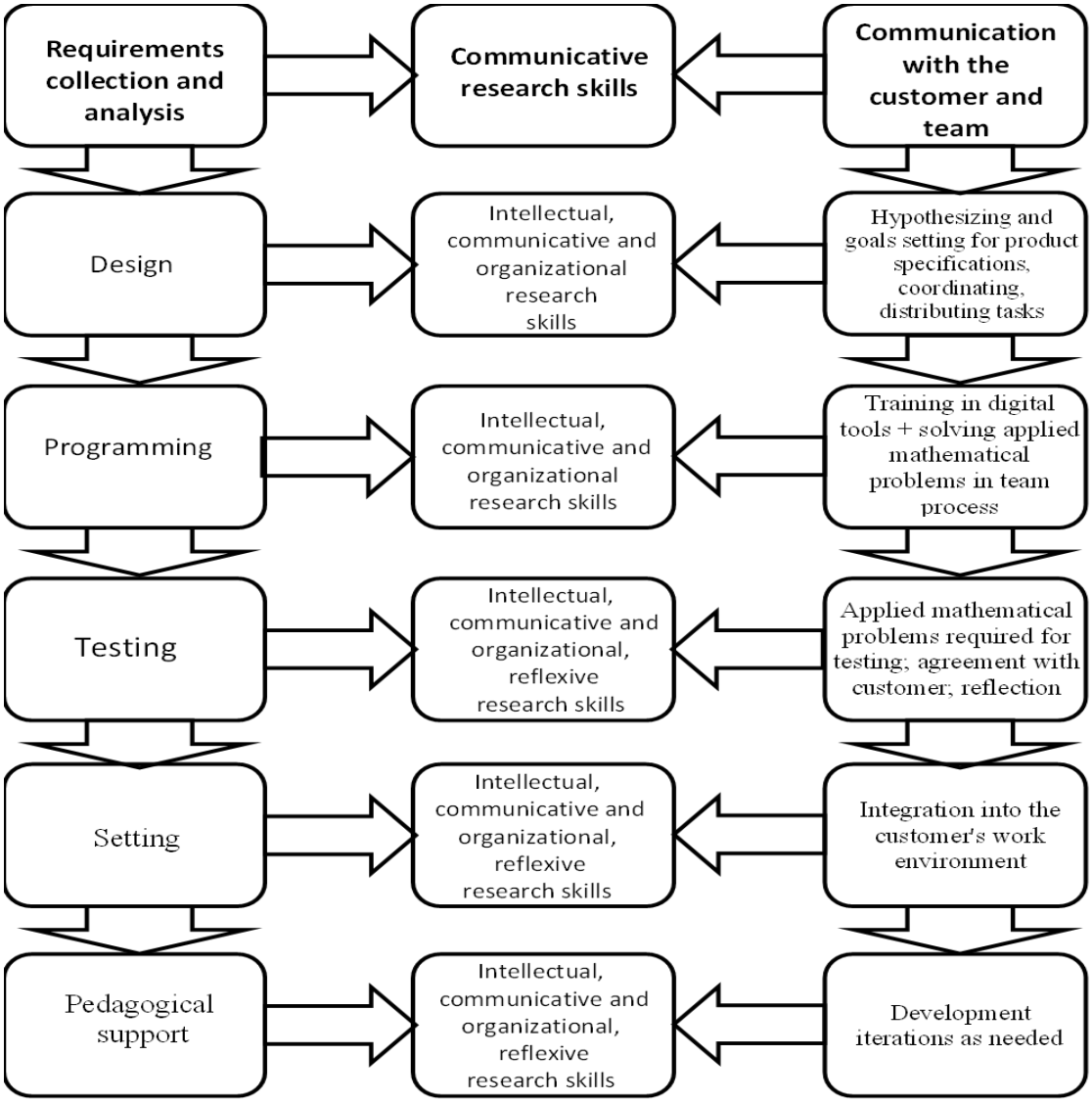

Fig. 1. Formation of research skills in the process of digital product developing

In order to use the human resources more efficiently, reduce the negative impact on an employee's health, and increase the sorting speed, it was decided to study the possibility of titanium sponge sorting by artificial neural networks using. According to the requirements of synergetic approach, our project should be carried out by students independently in the conditions of an open information and educational environment, exchange of information and cultures dialogue, information support, network and computer modeling and interaction. Therefore, the teacher only tells students about some methods of formulating goals, setting hypotheses and guides them, stimulating them to take responsibility in project different aspects for competent distribution of tasks.

Content and technology stage. General hypotheses: using artificial neural networks, it is possible to recognize the defective samples of titanium sponge; it is possible to automatically remove of titanium sponge specific samples from conveyor belt. From the general hypotheses, students come to a specific one: it is possible to develop an automated tool for defective samples recognizing of titanium sponge with their subsequent removal from the conveyor belt on an enterprise scale. Then, multiple goal setting is implemented by using one of selected methods. For example: Goal according to the 5W1H method: 1. What: to develop an automated tool for recognizing and removing on defective samples of titanium sponge. 2. Why: to improve the product quality and the efficiency of production process. 3. Who: A team of engineers and automation

specialists. 4. Where: At the manufacturing facility where the titanium sponge is produced. 5. When: Within the next year. 6. How: Using machine vision and automation technologies to integrate into the existing conveyor system.

Backward of planning method: The final goal is to implement an automated tool for recognizing and removing of defective titanium sponge samples in the facility. Step 5: Testing and debugging the system on the production line, training the staff – 1 month until project completion. Step 4: Integrate the developed tool into the production process, adjust the parameters – 2 months until project completion. Step 3: Developing software for defect recognition and removal system management – 4 months until project completion. Stage 2: Research and selection of automation and machine vision equipment, pilot testing – 6 months before project completion. Stage 1: Analysis of current processes and requirements, technical specifications setting – 8 months before project completion.

For planning, students choose one of the methods suggested by teacher. Then, based on the chosen methodology, students structure the substantive part of the project (indicating step-by-step results and by-products, bifurcation points and basins of attraction, attractors of dynamic processes, variability and fluctuations of initial states). At the identified stages, research skills are formed in the process of performing project activities. However, starting from the second stage, students can already solve applied mathematical problems, which also form research skills. For example, when discussing risks, we may encounter the problem of low efficiency of trained neural network. What if we empirically find out that the probability of correct sample recognition is 0.8, and we need a probability of at least 0.9? Students can use brainstorm and suggest various solutions to this problem, including mathematical ones. For example, take a picture of the sample several times. The probability of an error in one scan is 0.2. However, if you take a picture of the sample from several angles, for example, 4 times, the probability that neural network will make an incorrect conclusion 4 times is 0.0016. This problem will help in designing the hardware of elements analysis. So, students can propose that the sample fly through a photo frame that includes 4 photos of the sample from different sides. At subsequent stages of design, research skills are also formed within the framework of applied mathematical problems solving. For advanced students, more complex problems can be proposed, presented in the form of cases. Below are examples of problems encountered when neural network parameters optimizing.

Example 2. Students of grades 9-11 in the system of additional mathematical education completed the project "Creation and training of artificial neural network models for classification of various tomato diseases". The source material was pre-classified images with various types of tomato leaf diseases, as well as images of completely healthy leaves, published in the public domain on the Kaggle platform (kaggle.com). An open dataset consisting of 17,000 images was used. The described set was divided into the following samples: training: 10 classes of 800 photos; validation: 10 classes of 200 photos; test: 10 classes of 700 photos. Independently designed networks consisted on pairs of convolutional layers combinations with a convolutional kernel size of (3.3) with layers of dimensionality reduction by maximum element on two times, followed by straightening and processing in fully connected layers.

The optimization algorithm "Adam" was used to train the neural network. The choice of this algorithm is justified by the following advantages: support for learning rate for each parameter, typical for deep neural networks, especially for computer vision tasks; adaptation of learning rates for each parameter based on the average value of last gradient values for the weight. The value "lr = 0.0001" was empirically selected as setting for the hyperparameter of training step. The output layer consisted of 10 neurons with the activation function "Softmax". The best result was achieved by fully connected layers retraining without changing the parameters of convolutional layers. After retraining, classification accuracy of 95 % was achieved on a test sample of 7,000 photographs. The resulting network model was integrated into a bot in Telegram messenger. The software product determines the leaf disease in resulting image, lists the main signs of this disease, and also gives the recommendations for treatment. In addition to diagnostic functions, bot saves all received information, including the location of the bush, in the greenhouse disease database.

4. Discussion

The use of artificial intelligence in practical problems solving is widely represented in scientific publications. For example, in (Genaev, 2021), a neural network was developed that can detect the grain diseases at an early stage. This recognition method was implemented by

researchers as a bot called @wheat_healthy_bot on the Telegram platform, which allows for the assessment of plant damage in the field. Additionally, scientists studied the application of deep learning methods for an automatic classification and detection of cassava diseases based on leaf images. They used deep learning techniques such as convolutional neural networks and the concept of "transfer learning." New directions in science are opening up with the research of AlphaFold and AlphaFold2 artificial intelligence by DeepMind, which were created to predict the three-dimensional structure of a protein (Senior, 2020). Neural network technologies for developing project and student's research skills in studying morphology and linguistics are considered in the works (Starovoyt i dr., 2023; Burnashev i dr., 2024). A feature of this research is the identification of methodology and techniques of student's research skills forming in solving of practice-oriented tasks in natural science by artificial intelligence using.

5. Conclusion

Digital educational environments in the development of mathematics and natural sciences in school education in Russia are becoming a leading factor in the development and competitiveness of an individual in today's high-tech and unpredictable world. Students are now able to master of an artificial intelligence in education and deep machine learning methods as tools for solving and researching practical science problems through the analysis of large data sets, an automation of routine processes, self-organization, and the manifestation of synergistic effects. The study builds the strategies for digital transformation of education, a unity of scientific achievements and education, and the priority of personal values in the process of teaching mathematics and natural sciences at school, based on the actualization of models and standards for artificial intelligence using in solving practical problems in natural sciences. It has been shown that the formation of students' research skills is based on the actualization of focus centers of cognitive transformations of an individual: visual-digital and practice-oriented models of complex systems and knowledge, an emotional response to applied effects and prospects of higher education, cultures dialogue in the study of subject-specific education "problem areas", and possibility of generating artificial neural networks in applied issues of natural science. The results of the study confirm that the using of neural network technologies in project solution of practice-oriented problems of natural science can significantly improve the quality of education and contribute to the formation of student's research skills.

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Qualitative Research in the Field of Reflection of Pedagogical Practices

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Abstract

This study investigates the role of reflection in the development of tacit knowledge among student teachers during their teaching practicum. Reflection is viewed as a process through which students make their implicit, experience-based knowledge explicit, thereby linking their practical experiences with pedagogical and psychological theory. Using a qualitative research design grounded in hermeneutic and grounded theory methodologies, we analysed 108 student reflections from undergraduate teacher education programs. The participants included second- and third-year students who had completed courses in general didactics, enabling them to assess both pedagogical and professional aspects of teaching. The study aimed to identify the factors influencing the quality of teaching practice, students' perceptions of their personal growth, and their views on the teaching profession. Data were collected through written reflections and analysed using open, axial, and selective coding, with the support of the Atlas.ti software. The findings reveal that reflection plays a critical role in shaping students' professional self-concept and pedagogical competence, as well as their emotional and cognitive responses to the teaching practice. Positive working atmospheres in practicum schools, characterized by open communication and support, were also found to enhance the students' experiences. This research underscores the importance of reflective practice in teacher education and highlights how it fosters the integration of theoretical knowledge with real-world teaching experiences, contributing to the holistic development of future educators.

Keywords: reflection, reflective practice, tacit knowledge, teaching practicum, student teachers, qualitative research, pedagogical competence, professional self-concept, teacher education.

1. Introduction

It is evident that student reflections are an important part of students' tacit knowledge construction during teaching practice. Through reflection, students learn, and their teachers support this learning process.

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In recent years, teacher education has increasingly emphasized the development of reflective competence as a foundational pillar of professional teacher identity (Loughran, 2020; DeLuca et al., 2023). Within this context, student reflection during teaching practicum has emerged as a critical factor in shaping not only pedagogical knowledge but also tacit knowledge – the often unconscious, experience-based knowledge that teachers intuitively apply in complex classroom situations (Polanyi, 1966; Eraut, 2000; Xu et al., 2022). Despite this relevance, the process by which reflection helps make tacit knowledge visible and actionable remains underexamined in recent empirical literature, especially through the lens of students' authentic narratives.

We consider reflection to be a thought process in which an individual looks back on a lived experience. Thus, we are concerned with reflection "after the event" (Schön, 1983). We understand reflection as a chain of ideas that has a sequential ordering, in which each idea prefigures the next (Janík, Najvar, 2011: 68).

In our research, reflection is a tool by which partially expressible tacit knowledge can be made explicit after an experience (we assume the existence of deeply rooted tacit knowledge that cannot be made explicit). The student is not aware of this knowledge when dealing with a pedagogical situation because the teacher's action is significantly tacit (Slavík et al., Janík, 2015: 6). Reflection "after action" can be considered as a link between these unconscious creative processes and their conscious highlighting (Slavík et al., 2013: 136). The successful functioning of the above-mentioned conception of teaching practice presupposes that students' practical experiences are connected to the pedagogical-psychological theory that students acquire in pedagogical and psychological courses. Building bridges between teaching practice and teaching is simplistically suggested in Figure 1.

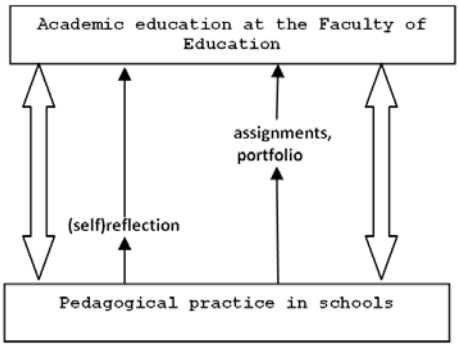

Fig. 1. Creating bridges between theory and practice
Source: Pravdová, Švec, 2014

We can also judge the effectiveness of teaching practice based on the testimonies of the student teachers themselves. Pravdová (2016) investigated how students of teaching perceived the benefits of teaching practice immediately after completing the full cycle of three teaching practice sessions. Her analysis revealed that students perceived that the key benefit of the teaching practicum was gaining their own teaching experience and new knowledge about themselves in their role as a teacher.

It was also confirmed that the teaching practicum combined with reflective seminars on the practicum had a significant impact on the formation of the professional self-concept of the future teachers.

Some more recent research examines the emotional dynamics of the practicum (Ji et al., 2022) or the effect of mentoring on knowledge transfer (Xu et al., 2022), but few investigate how students themselves articulate the gradual construction of their pedagogical identity and tacit understandings through reflection. Likewise, emerging studies on digital support tools (Kager et al., 2025) and structured reflection (Hußner et al., 2023) reveal the potential of guided practices, yet they often lack an inductive approach to uncover student-generated meaning from authentic practicum experiences.

An important integrating role in the innovated model of teaching practice is played by the student portfolio, which includes tasks whose solution also requires the use of theoretical pedagogical and psychological knowledge (see Pravdová, Švec, 2014) and Kostrub (2022). The direct organisational support of the student lies in the collaboration between the faculty and

the schools where the students carry out their practice. The faculty provides students with schools where they can practice. The direct professional support of the student involves a series of interactions designed to ensure that future teachers acquire practical knowledge and that this is related to their theoretical preparation. This includes the student's interaction with the practicing teacher at the school and the student's interaction with the teacher educator, the field didactic in the reflective seminar at the faculty.

This study addresses this gap by analysing 108 reflective texts from student teachers in undergraduate education programs using hermeneutic and grounded theory methodologies. It uniquely captures how students' written reflections reveal their evolving thinking about teaching, pedagogy, self-concept, and the profession. Through open, axial, and selective coding, we constructed a causal model illustrating how reflection functions as a bridge between theory and experience, cognition and emotion, intention and action.

The relevance of this research lies in three main contributions:

It offers empirical evidence on how reflection facilitates the formation of tacit pedagogical knowledge during teaching practice.

It provides an original conceptual framework that maps how reflection contributes to the development of professional identity and self-understanding in novice teachers.

It responds to recent international calls to include student teachers' authentic, affective, and cognitive perspectives in the study of teacher education (DeLuca et al., 2023; Loughran, 2020).

This study advances educational science by providing a data-driven model of how student teachers transform experience into professional knowing. It emphasizes the role of reflection not merely as a curricular requirement, but as a transformational mechanism that enables the emergence of pedagogical tact, emotional regulation, and adaptive expertise.

The aim of the research

The aim of the qualitative analysis of students' reflections on teaching practice was to find out factors of quality of the teaching practice in the preparation of future teachers of undergraduate students of teacher education programs in the common social scientific, pedagogical and psychological basis of teaching.

In this sense, we have oriented and focused our attention on the following sub-objectives:

– To find out how students reflect on the quality and contribution of teaching practice,

– To find out how students perceive the personal benefits of the teaching practice,

– To find out the students' opinion about the trainee teachers and their attitude during the implementation of the practice,

– To find out how students characterise the observed teaching,

– To find out the students' reflections on the teaching profession after the practicum.

2. Research methodology

In the research we decided to use a qualitative methodology approach, which allowed us to capture the formation of students' opinion through reflection. Qualitative methodology mainly focuses its attention on the depth or quality of phenomena, their interrelationships and situations, thus attempting to create a comprehensive picture through the process of induction (Švec, 1998). Its main aim is to reveal or decipher the subjective perspectives and ways in which research subjects view phenomena, their actions and what they attribute meaning to (Hendl, 2016). "Qualitative research is in line with the tenets of the interpretive paradigm, i.e., it focuses on exploring the subjective experiences of the individual and on recognizing the significance that the individual attributes to specific events" (Kostrub, 2016: 24). In a figurative sense, we could say that this kind of methodology searches for the kernel of the core of the phenomenon under investigation. It also gives us the possibility of transforming implicit data into the form of explicit and at the same time explicative statements of the subjects under study.

The partial research data, the subjects' statements, only make sense to us in terms of their totality, and each interpretation of the research subject's meanings and perspectives carries its own importance in the process of reconstructing the students' opinion through self-reflection.

We have chosen hermeneutics as a type of qualitative inquiry, which "is a theory and a tool for interpreting meaningful human action. It allows for in-depth interpretive analysis with identification of meanings" (Kostrub, 2016: 36). It can also be explained as an art or theory of explaining and understanding acts. Through these, we can learn about the structure of signs, meanings and interrelationships that are mediated by the research subjects (Hendl, 2016).

The different stages of qualitative research go through a multi-cyclical logic, which is also analogous to the process of understanding phenomena in hermeneutics. This process of understanding facts, in terms of meaning, can be described as spiral. In both cases, the research activity has an iterative character because the aforementioned understanding is subject to continuous revision in a specific context and contributes to the formation of a holistic picture of the phenomenon under study. In the research, emphasis and attention is placed on the process of forming a subjective view of the self, which the student acquires primarily through self-reflection. An anchored theory is a set of systematic inductive steps aimed at theory formation. At its core is encoding. In the process of open coding, data are broken down into fragments, conceptualized, and then composed in a new way. Open coding represents the first stage of coding, which is followed by axial coding. The essence of axial coding is the identification of relationships between categories that have emerged from the previous stage. Axial coding is followed by selective coding as the most demanding coding technique (Švaříček et al., 2007).

Grounded theory is a specific research procedure of qualitative inquiry that allows for the creation of new theory. Theory is built, grounded in the data collected. The researcher does not establish hypotheses or variables; these emerge as the researcher progresses through the levels of coding. In the process of analysis, there is progressively higher abstraction and emergence of variables and relationships between them. Strauss and Corbin (1999) describe this process in detail.

The decision to use the grounded theory strategy in our research was based on the very nature of the chosen phenomenon. The adequacy of our choice was also based on the statements of Strauss and Corbin (1999), who argue that it is appropriate to use qualitative research in those cases where we are trying to uncover the nature of someone's experience of a particular phenomenon. If we want to find out how someone subjectively deals with certain situations, how they understand certain phenomena and how they react to them, the most appropriate way of investigation is to use grounded theory, for which symbolic interactionism is the methodological starting point (Hendl, 2016).

Data were collected from written reflections written by students during and after their teaching practice. The validity of the research instrument is ensured by direct contact with students after the completion of the teaching practice and authentic testimonies as well as by systematically comparing each classification of research data with each other.

Research problem and research questions

We have outlined the definition of the research problem in light of the fact that student reflection as a phenomenon takes place in social reality and needs to be explored more deeply in the broader contexts, structures and manifestations of human activity. We conceived it on the basis of the natural chronological development of subjective opinion and at the same time, the action of the qualitative development of students, that is, especially in the context of dynamic change in the view of oneself.

Based on the focus of the research and the characteristics of the research problem, we formulated the following basic research questions for the purpose of the research in this context:

What are the students' expectations, emotions, and fears before practice?

How do students think about the teaching profession?

What specific suggestions do students have for the implementation of hospitality teaching practice?

How do students understand the benefits of the implemented practice?

What is the working atmosphere in the practicum schools during the implementation of the practicum?

How do the students think about the pedagogical competence of the practicing teachers?

How do students characterize the observed teaching?

Subjects of research

The selection of research subjects is crucial for qualitative research. We chose 2nd and 3rd year undergraduate students who had taken a course in general didactics to be able to assess the didactic and professional aspects equally. In qualitative research, the selection of subjects is always deliberate. In our research, we used theoretical sampling proposed by Glaser and Strauss (1967, in: Švaříček et al., 2007).

Our research material consisted of 108 reflections from students (84 female, 23 male) of undergraduate teacher education programs in the common social scientific, pedagogical, and psychological foundations of teaching.

Data analysis and interpretation

Open coding results in a number of inductively created terms, codes, concepts and categories that share a common core in terms of close links to the research questions. After very detailed and time-consuming work at the end of the analysis, the research data was reduced to the main indicators and at the same time expanded in relation to the interpretations of the phenomena under study. The research data were first mechanically processed by analysing the texts and then we used the software program ATLAS.ti. We chose this method mainly because of its greater clarity. In this study, we used Atlas.ti 23 a professional computer-assisted qualitative data analysis software to support the systematic analysis of 108 written reflections by student teachers. The decision to use Atlas.ti was based on its robust capacity to manage large corpora of qualitative text and its compatibility with grounded theory methodology, particularly in handling open, axial, and selective coding processes. We used network views and memo tools in Atlas.ti to integrate key categories around the central theme: Student Teachers' Reflection on Teaching Practice. The software's ability to create semantic networks allowed us to visualize and validate connections among categories.

Benefits Atlas.ti in our study are: ensured consistency and transparency in coding across a large dataset; enabled iterative comparison and refinement of categories as recommended by grounded theory methodology (Strauss, Corbin, 1998); enhanced the validity and reliability of findings through constant comparison, memoing, and visualization tools.

One of the components of the teaching practice portfolio is the final reflection, which provides a space for deeper analysis of teaching practice. Given the nature of the research data, we have chosen a qualitative research design. We subjected the final evaluation reflections to textual analysis (Řiháček, Hytych, 2013), looking for common and different elements in the evaluation of pedagogical practice.

Textual analysis of the data was conducted between January and March 2024. Based on the semantically similar responses, we thematically classified the identified elements into one of seven categories that emerged from the textual analysis of the reflections. We processed the analysed research data in Atlas.ti individually for each student's reflection, creating 108 hermeneutic units. The creative process of mental abstraction and open-coding analysis of the research data resulted in the abstraction and subsequent creation of 7 main interpretive categories (Table 1), which are further subdivided into their associated interpretive subcategories.

Table 1. Main interpretive categories and subcategories

Status	Interpretive categories	Interpretive subcategories
State at the entrance	Emotions, thoughts, fears, expectations of the student before the practice	Previous experience
		Reactions to unfamiliar environments
		Expectations before practice
		Pre-exam meeting and preparation
		Expectations related to didactics
		Positive emotions
		Stress and nervousness
State of the process	Characteristics of observed teaching	Clear articulation of learning objectives
		Variability of teaching methods
		Didactic principles
		Interaction between teacher and pupils
		Individual approach to pupils
		Use of material means
State of the process	Atmosphere during teaching	Friendly and supportive atmosphere
		Cooperation and teamwork
		Mutual respect
		Open communication

Status	Interpretive categories		Interpretive subcategories
			Focus on individual needs
State of the process	Supervising teacher	Supervising teacher approach	Professionalism and willingness
			Diversity of approaches
			Interaction and support
			Commitment and interest in teaching
			Variability of pedagogical approaches
		Pedagogical competences of a supervising teacher	Professionalism and dedication
			Communication and interaction
			Flexibility and variety of teaching methods
			Authority and relationships with students
			Commitment and interest in teaching
State at the exit	Benefit of the internship for the student		Gaining practical experience
			Connecting theory with practice
			Personality development and self-development
			Reflection and understanding of the teaching profession
State at the exit	The vocation of a teacher		Insights and attitudes
			Reflection and self-evaluation
			Interest in education and youth work
			Practice and experience
Recommendations and proposals for changes			Adaptation of the timetable
			Positive and negative experiences
			Organisation and communication in school
			Diversity of teaching methods

Each of the thematic categories represents several elements that have their own narrative value. For each category, we identified elements of similar content focus that emerged from the content analysis of the reflections.

The methods we used at each stage of the research were based strictly on the application of grounded theory. In the collection phase, we used the method of content analysis of the texts of the students' reflections. In our research, we sought to use the qualitative method of written self-reflective narrative. According to Woods (1986), this is an excellent source of data. Its positive point is that through such method it is possible to reach the internal perspective of the actors (Šeďová, 2012).

We worked using the software program Atlas.ti. We chose this tool mainly because of its ability to clarify and systematize greater corpora of data (Figure 2. Example of research data analysis by open coding using the Atlas.ti software).

Fig. 2. Analysis of research data using Atlas.ti

The next step was axial coding, which follows seamlessly from open coding. "It aims at making connections between categories and subcategories" (Strauss, Corbin, 1999 in Švaříček et al., 2007: 232). Both types of interpretive categories involve existing phenomena emerging from the congruent features and nature of the research data, emerging from students' reflections. Using induction to identify specific elements of the symbols, we uncovered conceptual relationships that contribute to the creation of a holistic picture of the phenomenon under study in students' reflections. In doing so, we contributed to the re-grouping of categories that implies the creation of structure through the systematic categorization of research data. In short, we identified interrelationships, which were later used in the creation of the conceptual map (Figure 4). Thus, the aim of axial coding was to create several axes that link interpretive categories and subcategories to each other. We conceived the axes on the basis of a paradigmatic model (Figure 3). Example of the creation of a schema of the phenomenon under study.

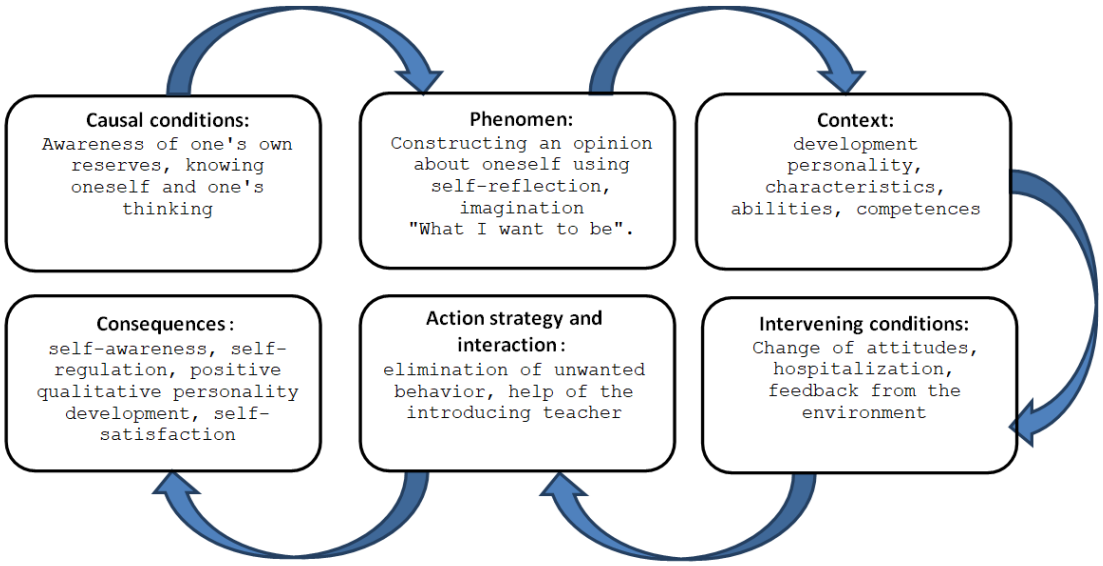

Fig. 3. Paradigmatic model

The above paradigmatic model allowed us to think systematically and form new interrelationships between the main interpretive categories and subcategories.

The last analytical technique we used was selective coding. According to Strauss, Corbin (in Švaříček et al., 2007: 233), it "involves the selection of a single key category around which the basic analytic narrative is organized". The other categories are closely linked to it, i.e. they are correlated. The central category is "Student Teacher Reflection on Teaching Practice," to which the sub-category of constructing a view of the teaching profession, containing the phenomenon under investigation, is linked. In selective coding, we focused on describing the phenomenon under study based on the frequency of relationships between the categories with each other and the dimensions resulting from axial coding. In this step, it was mainly a repeated analysis of the interrelationships, which we continuously verified and improved, thus bringing a dynamic effect of constructing the student's opinion of the teaching profession into the interpretation of the phenomenon under study. Thus, based on the causal model, an analytic story emerged in which any change in conditions causes a transformation in the underlying phenomenon. Thus, the student's subjective view of himself through his self-reflection and reflection changes depending on the influence of various factors such as personality development, feedback from the environment, forms of self-reflection, and so on. The structure of the conditions of constructing the student's opinion of himself is also related to the change of opinion, the way of changing the opinion, the development of personality, and the frequency of self-reflection realization. The conditions cannot be understood as a static fact, especially because the variables of the causal model forming interrelations are dynamic and influence the phenomenon under study itself depending on the particular trajectory of the formation of the student's opinion of himself as a future teacher.

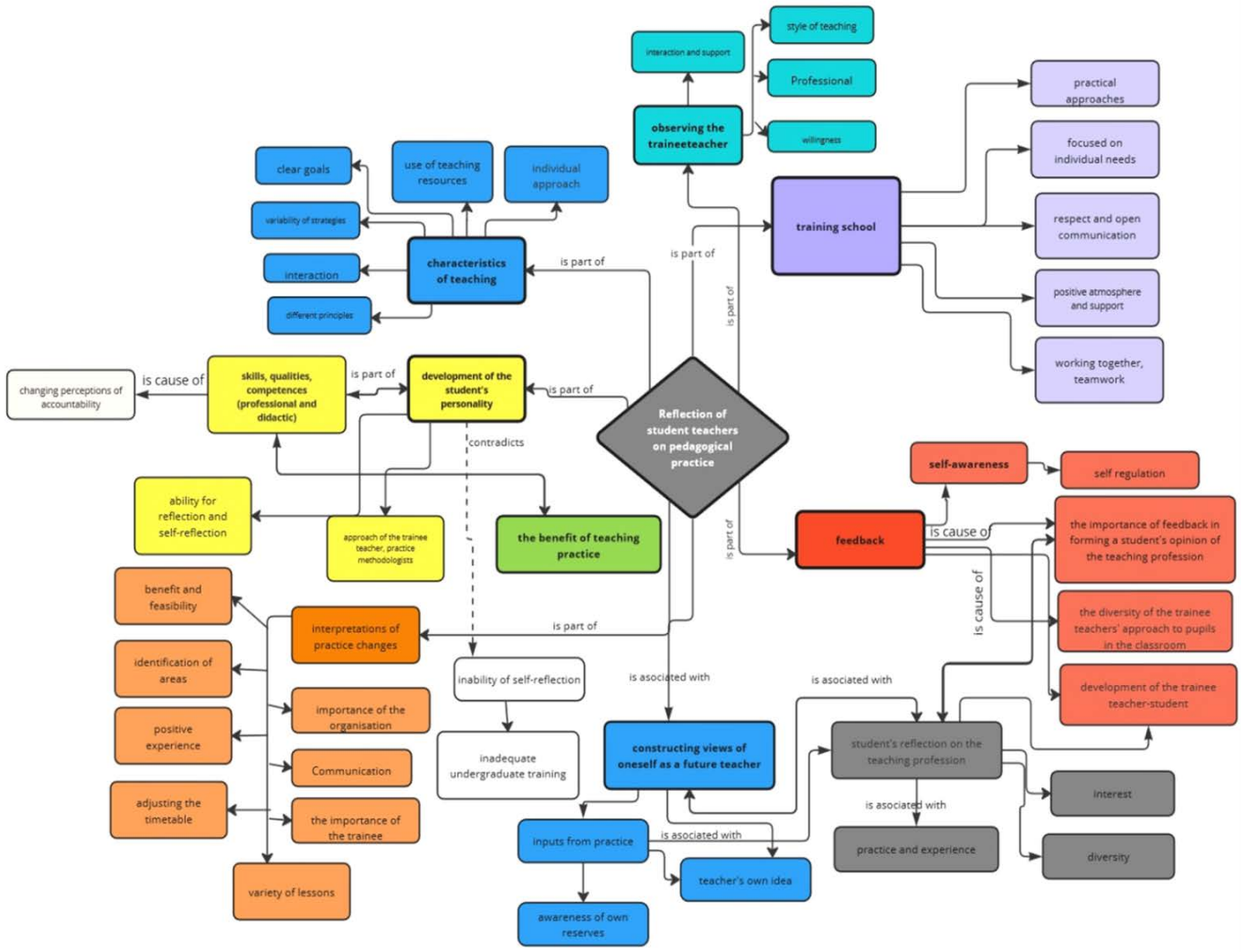

Fig. 4. Causal model based on selective coding

3. Results

In this section, we present the most important research findings based on the analysis of the research data in the form of interpretations of individual indicators, i.e. categories and subcategories from the students' written reflections. First of all, it is about the creation of explicative diagrams, which are theoretical in nature, and offer answers to the research questions. We want to draw attention to the fact that the results are not a trivial description of what is said or a simple description of students' shared experiences, but they provide a picture of the process of gradual formation of students' opinion conditioned by self-reflection, through the analysis and subsequent interpretation of the research data. Through analytical techniques, we have created a structure that includes interpretations of the research findings from the students' perspectives.

Using the analytical technique of axial coding, we avoided a fragmented, i.e. fragmentary, description of the phenomenon under study. In interpreting the research findings, we focused on uncovering and explaining the incentive of a particular action in the role of the student as a future teacher.

What are the students' expectations, emotions, and fears prior to practice?

Some common interpretations for students' expectations, feelings and fears prior to practice can be drawn from the reflections and identification of interrelationships:

Previous experiences influence expectations: Completing the teaching practice (A), influenced their feelings before the teaching practice (B). Those who had a positive experience with previous practice had less stress and fears before the next practice.

Different reactions to unfamiliar environments: students had mixed feelings or fears about new environments, especially a school they were not yet familiar with. Those who already had experience with the school had fewer concerns.

Expectations related to didactics: students expressed interest in the didactic aspect of teaching and looked forward to the opportunity to observe the teaching methods and practices of the teachers.

Stress and nervousness before new tasks: Selected students admitted that even though they had previous experience, they still felt some nervousness or stress before new tasks and challenges, especially when it came to the didactic focus of the practice.

Positive emotions after the internship: Students expressed themselves positively about the internship after the internship, highlighting the beneficial experience and the good environment in the school.

Overall, teaching practices are an important part of the preparation of future teachers and influence their feelings, expectations and experiences in teaching and education. The main indicators and extensions in relation to the interpretations of the phenomena under study can be the following: previous experience, emotional reaction, expectations from the practice, reactions after the practice.

What is the working atmosphere like in the training schools during the implementation of the internship?

The following interpretations and conclusions can be drawn from the students' reflections:

Positive atmosphere and support: Descriptions of the practice schools emphasize the pleasant atmosphere and support from the management, teachers and even among the students themselves. This support creates an environment in which students felt comfortable and motivated.

Respect and open communication: relationships between teachers, pupils and students were based on respect and open communication. Students also had the opportunity to express their opinions and have a conversation with the school management as well as with the teachers, which contributes to a better pedagogical practice.

Focus on individual needs: students had the opportunity to observe that teachers try to adapt teaching to pupils' individual needs and support their development not only in educational but also in social areas.

Collaboration and teamwork: In the training schools, collaboration and teamwork are also given attention, which helps students to develop social skills and to learn from each other.

Overall, we can conclude that, according to the students, training schools are places where not only cognitive performance is important, but also the development of students' personality and social skills. There should be a friendly and supportive atmosphere in the schools, mutual respect between management, teachers and pupils, and open communication with students as well.

From the above indicators, a suggestion was made to organize workshops, team building activities, emphasizing the importance of cooperation in all aspects of education. Furthermore, the possibility of providing space for individual meetings between practising teachers and students to solve problems, organising events that strengthen relationships and cooperation between teachers, pupils and practising students, such as sports competitions, theatre performances and joint activities outside the school.

How do students think about the pedagogical competencies of supervising teachers and also the approach of supervising teachers?

Common interpretations and conclusions could be drawn from the comments on the pedagogical competencies and approach of supervising teachers:

Professionalism and willingness: According to the students, the supervising teachers are professional in their profession, willing to help the students. Their ability to communicate with students and answer questions are highlighted as positive aspects.

Variety of approaches: The supervising teachers have different teaching styles and use different methods. Some preferred classical methods, while others were more open to interactive methods and also used modern technology. This diversity gave students a broader perspective on teaching and teaching methods.

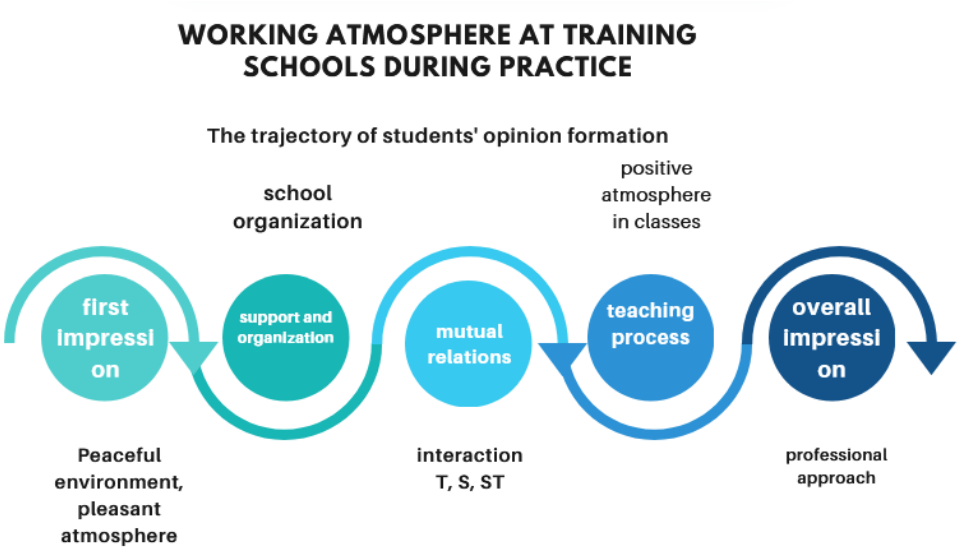

Fig. 5. Trajectory of shaping students' views on the atmosphere in training schools

Interaction and support: The supervising teachers had a positive relationship with the students during the placement and tried to support them. Their ability to actively interact, be approachable and support students in learning are highlighted as strengths.

Dedication and interest in teaching: The supervising teachers were passionate about working with students and showed interest in teaching, according to the students. Their friendly but still authoritative approach was encouraging to the students.

In the next section, we present the trajectory of the formation of students' views of supervising teachers.

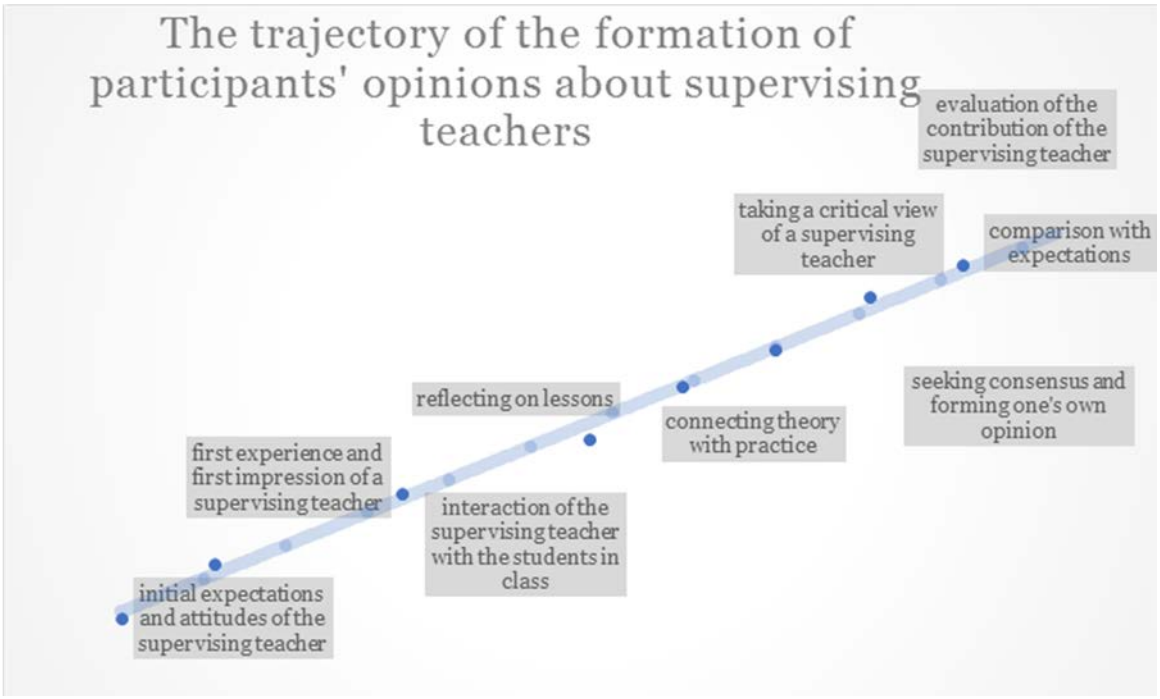

Fig. 6. Trajectory of students' opinion formation about introducing teachers

How do students characterize the observed teaching?

Common interpretations and inferences for the characteristics of observed teaching during teaching practice can be stated as follows:

Diversity of methods and approaches: students had the opportunity to observe a variety of teaching methods, indicating that teachers tried to adapt their approach and methods according to the needs of the classroom and the subject.

Clear articulation of teaching objectives: Teachers clearly articulated teaching objectives, which is important for structuring and effective teaching.

Use of didactic principles: Teachers tried to apply didactic principles such as appropriateness, intuition and activity, which can have a positive impact on pupils' retention and understanding of the material and/or learned content.

Appropriate use of material resources: The material resources were well adapted to the content of the lesson and helped pupils to better understand the content.

Interaction between teacher and pupils: the students were able to see that the supervising teachers tried to create an interactive environment where there was room for discussion, questions and pupils' involvement in the teaching process.

Individual approach: students reported that teachers were aware of the needs of individual students and tried to adapt the teaching to suit them, whether through individual work, pair work or group work.

These shared interpretations and conclusions suggest that dynamic and adaptive teaching was identified by the subjects in their pedagogical practice, which sought to take into account the needs of the learners and to effectively achieve the stated learning objectives.

What is the student´s thinking about the teaching profession?

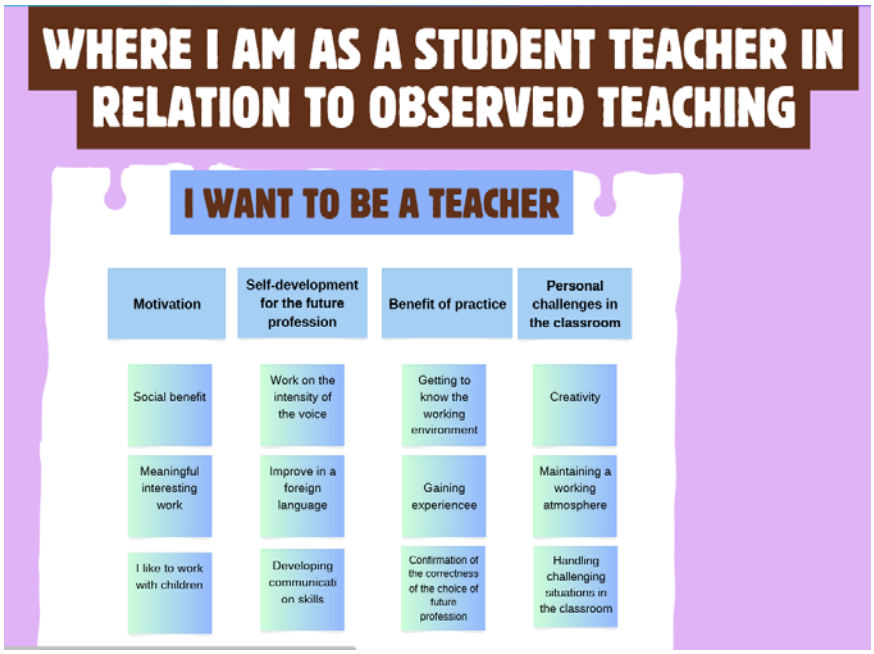

Fig. 7. Graphical representation of the trajectory of forming a student's opinion of him/herself as a future teacher through self-reflection

From the students' reflections, we can draw several common interpretations and conclusions regarding students' thinking about the teaching profession:

Diversity of perspectives: students have different perspectives and attitudes towards the teaching profession. Some see it as a stable and important profession, while others are concerned about the difficulty and poor pay.

Enriching experience: Students perceive the experience of observing teaching as enriching and motivating. The experience provided them with a space to reflect on their future careers and gain necessary knowledge and experience.

Commitment to education: Students realise that the teaching profession is not just a job, but also a commitment to pupils and their education. This involves: responsibility, patience and challenges.

Decision-making process: Some students feel more confident in their decision to become teachers after the experience, while others remain unsure or become more open to other options such as working in psychology or other support roles in education.

Working with people: students recognise that working with people, especially children and young people, is challenging but fulfilling. They are interested in learning and influencing the next generation.

The need for practice and self-improvement: It is important for students to gain experience in the field and to continuously improve in their profession. Practice allows them to gain knowledge about the realities of teaching and communicating with students.

These shared interpretations and conclusions give us insight into the diverse reflections and experiences of students.

How do students characterize the benefit of the implemented practice?

From the students' reflections, common interpretations and conclusions regarding the benefit of pedagogical practice for students can be drawn:

Gaining practical experience: Students reported that the teaching experience allowed them to gain practical experience and competences that are important for their future profession. This experience helped them better understand what it means to be a teacher and how to cope with the challenges of teaching.

Linking theory with practice: Students emphasized the importance of linking theoretical knowledge acquired during studies with practical experience from (observation of) teaching practice. This connection enabled them to better understand and, in the future, to better apply didactic principles and methods in a real teaching environment.

Personality development and self-development: Students mentioned that teaching practice helped them not only to acquire professional knowledge, but also to develop personal qualities such as critical thinking, flexibility, ability to adapt and building relationships. These aspects are just as important for successful teaching as professional knowledge.

Reflection and understanding of the teaching profession: Students expressed that the teaching observation experience allowed them to gain a deeper understanding of what it means to be a teacher and the impact they can have on the lives of their students. This experience motivated them to further personal and professional growth in the field of teaching.

Pedagogical practice has a significant benefit for students, as it provides them with the opportunity to connect theory with practice, gain a form of practical experience and develop personal qualities necessary for successful teaching.

What specific suggestions do students have for the implementation of the teaching practice?

From the reflections of the students, we can state several main interpretations and conclusions about proposals and recommendations for the implementation of pedagogical practice:

The importance of a variety of teaching methods: Students emphasize the importance of experiencing different types of teaching strategies. They suggest that the internship should include different classes, subjects and teachers, which would allow them to gain a varied perspective on teaching approaches and school environments.

The importance of better organization and communication: Students point out the importance of good organization and communication in schools. Students seem to appreciate an environment where it is easy to navigate and where school staff are friendly and helpful.

The need to adjust the schedule: Students expressed the need to adjust the practice schedule to include more different classes and teachers and to focus on subjects within their approbation. This proposal emphasizes the need to ensure that students gain sufficiently diverse experiences during their internship.

Positive and negative experiences with practice: students report rather positive experiences with practice and do not see the need for any fundamental changes.

From these interpretations and conclusions, it follows that important aspects for the implementation of pedagogical practice are the diversity of experiences, effective organization and communication in the school, and adaptation of the schedule so that students get the most from their practice.

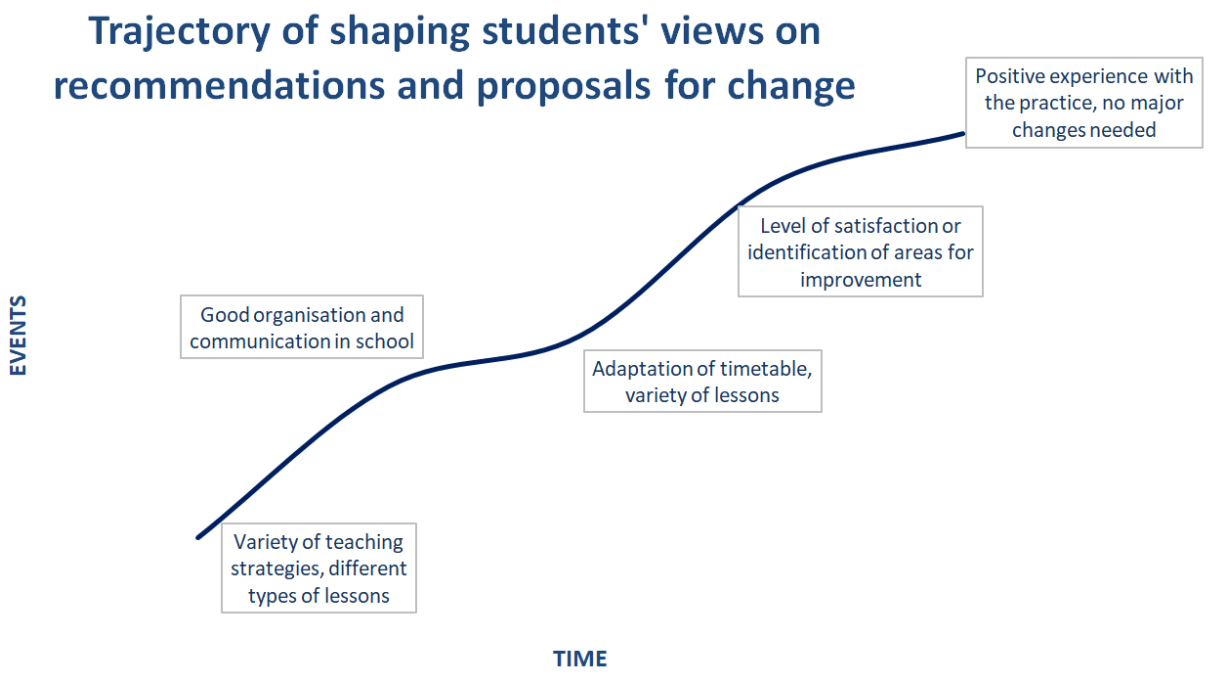

Fig. 8. The trajectory of forming students' opinions about recommendations and suggestions

In the final phase of colloquia (reflective discussions) of pedagogical practice, we asked the students to comment on the implementation of the colloquia. We asked the students to give their evaluation and feedback on the colloquium. Here are some parts of the students' statements:

S-1: "I was very satisfied with the colloquium... I know that it helped many, including me, in clarifying several didactic concepts."

S-2: "The course of the colloquium followed what was announced at the beginning, everyone had a chance to express themselves."

S-3: "I liked the colloquium. It was individual enough, so everyone had room to express themselves. There was also plenty of time for additional questions".

S-4: "Pleasant, it didn't miss a point. It's a shame that little time was spent on the discussion".

S-5: "The colloquium was held in a pleasant atmosphere, I liked the individual opportunity to comment on the evaluation, the acceptance of feedback and the willingness on your part. The discussion was stimulating, the questions were practical, focused on reasoning, I positively assess that the focus is on real experiences and not theory from lectures".

S-6: "Very pleasant atmosphere. I appreciate this opportunity to have an open and free discussion, also considering that there is also a director with experience and a rich perspective on the matter".

S-7: "It is an effective activity that allows students to point out the shortcomings but also the strengths of their performance in the field of practice. It allows students to "take on" the role of a teacher and make students think about how they would proceed".

S-8: "In my opinion, it was well organized. I liked that it was split into two parts. One that was dedicated to our portfolios and the other that worked on the style of the debate. It was also in a pleasant atmosphere.

S-9: "In my opinion, feedback on our portfolios for pedagogical practice is very important for us students, so that we know in which part of the portfolio we expressed ourselves incorrectly, in order to confirm or gain knowledge regarding the education of pupils and that we could defend our opinions. I liked that it was completely open and everyone could comment on the topic or their portfolio." Based on the students' statements, we can create the following causal model of students' thinking about the final colloquium – Figure 9.

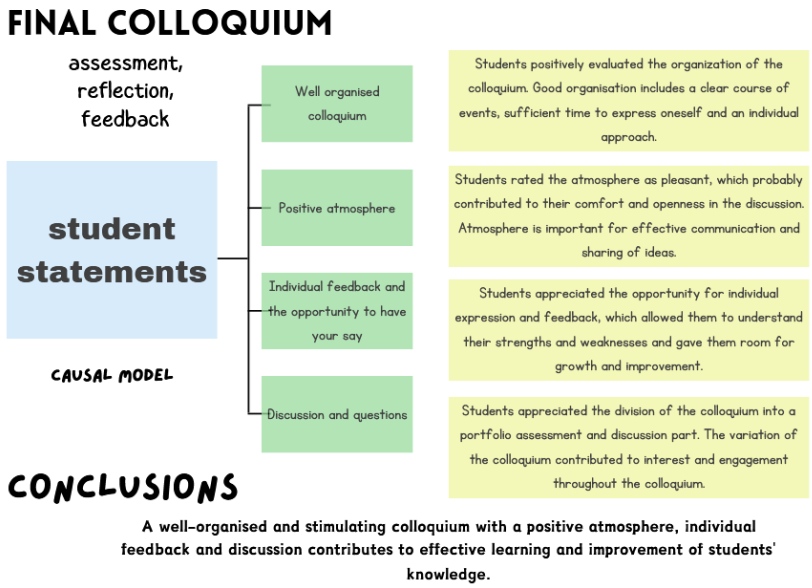

Fig. 9. Student's reflection on final colloquiums

Overall, we can say that a well-organized and stimulating colloquium with a positive atmosphere, individual feedback and discussion contributes to effective learning and improvement of students' knowledge.

4. Discussion

The findings of this study confirm that reflection is an essential process in the development of student teachers' tacit knowledge and professional identity during teaching practice. This supports Schön's (1983) concept of "reflection-on-action," where individuals engage in meaning-making after a professional experience. Through their reflections, students in our study articulated deeply personal and professional transformations, often drawing connections between theory and practice – an outcome emphasized as essential by Korthagen et al. (2011) in their model of realistic teacher education.

In alignment with the work of Loughran (2020), who highlights reflection as a bridge between knowledge and professional growth, our data show that reflection enabled student teachers to critically analyze their experiences and internalize key pedagogical principles. The students' ability to identify effective teaching strategies, classroom dynamics, and their own emotional and cognitive responses suggests that reflective practice nurtures the integration of practical and theoretical knowledge.

The supportive and communicative atmosphere in practicum schools, as highlighted by our participants, resonates with the findings of Zeichner, Liston (1996), who emphasize the importance of mentoring relationships and school culture in shaping pre-service teachers' learning. Similar to the work of Hobson et al. (2009), our study underscores that the quality of mentoring – characterized by openness, feedback, and professionalism—significantly contributes to the student's confidence and identity development as future teachers.

Moreover, the observation that students valued variety in teaching methods and mentoring styles corresponds with the findings of Farrell (2013), who argues that diversified teaching exposure is crucial for fostering reflective capacities and adaptability among future teachers. This variety allowed students to compare approaches, evaluate effectiveness, and imagine their own teaching personas, which is a key outcome in teacher professionalization, as noted by Beauchamp, Thomas (2009).

A particularly important outcome of our study is the recognition of tacit knowledge as a formative element in the professional growth of student teachers. Following Polanyi's (1966) theory, which states that "we know more than we can tell," our research illustrates that reflective writing enables students to uncover, articulate, and refine knowledge that is otherwise inaccessible or unconscious. Similar observations have been made by Eraut (2000), who emphasizes that

professional knowledge is largely tacit and that reflection serves as a vehicle for making it accessible and actionable.

The final colloquia, as described by the students, proved to be meaningful reflective spaces that encouraged deeper engagement with teaching concepts and allowed for open dialogue – mirroring the role of structured reflection seminars described by Hatton, Smith (1995) as central to effective teacher education programs. Students appreciated not only the feedback and discussion but also the opportunity to verbalize their self-concept and internal changes, reinforcing the idea that professional identity is constructed socially and dialogically.

Lastly, our results suggest that pedagogical practice is not only a technical training but a transformational experience, supporting the view of teaching as an evolving identity (Beauchamp, Thomas, 2009; Sachs, 2005). The teaching practicum, when embedded in reflective structures, fosters critical thinking, personal development, and a deeper commitment to the teaching profession.

5. Limitations and prospects for further research

Despite the rich insights gained from this study, several limitations must be acknowledged. The research was conducted using written reflections from a specific group of undergraduate student teachers from selected programs. This limits the generalizability of the findings to other educational contexts, cultures, or institutional settings. Since participants were voluntarily submitting reflections as part of their course portfolio, there is also a possibility of social desirability bias, where students may have emphasized positive experiences or downplayed critical views.

The study relied exclusively on qualitative, text-based data, without triangulation through classroom observations, interviews, or mentor perspectives. As a result, the findings capture only students' subjective interpretations of their teaching practice and not the actual classroom performance or mentoring quality. Although grounded theory and hermeneutic analysis provide deep insights, they do not allow for statistical validation of findings across larger populations.

In this paper, we present only the results of the content analysis of the written products, but our broader analyses of reflections on pedagogical practice included analysis of interviews with research participants in the colloquia. The interviews conducted support the theory derived from the content analysis method of the products. The scope of this paper, however, did not allow for the inclusion of these interview analyses in the results.

The data were collected at a single point in time—immediately after the practicum – making it difficult to assess long-term impacts of reflection on professional development or tacit knowledge retention. Reflection is a dynamic process that evolves over time, and longitudinal studies would be needed to understand how initial insights from practicum experience influence later teaching practice.

Future research could build on these findings in several directions:

– Longitudinal studies could track student teachers from practicum through their induction years, analysing how early reflections influence later professional identity and classroom behavior.

– Mixed-methods approaches incorporating interviews, video analysis, or teaching portfolios could provide a more comprehensive picture of how tacit knowledge develops and manifests in real teaching actions.

– Comparative studies across different teacher education systems and cultural contexts could offer valuable insights into how reflective practices and professional growth are shaped by institutional frameworks and local norms.

– The integration of digital tools for reflection (e.g., video journals, online feedback platforms, AI-supported analysis) also represents a growing area for exploration, particularly in the context of hybrid or online practicum experiences.

– Finally, future studies could include mentor and supervisor reflections, enabling a multi-perspective analysis of how different stakeholders interpret teaching practice and support the development of novice teachers.

By addressing these limitations and extending the scope of inquiry, future research can contribute to a more comprehensive understanding of the role of reflection in teacher professionalization, especially in cultivating tacit pedagogical knowledge, emotional resilience, and adaptive expertise in diverse educational environments.

6. Conclusion

The findings from this research highlight the significance of reflective practice in the preparation of future educators. Through reflection, students not only internalize their observed

teaching experiences but also build fundaments to bridge the gap between theoretical knowledge and practical application. The process of reflection allows them to better understand their personal and professional growth as educators, as seen in their evaluations of teaching practices. The qualitative approach, particularly grounded theory, enabled us to uncover how students' expectations, emotions, and perceptions evolve throughout their practicum experience.

Moreover, the positive atmosphere in the training schools, characterized by support, respect, and open communication, plays a crucial role in shaping students' perceptions of the teaching profession. Collaborative environments and tailored teaching methods further enrich the student-teacher experience, encouraging both cognitive and social development.

Teaching practice is not merely a procedural requirement but a transformative journey for future teachers. By integrating reflection into the curriculum, educators can better prepare students for the dynamic and multifaceted nature of teaching, ensuring that they enter the profession not just with knowledge but with the ability to critically assess and improve their practice.

7. Acknowledgments

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Bibliometric Analysis of STEAM Education and Technical Thinking in Primary Schools: Trends and Prospects (2014–2025)

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Abstract

Relevance: The integration of Science, Technology, Engineering, Art, Mathematics (STEAM) education in primary schools aims to foster students' technical thinking and creativity, and establish foundations for success in technology fields. A bibliometric analysis of Scopus research shows a growing interest in STEAM education in primary schools, identifying trends and key authors.

Method: This study presents a bibliometric analysis of 1364 scientific publications on STEAM education, primary education, and technical thinking development based on Scopus data from 2014 to 2025. The focus was on how STEAM approaches are integrated into primary education to promote critical and technical thinking.

Results: Since 2018, publication activities have increased, indicating growing global interest in interdisciplinary learning models.

Conclusions: Most studies were conducted in developed countries including the United States, South Korea, China, and Spain. Four main thematic clusters emerged: STEAM curriculum integration, cognitive and problem-solving skills development, digital tools and robotics use, and teacher training.

Keywords: bibliometric analysis, elementary school, Scopus, STEAM, technical thinking.

1. Introduction

The integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) into primary education is recognized as a promising approach for fostering technical thinking in young learners (Bertrand, Namukasa, 2020; Asunda et al., 2023). This interdisciplinary paradigm focuses on cultivating creativity, problem-solving abilities, and critical thinking through project-based activities (Mutawah et al., 2021; Rahmawati et al., 2019). Given the rapid technological

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advancement across all spheres of life, developing these competencies from an early age becomes critically important for preparing students for the future. Technical thinking enables pupils not only to navigate the technological world but also to actively shape it, understand the principles underlying technologies, and apply them to address relevant challenges (Lytra, Drigas, 2021; Ayanwale et al., 2024). It provides a structured approach to solving complex problems, develops analytical capabilities (Kurnia, Caswita, 2020), serves as a catalyst for creativity and innovation (Mamaeva et al., 2020), and establishes a foundation for adaptability and lifelong learning amidst constant technological change (Fleer, 2020). Furthermore, cultivating technical thinking in primary school students represents a strategic response to the global shortage of qualified professionals in technical fields (Marín et al., 2021; Reinhardt, 2024).

However, the successful integration of STEAM education in primary schools faces significant challenges, primarily related to teacher preparedness and technological accessibility issues. Many primary school educators lack specialized training in interdisciplinary STEM/STEAM methodologies, which is crucial for effective implementation (Afizal Abd Ghani et al., 2023; Agudelo Rodríguez et al., 2024). Professional development programs often remain fragmented and fail to equip teachers with the necessary pedagogical content knowledge and confidence to lead project-based STEAM activities (Huang et al., 2022; Fabian et al., 2024).

Simultaneously, equitable access to digital tools and resources remains a critical issue. Disparities in technological infrastructure between regions and schools can exacerbate existing educational inequalities, hindering the adoption of hands-on, technology-enhanced learning, which is central to STEAM (UNESCO, 2023; OECD, 2023). The effectiveness of interventions such as Bring Your Own Device (BYOD) policies also depends heavily on supportive school environments and teacher readiness to integrate personal technology into the curriculum (McLean, 2016; Schmitz et al., 2024).

These intertwined challenges of teacher competency and digital equity represent a significant gap between the theoretical potential of STEAM education and its practical application in diverse primary school contexts in Malaysia. Therefore, a systematic analysis of existing research trends is needed to map the current knowledge landscape, identify effective strategies for teacher support, and highlight directions for overcoming the technological barriers. This bibliometric review aims to address this need by examining publication trends, key themes, and research fronts in STEAM education and technical thinking development from 2014 to 2025.

2. Literature review and problem statement

Research confirms the effectiveness of contemporary pedagogical tools for developing essential skills. Specifically, the use of 2D and 3D didactic games has proven effective in enhancing spatial reasoning and components of STEAM thinking among students. Incorporating such games into the educational process facilitates the integration of interdisciplinary knowledge, fostering logic, creativity, and visualization skills (Totikova et al., 2020; Pytlík, Kostolányová, 2019). Educational games stimulate student interest and engagement, positively impacting motivation and academic outcomes (Durak, Yılmaz, 2019). While 2D games (e.g., puzzles, graphic builders) develop fundamental understanding of geometric shapes and proportions, 3D games enable students to interact with objects in three-dimensional space, significantly improving mental rotation and design capabilities (Forbes, 2020; Totikova et al., 2019).

The pedagogical potential of STEAM lies in its interdisciplinarity: it enables the exploration of scientific concepts through the lens of technology and engineering, their interpretation through the arts, and grounding in mathematical logic (Sun, 2021; Sung et al., 2023; Long, 2017). This approach promotes the development of STEM literacy, problem-solving skills, collaboration, and critical thinking (Rice, 2020; Okwara, Pretorius, 2023), alongside understanding STEM concepts, creativity (Bui et al., 2022; Antwi et al., 2022), and computational thinking as a fundamental skill for the digital era (Bedar, 2020). The integration of digital tools (augmented reality, platforms like Smart cars) and innovative technologies opens new avenues for immersive and project-based learning within STEAM (Rahmawati et al., 2021; Li et al., 2020), enhances digital literacy (Lu, 2020; Piila et al., 2020), and necessitates corresponding teacher preparation (Handayani, 2020; Liu, Shi, 2019; Le et al., 2021).

Bibliometrics serves as an effective tool for systematizing the growing body of research in STEAM education. Bibliometric analysis, understood as a quantitative method for assessing the research landscape, allows for the identification of trends, key authors, influential publications,

citation networks, and the intellectual structure of the field (Lytra, Drigas, 2021). Such studies are particularly valuable for understanding the state of the art, priorities, methodological approaches, and geographical distribution of work in dynamically evolving interdisciplinary areas like STEAM in primary education focused on technical thinking development (Bedar, 2020: 84). Despite increasing interest in STEAM and technical thinking (Phuong et al., 2023), there remains a need for a systematic bibliometric study specifically focusing on the convergence of three key elements: STEAM education, primary school, and technical thinking development. Existing bibliometric works on STEM/STEAM (Supriyadi et al., 2025; Ekawati et al., 2025; Ha et al., 2020) do not address this specific yet significant niche. Identifying the most productive research directions, influential works, and crucially, existing gaps specifically within the context of developing technical thinking in primary school students through STEAM remains a pertinent task.

Research aim and objectives

In light of the above, the aim of this study is to conduct a comprehensive bibliometric analysis of scientific publications indexed in the Scopus database from 2014 to 2024, to identify trends, structure, and future research directions in the application of the STEAM approach in primary education for developing technical thinking.

To achieve this aim, the following objectives are addressed:

1. Identify key elements of the research landscape: determine the most influential publications, authors, scientific journals, institutions, and countries contributing significantly to this field.

2. Analyze the conceptual structure of the field: identify main topics, trends, and their developmental dynamics through the analysis of keywords, thematic clusters, and the evolution of research interests.

3. Assess scientific impact and collaboration: analyze citation networks to evaluate the impact of key publications and map collaboration networks between authors, institutions, and countries.

4. Identify gaps and promising directions: based on the identified trends and field structure, delineate under-researched aspects and formulate recommendations for future research.

5. Synthesize findings for educational practice: summarize the analysis results to provide evidence-based recommendations for designing and enhancing STEAM curricula, pedagogical strategies, and activities that effectively develop technical thinking in primary school students.

The conducted analysis aims to provide a deep understanding of the current state of research, serve as a foundation for further inquiry, and contribute to the development of more effective educational practices and policies in STEAM education at the primary level (Saputra, 2025).

3. Methodology

The Scopus database was selected as the source of bibliographic data – a leading bibliographic platform covering a wide spectrum of peer-reviewed scientific publications in education, including research related to the STEAM approach (Alreahi, 2023).

Only peer-reviewed journal articles, conference proceedings, and book chapters were included; non-peer-reviewed sources such as editorials, opinion pieces, and dissertations were excluded to maintain research integrity. Following the initial search, a multi-stage screening process was applied. Records were imported into reference management software for deduplication and organization.

Bibliometric methods enable detailed analysis of publication trends, document types, and language distribution. VOSviewer software was employed to identify thematic clusters and conceptual relationships through keyword co-occurrence analysis (Verma, 2020). Similarity viewer tools facilitate the visualization of bibliographic linkages between sources and countries (Modak, 2020). Extracted data included titles, abstracts, authors, affiliations, publication years, keywords, and citation counts (Shatu et al., 2022).

Research scope and analytical objectives

This study aims to systematize and visualize the scientific discourse concerning STEAM education, technical thinking, and primary schooling. Its primary objective is to identify leading authors, institutions, countries, dominant research topics, and the dynamics and structure of publication activity within this domain from 2014 to 2025.

The publication filtering and selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, ensuring reproducibility, transparency, and analytical consistency (Page et al., 2021; Parums, 2021).

Data source

Scopus was chosen as the primary bibliographic database due to its extensive coverage of peer-reviewed scientific journals worldwide and its provision of reliable data for bibliometric studies (Figure 1).

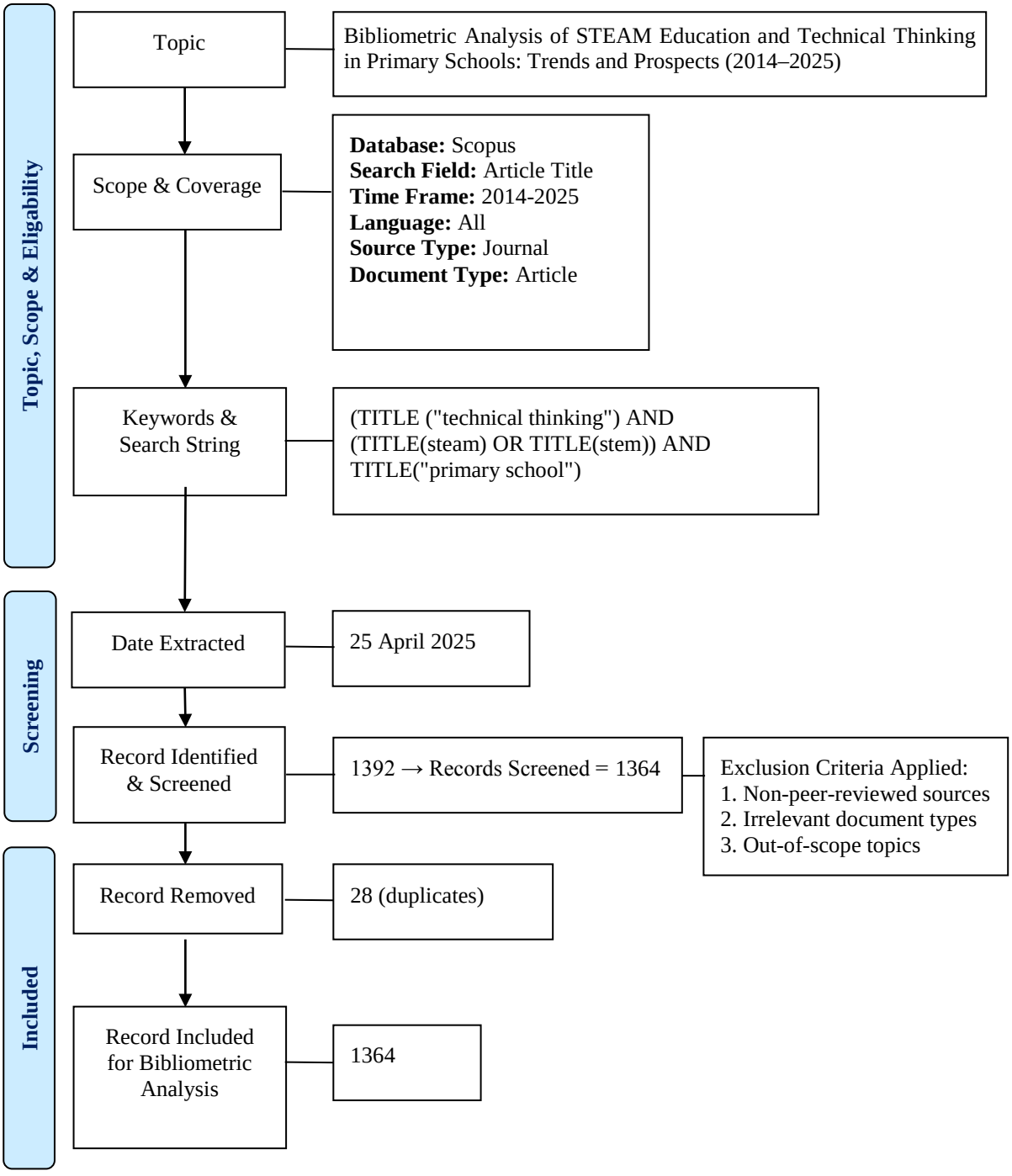

Fig. 1. PRISMA Flowchart of the Search Strategy

Search criteria

The search strategy was designed to maximize the coverage of relevant publications while maintaining precision. The query was constructed using Boolean operators (AND, OR) and truncation (*) to account for plural forms and common suffixes of the words.

The initial search string was refined through multiple pilot searches to balance the recall and relevance. The final query searched for terms in the article title, abstract, and keyword fields. To address the reviewer's concern regarding synonyms, the search incorporated alternative terms for the key concepts.

"Primary school" was expanded to include its common synonym "elementary school".

"Technical thinking" was expanded to include the related term "engineering thinking".

The acronyms "STEAM" and "STEM" were searched as they are standardized terms in the literature.

No subject area filters were applied to the database to ensure a comprehensive search across all potential disciplines, including social sciences, engineering, computer science, and education.

The final search string used in the Scopus database is as follows:

(TITLE-ABS-KEY ("technical thinking" OR "engineering thinking") AND TITLE-ABS-KEY (steam OR stem) AND TITLE-ABS-KEY ("primary school" OR "elementary school"))

Search parameters:

1. **Database:** Scopus
2. **Search Field:** Title, Abstract, Keywords
3. **Time Frame:** 2014-2025
4. **Document Type:** Article or Review
5. **Source Type:** Journal
6. **Language:** All
7. **Subject Area:** No filters applied

The database search was conducted in April 2025. After filtering for document type and removal of duplicates, 1364 unique publications were identified for inclusion in the subsequent analysis.

Data Analysis Methods

The following bibliometric tools and methods were employed:

– Publication Trend Analysis: Reflecting the quantitative dynamics of publications by year.

– Author and Affiliation Analysis: Identifying the most prolific researchers, institutions, and countries.

– Source Analysis: Determining the most cited scientific journals.

– Co-authorship and Citation Analysis: Conducted using VOSviewer and Bibliometrix (R package).

– Keyword Analysis: Reconstructing the conceptual structure of the research field.

– Data Visualization: Generating science maps, cluster models, and thematic networks using VOSviewer and SciMAT.

– Data extracted from Scopus included publication titles, abstracts, authors, affiliations, publication years, keywords, and citation counts (Shatu et al., 2022).

Limitations

The analysis covers only publications indexed in the Scopus database and does not include other databases such as Web of Science or ERIC.

SciMAT was used to analyze data pertaining to the dynamic and structural longitudinal development of the entire literature corpus.

A longitudinal analysis was conducted across three time periods: P1 (2014–2017), P2 (2018–2021), and P3 (2022–2025). This periodization was not arbitrary but was justified through a combined qualitative and quantitative approach.

Quantitative Justification: An analysis of the annual publication growth rate revealed distinct phases of activity in the field. The transition from P1 to P2 (2017–2018) coincided with a significant acceleration in the number of publications, marking the field's move from an emergent to a growth phase. The end of P2 (2021) was selected because it preceded the observed diversification of research topics and methodologies in P3, which aligned with a new, even steeper growth trajectory.

Qualitative Justification: The periods correspond to major contextual shifts in global education.

P1 (2014–2017): The formative years, when research focused on establishing the foundational principles of STEAM in primary education.

P2 (2018–2021): A period of institutionalization and rapid growth, heavily influenced by the global push for digital skills and the immediate impact of the COVID-19 pandemic, which accelerated the adoption of educational technology.

P3 (2022–2025): The current phase of maturation and diversification is characterized by the integration of advanced technologies (AI, AR/VR) and a stronger focus on sustainable and inclusive pedagogical models.

This division into four-year intervals effectively captures major evolutionary stages while providing a sufficient number of publications per period for a robust bibliometric analysis.

Keyword trend analysis revealed sustained growth in publications on the topics:

– "Educational Robotics" (average annual growth: +25 %)

– "Development of Technical Thinking" (+18 %)

– "Interdisciplinary Approaches" (+15 %).

– The most significant publication growth occurred between 2019 and 2023.

This includes examining the evolution of keywords grouped by theme across distinct, predefined time periods (Oliveira et al., 2019).

Term recognition and cluster construction were based on 263 keywords, of which 70 were identified as most significant.

Additionally, a semantic network was constructed to illustrate the logical relationships between core terms (Figure 2a). Node size corresponded to keyword frequency, color indicated cluster affiliation, and line thickness represented the strength of thematic association.

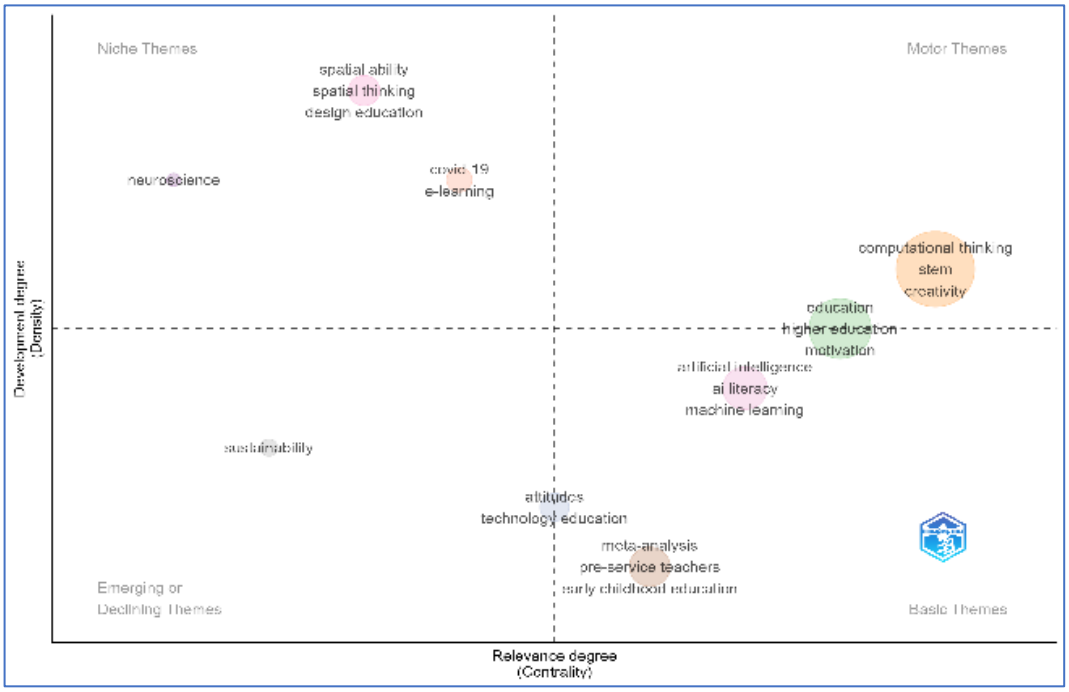

Fig. 2a. Strategic diagram of thematic clusters (based on density and centrality metrics indicators)

This matrix classifies research themes into four quadrants using two metrics:

1. Centrality (horizontal axis): Degree of connection with other knowledge domains.

2. Density (vertical axis): Level of internal theme development.

Thematic clusters were classified based on centrality (influence on other themes) and density (internal theme maturity), assigning them to one of four quadrants:

Q1 (Upper Right): Motor/Trending Themes (High centrality and density): "STEAM Pedagogy", "Project-Based Learning".

Q2 (Upper Left): Established/Niche Themes (High density, low centrality): "Assessment of Technical Thinking".

Q3 (Lower Left): Emerging/Declining Themes: "Augmented Reality in Primary Education".

Q4 (Lower Right): Fundamental/Cross-cutting Themes (High centrality, low density): "Interdisciplinary Approaches".

Circle size corresponds to publication volume per theme (Yan, Wang, 2023).

The visualization illustrates:

1. Nodes (circles): 70 key terms selected by occurrence threshold (minimum 5 mentions).

2. Node Size: Frequency of the term's appearance in publications (n = 263 keywords).

3. Cluster Colors: Thematic groups identified by the clustering algorithm.

4. Line Thickness: Strength of conceptual associations between terms.

Primary clusters (Figure 2b):
Red: Technical Thinking and Engineering Competencies.
Blue: Digital Tools in Education.
Green: STEAM Pedagogical Strategies.
Yellow: Cognitive Development of Primary School Students.

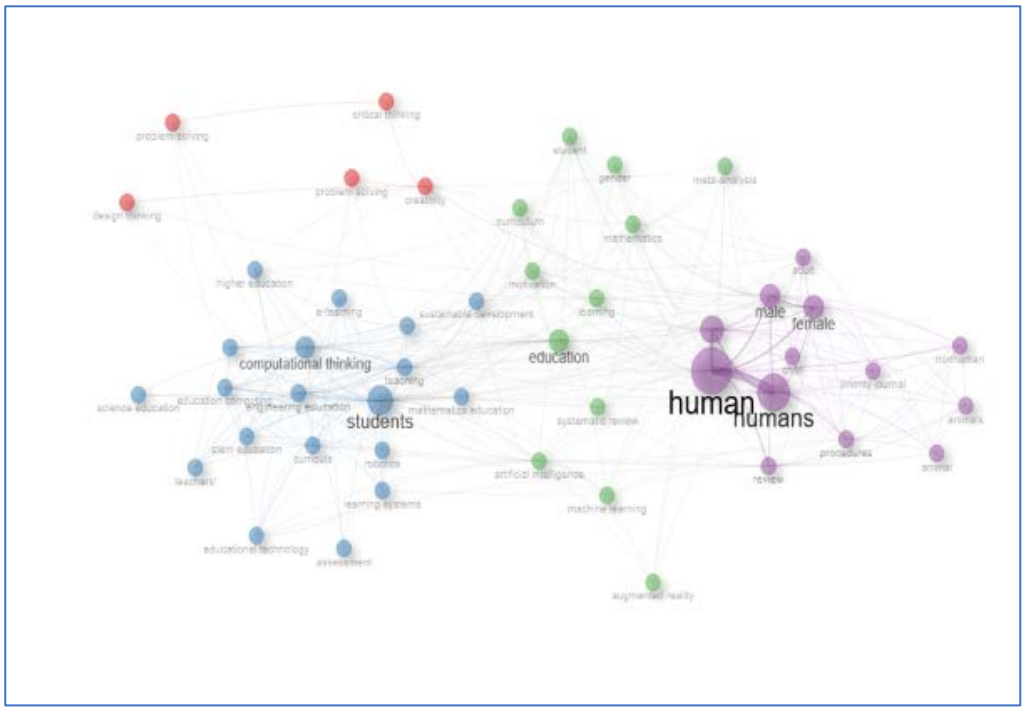

Fig. 2b. Semantic network of key terms relationships

Dynamic Discipline Development Model (Figure 2c)
This corresponds to the application of SciMAT for analyzing structural and temporal theme evolution (Ha et al., 2020). Results indicate a shift from isolated pedagogical studies towards comprehensive interdisciplinary models.

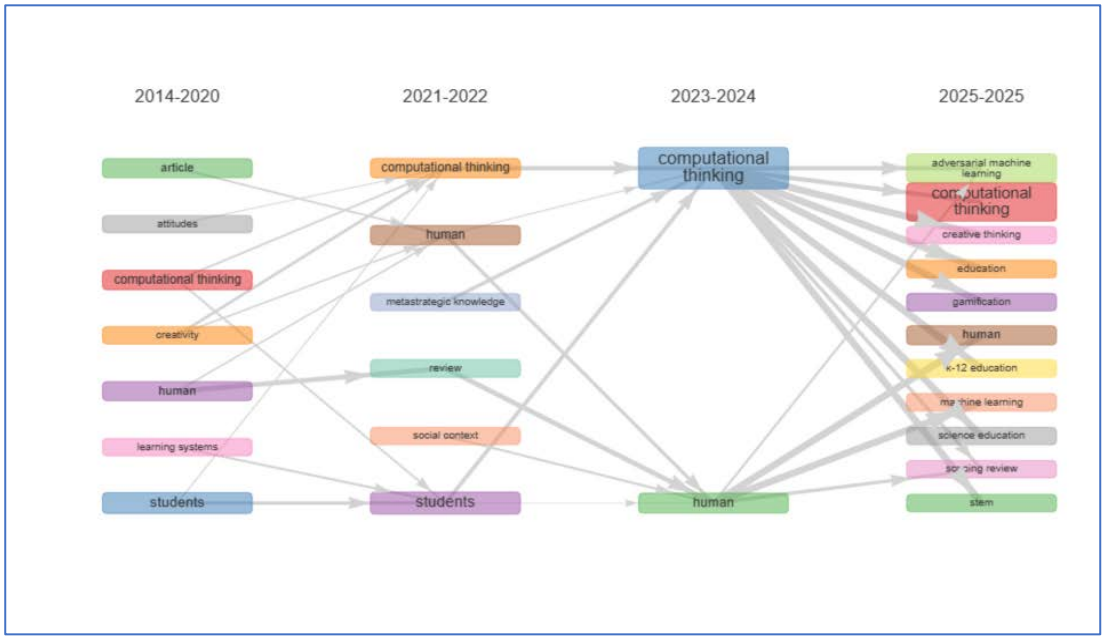

Fig. 2c. Thematic Evolution: Evolution of thematic areas across periods (P1: 2014–2017, P2: 2018–2021, P3: 2022–2025).

The evolution map reflects thematic transformations across three periods:
P1 (2014–2017): Field Emergence
Dominant Themes: "Foundational STEM Education", "Basic Engineering Skills".
Growth Rate: +8.2 % annually.
P2 (2018–2021): Institutionalization
Emerging Themes: "Educational Robotics" (+25 % annually).
Stabilizing Themes: "Development of Technical Thinking" (+18 %).
P3 (2022–2025): Diversification
Trends: "AI in Primary Education", "STEAM Gamification".
Interdisciplinary Linkages: +34 %.
Legend:
Solid Lines: Direct thematic continuity.
Dashed Lines: Partial conceptual inheritance.
Line Thickness: Strength of thematic association.
Colors: Correspond to clusters in Figure 2b.

4. Results

In recent years, the concepts of Education, Science and Technology, Engineering, Arts, and Mathematics (STEAM) have become increasingly important in primary education. Particular attention is paid to the formation of technical thinking in primary school students as a fundamental cognitive competence that contributes to the development of a creative and logical approach to problem-solving. Against the backdrop of the active introduction of technology into the educational process, the relevance of research in this area has increased significantly. Bibliometric analysis allows quantification of the scale of academic interest and identification of key areas, centers of scientific activity, and dynamics of the development of STEAM approaches in the context of primary education.

The Scopus database was chosen for analysis *because of* its broad coverage, high level of representativeness, and strict indexing criteria to ensure the quality and relevance of scientific publications. This study covered publications from 2014 to 2025. The selection of materials was carried out according to the keywords "STEAM", "primary school" and "technic think," with restrictions on language (English) and type of documents (scientific articles, reviews, conference proceedings). The data was carried out using Microsoft Excel, and subsequent bibliometric analysis was carried out using VOSviewer, Bibliometrix (R-package) and the "Publish or Die" tools.

During the analysis, 1392 publications were identified for the period of 2014–2025. After removing duplicate publications (n = 28), 1364 publications were selected for bibliometric analysis.

The analysis presented in Table 1 covers 1,364 publications classified by source type. The leading position is occupied by articles–659 publications (48.3 %)–which indicates the steady dominance of journal publications in the academic landscape. This was followed by books (384, 28.2 %) and chapters (119, 8.7 %), which also occupied a significant share, especially in interdisciplinary fields and the humanities.

Reviews and conference proceedings were presented at 7.8 % and 7.0 %, respectively, confirming their importance as formats for systematizing and disseminating new scientific ideas. Less common forms of publication include editorials, notes, and a single retracted source, demonstrating differences in the academic culture of publications by field of expertise.

The results of the analysis confirmed the key role of scientific articles as the main format of communication in the academic environment, especially in the natural and applied sciences. However, the high proportion of books and chapters also highlights the importance of in-depth theoretical elaboration in the humanities and social sciences (Donthu et al., 2021).

This source allocation structure is consistent with previous research, showing the growing role of journals as the main channels for the dissemination of scientific knowledge. However, the growing number of books and peer-reviewed chapters point to the importance of alternative forms of knowledge representation, especially in the fundamental theoretical works of Marzi et al. (2024) and Passas (2024).

Table 2 shows the distribution of publications by the language used in science communication. Of the total number of 1,364 publications, the vast majority (1,351; 99.04 %) were written in English. The remaining languages, Spanish, Chinese, Turkish, Russian, Persian, Italian,

German, and Arabic, are represented by a minimum of one to three publications, which together account for less than 1 % of the total.

Table 1. Source Type

Source Type	Total Publications (TP)	Percentage (%)
Article	659	48,3
Book	384	28,2
Book chapter	119	8,7
Review	106	7,8
Conference paper	96	7,0
Total	**1364**	**100,0**

This distribution indicates the dominance of English in academic discourse, confirming its status as a global scientific language. This observation is consistent with existing research showing an increase in publications in English, even in countries with a different official language, which is often attributed to the authors' desire for greater international coverage and citations (Liu et al., 2020).

The minimal presence of other languages is indicative of both the globalization of the academic environment and possible marginalization of scientific knowledge presented in local languages. This raises important questions about the accessibility and inclusiveness of scientific information, especially in the context of the development of open access and science communication in the global South Conroy, 2023.

Table 2. Languages must be retrieved from the database

Language	Total Publications (TP)*	Percentage (%)
English	1351	99,04
Spanish	3	0,22
Chinese	3	0,22
Turkish	2	0,15
Russian	1	0,07
Persian	1	0,07
Italian	1	0,07
German	1	0,07
Arabic	1	0,07
Total	**1364**	**100.0**

* One document was prepared in dual language.

The analysis of publications is presented in Table 3 and Figure 3 and covers a wide range of scientific disciplines. The largest number of publications was in the social sciences (36.9 %), which confirms a significant focus on the humanities and social aspects of academic research. This may be due to the diversity of topics covered in this field and the interdisciplinary nature of modern scientific approaches.

The second highest was computer science (11.1 %), reflecting the growing importance of digital technologies in science and society. Psychology (7.5 %) and medicine (6.9 %) showed a sustained interest in mental well-being and healthcare, particularly during the post-pandemic period. Engineering (6.6 %), Arts & Humanities (4.9 %), and Business & Management (3.5 %) made significant contributions to the science space.

Less well-represented fields included the Economic Sciences (2.9 %), mathematics (2.6 %), and Environmental Sciences (2.4 %). Many sciences representing a highly specialized focus are often limited by the applied context or level of funding (14.7 %).

This distribution confirms existing bibliometric trends, indicating a disproportionate distribution of academic output between the humanities and exact sciences (Liu et al., 2023), and emphasizes the need for interdisciplinary collaboration and strategic support for less-funded areas.

Table 3. Subject Area

Subject Area	Total Publications (TP)	Percentage (%)
Social Sciences,	503	36,9
Computer Science,	151	11,1
Medicine,	94	6,9
Psychology,	102	7,5
Engineering,	90	6,6
Arts and Humanities,	66	4,9
Business, Management and Accounting,	47	3,5
Economics, Econometrics and Finance,	39	2,9
Mathematics,	35	2,6
Environmental Science,	32	2,4
Other	200	14,7
Total	1364	100,0

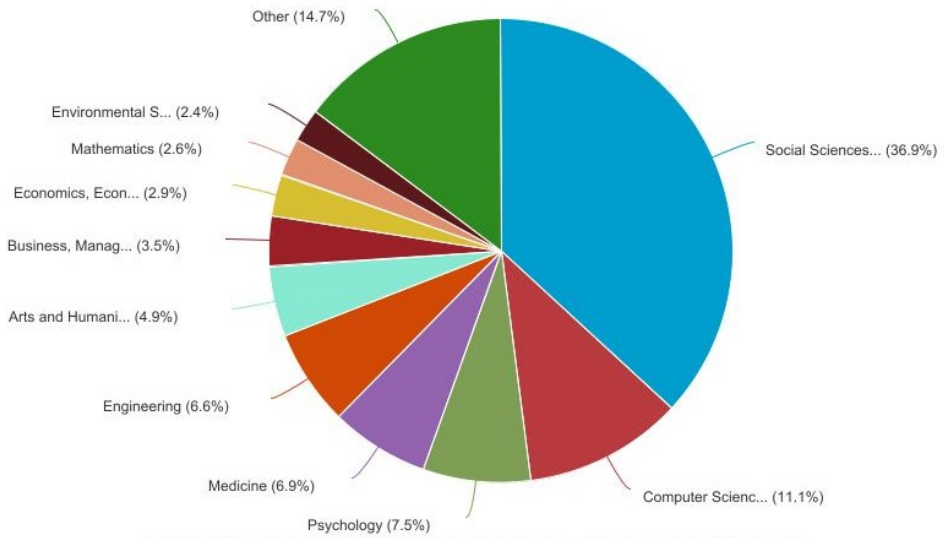

Fig. 3. Subject Area

Table 4 and Figure 4 show the annual statistics of publication activity and citations for the period 2014–2025. The total number of publications was 1,364, of which 1,009 were cited at least once. The total number of citations was 43,294.

The most productive years in terms of the number of publications were 2024 (307 publications) and 2023 (236 publications), which may reflect both an increase in research activity and the development of digital publishing platforms. However, the highest citation rate was observed in 2020, with 101 publications providing 14,414 citations, an average of 28.54 citations per publication and 29.84 per cited publication. This is likely due to global scientific mobilization in response to the COVID-19 pandemic, which is supported by the similar bibliometric results.

The highest Hirsch and g-indices were recorded in 2020, 2022, and 2023, indicating stable citation levels and scientific impact of publications in these years. At the same time, later years (2024–2025) still showed low citation levels, which is natural because of the time lag between publication and the start of active citations.

This analysis emphasizes the need to consider the time factor when assessing scientific productivity, and the importance of combining quantitative and qualitative metrics (such as h- and g-indices) to build an objective bibliometric picture (Passas, 2024: 1517).

The study included the following key bibliometric metrics: total number of publications (TP), number of cited publications (NCP), total citations (TC), average number of citations per publication (C/P), average number of citations per cited publication (C/CP), Hirsch index (h-index) and g-index to assess scientific impact and citation sustainability.

The data show a clear wave-like trend in publication activity, with the highest number of citations concentrated between the turn 2020–2022. This emphasizes the importance of exogenous factors (e.g., pandemics) in shaping scientific interest and publication resonance. Temporal variations in Hirsch and g-indices also indicate differences in the sustainability of scientific contributions over time. The integration of visualized co-author networks and keyword analysis confirmed the growth of interdisciplinary collaboration and the emphasis on health, digitalization, and sustainability during this period.

Table 4. Year of Publication

Year	TP	NCP	TC	C/P	C/CP	AC	h	g
2025	79	16	68	0,86	1,84	37	4	7
2024	307	155	498	1,62	0,37	1342	9	10
2023	236	186	3718	7,88	4,08	912	24	56
2022	172	150	4459	8,64	6,25	714	25	63
2021	149	131	3602	6,04	7,02	513	32	56
2020	101	95	14414	28,54	29,84	483	25	101
2019	87	81	2929	5,61	10,13	289	27	53
2018	75	66	3417	6,51	7,21	474	28	58
2017	68	62	1961	3,60	9,85	199	21	43
2016	41	38	5776	15,65	21,24	272	20	41
2015	28	12	735	2,53	10,65	69	13	27
2014	21	17	1717	7,43	28,62	60	10	21
	1364	**1009**	**43294**	**94,93**	**137,09**	**5364**		

Notes: TP, total number of publications; NCP, number of cited publications; TC, total citations; C/P, average citations per publication; C/CP, average citations per cited publication; AC, Authorcount; h, h-index; g, g-index.

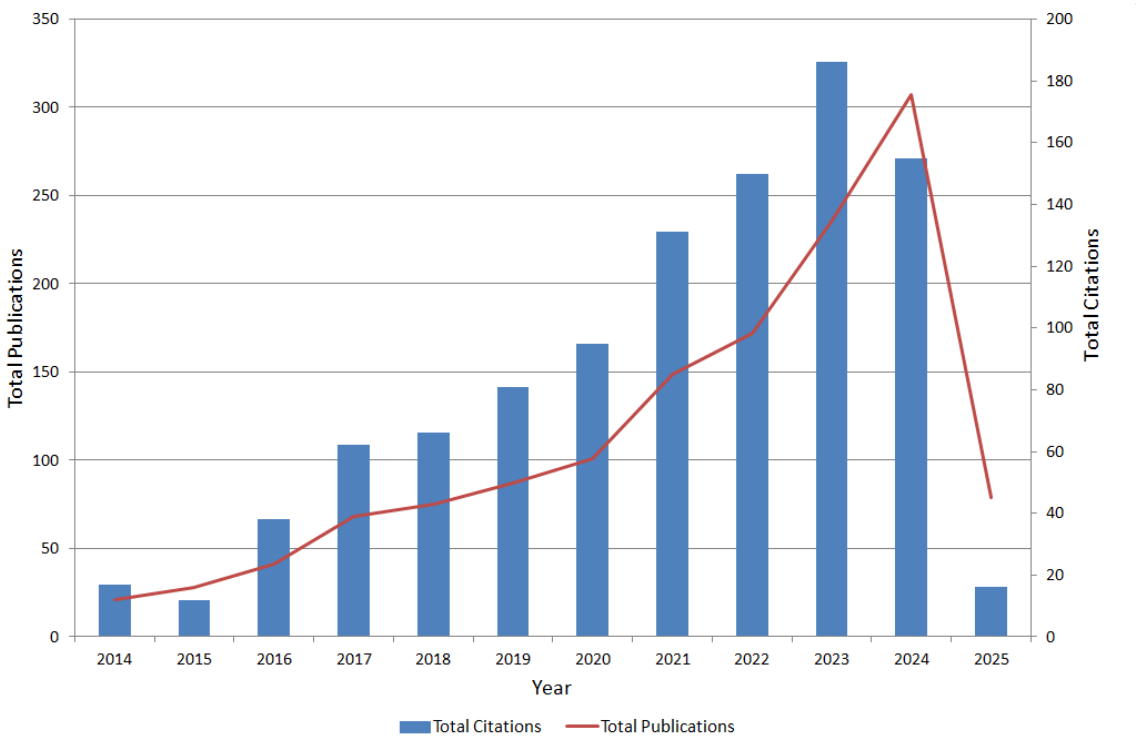

Fig. 4. Total number of publications and citations by year

Table 5 presents an analysis of the top ten countries that have contributed the most to scientific publications on STEAM education, technical thinking, and primary education.

The United States remained the leader in terms of the number of publications (414), followed by the United Kingdom (85), China (75), and Australia (52). At the same time, Germany shows the highest citation rate with 52.38 citations per publication and 59.86 per cited publication, despite its

relatively modest volume of publications (40). These findings indicate the importance of high-quality German research in this field.

In terms of scientific impact, the United States also leads in all key indicators: total citations (13,461), Hirsch index (46), and g-index (109). The UK and China form a stable core of scientific activity with high citation levels and comparable indices. The remaining countries – Canada, Spain, India, the Netherlands, Iran, and Canada – show moderate publication and citation activities but confirm the global nature of interest in STEAM in education.

The geographical distribution of publication activity shows a dominance of English-speaking and industrialized countries, with a clear concentration of scientific influence in the US, United Kingdom, China, and Germany. High citation rates with relatively few publications in some countries (e.g., Germany) provide a focused and qualitative contribution to the research agenda. This emphasizes the importance of transnational research cooperation in the field of educational innovation and development of cognitive competence in elementary schools.

After 2020, there has been a steady upward trend in the number of publications, which can be linked to the global focus on digitalization and innovation in education. The geographical distribution shows the dominance of English-speaking countries, such as the US, United Kingdom, and Australia, among the top 15 active countries. The main contribution to publication activity comes from specialized journals in the field of pedagogy and technology as well as from a few leading authors who form the core of scientific citations on the topic.

Table 5. Top 10 Countries contributed to the publications

Country	TP	NCP	TC	C/P	C/CP	h	g
United States	414	339	13461	32.51	39.71	46	109
United Kingdom	85	69	2225	26.18	32.25	23	46
China	75	61	2177	29,03	35.69	19	46
Australia	52	44	1058	20.35	24,05	14	32
Germany	40	35	2095	52.38	59.86	14	40
Spain	31	24	408	13.16	17	8	20
Canada	30	20	378	12,6	18,9	7	19
India	29	18	478	16.48	26.56	7	21
Netherlands	26	22	326	12,54	14.82	10	17
Iran	10	6	86	8,6	14.33	3	9

Notes: TP, total number of publications; NCP, number of cited publications; TC, total citations; C/P, average citations per publication; C/CP, average citations per cited publication; h, h-index; and g, g-index.

Collaboration between institutions and countries: This section analyzes collaboration between institutions and countries, which is often visualized using network maps. This can help identify important research centers and international partnerships. Li et al. (2023) provide an example of how institutional collaboration can be analyzed in bibliometric research.

Analyzing International Research Collaboration

Table 6 presents data on the publication activities of different universities and research centers in international scientific cooperation. The table contains a metric that reflects the strength of cooperative ties with other organizations.

Arizona State University (USA) has the highest number of citations (1200), indicating a high level of scientific impact of its publications. This significantly exceeds the indicators of other institutions despite the identical number of papers in many of them.

Michigan State University (USA) demonstrates the highest strength of cooperation (109) with a relatively low level of citations (17), which may indicate a wide international network of partnerships but an insufficient scientific impact of the publications themselves.

The University of Canberra (Australia) has a moderate number of citations (171) with a relatively high rate of collaboration (21), which indicates balanced scientific activity, both in terms of the quality of publications and interaction with other institutions.

Beijing Normal University (China) has one of the lowest citation rates (5) despite a high co-op rate (67), which may indicate a lack of visibility or impact of their publications in the international research environment.

In terms of geographical distribution, universities from the US are the most active, as evidenced by both the number of organizations in the sample and their citation and co-op metrics.

Some organizations show high connectedness with other institutions but low citations, indicating the need for an in-depth analysis of the quality of scholarly output in the context of international connections.

Universities with high "total link strength (TLS)" values but low citations (e.g., Indiana University and Beijing Normal University) have the potential to increase scientific impact by strengthening the quality of publications and their international visibility.

Table 6. Most influential institutions with minimum of three publications

Organization	Country	Documents	Citations	Total Link Strength
Arizona State University	United States	3	1200	11
The University Of Hong Kong	Hong Kong	3	320	16
University Of Canberra	Australia	3	171	21
Northwestern University	United States	4	98	60
Northwestern University	United States	3	68	27
Johns Hopkins University	United States	3	48	7
North Carolina State University	United States	3	40	54
Utah State University	United States	3	36	24
Indiana University	United States	3	31	69
Michigan State University	United States	4	17	109
University Of Auckland	New Zealand	3	13	14
University Of Central Florida	United States	3	13	43
Purdue University	United States	3	12	25
Beijing Normal University	China	3	5	67
University Of South Africa	South Africa	3		9

Table 7 presents the bibliometric profiles of the 11 most productive authors who made significant contributions to the study of STEAM approaches in primary education and the development of technical thinking.

Table 7. Most Productive Authors

Author's Name	Affiliation	Country	TP	NCP	TC	C/P	C/CP	h	g
Klapwijk, R.	Delft University of Technology	Netherlands	6	5	53	17,7	8,2	4	6
Rau, M.A.	ETH Zurich,	Switzerland	5	5	270	33,7	220,8	4	5
Yadav, A.	Michigan State University College of Education	United States	5	4	76	15,2	25,3	3	5
Cózar-Gutiérrez, R.	University of Castilla-La Mancha	Spain	4	4	230	46	76, 7	3	4
Franklin, D.	Brigham Young University	United States	4	4	116	14,5	26,4	3	4
González-Calero, J.A.	University of Castilla-La Mancha	Spain	4	4	230	46	76,67	3	4
Runco, M.A.	Southern Oregon University	United States	4	4	702	36,95	702	4	4
Zhu, C.	Delft University of Technology	Netherlands	4	3	35	17,5	5,2	2	4

Author's Name	Affiliation	Country	TP	NCP	TC	C/P	C/CP	h	g
Hartung, T.	Sanofi Deutschland GmbH	Germany	3	3	245	30,63	24,5	3	3
Leist, M.	Sanofi Deutschland GmbH	Germany	3	3	245	30,63	24,5	3	3
Volpe, J.J.	University of California Irvine	United States	3	3	26	3,25	13	2	3

Notes: TP, total number of publications; NCP, number of cited publications; TC, total citations; C/P, average citations per publication; C/CP, average citations per cited publication; h, h-index; and g, g-index.

The leader in terms of number of publications was Klapwijk (six publications, Delft University of Technology, Netherlands). However, Runco (Southern Oregon University, USA) showed the highest citation rate and the highest average citation rate of the university, with 702 citations of only four publications, corresponding to 36.95 citations per article and 702 citations per cited publication. Rau (ETH Zurich, Switzerland) also scored high, with 270 citations, whereas Cózar-Gutiérrez and González-Calero (both from the University of Castilla-La Mancha, Spain) received 230 out of four publications.

An interesting contribution was made by researchers from the pharmaceutical industry, Hartung and Leist (Sanofi, Germany), who each published three articles with high citation rates (245 citations and C/P > 30), which may indicate an interdisciplinary interest in the topic.

Scientific productivity in STEAM and technical thinking are distributed among academic institutions in the US, Europe, and Asia. The leaders in terms of quality indicators (citation rates) are researchers from the USA, Switzerland, and Germany, confirming their influence on the international research agenda. The significant citation rate of several authors with a small volume of publications indicates the high relevance of their work to the academic community.

Keywords extracted from titles, abstracts, and selected author terms are important indicators of research focus and prioritize topics in the scientific literature. Table 8 and Figure 5 show the keyword overlap analysis, revealing the main semantic clusters in STEAM, technical thinking, and educational publications. The evaluation was based on the number of keyword overlaps (occurrences), the Total Link Strength, the proportion of publications in which the term occurred, and the relative relatedness per publication.

Table 8. Keyword overlap analysis: identifying semantic clusters in STEAM and technical thinking studies

Group	Occurrences	Total link strength	% of publications	TLS for publication
human	197	1711	19,86	8,69
computational thinking	111	365	11,19	3,29
student	106	605	10,69	5,71
literature review	84	84	8,47	1
STEM	78	247	7,86	3,17
education	76	364	7,66	4,79
systematic review	65	144	6,55	2,22
primary school	60	134	6,05	2,23
learning	57	176	5,75	3,09
curriculum	45	224	4,54	4,98
animal	33	292	3,33	8,85
problem solving	30	95	3,02	3,17
educational robotics	26	110	2,62	4,23
teacher training	24	119	2,42	4,96
Total	**992**	**4670**	**100,0**	**60,38**

The key cores of the semantic structure are the terms "human" (19.86 %), "computational thinking" (11.19 %) and "student" (10.69 %), showing high values in terms of both the number of occurrences and connectivity in the semantic network. This confirms the focus on the human-centered approach, role of the learner, and cognitive components of STEAM education.

The performance of the term "animal" (3.33 % of publications, TLS/publication = 8.85) and "human" (TLS/publication = 8.69) indicates a high relatedness of these concepts to other terms, which may be related to the application of STEAM approaches in biology, neuroscience, or behavioral research.

Topics reflecting the methodological aspects of research, such as literature reviews, systematic reviews, and curricula, also feature prominently, demonstrating the high level of formalization and maturity of the research field.

The keyword analysis revealed a consistent semantic structure dominated by themes related to learners, technical thinking, and educational methodologies. The presence of the terms "primary school", "learning", "educational robotics", and "teacher training" confirms the research focus on the practical applications of STEAM in elementary schools. The overall strength of the links (TLS = 4670) and the high overlap of key terms indicate an established but evolving thematic network with a tendency towards interdisciplinary integration and increasing conceptual complexity.

Semantic analysis of the citation network shows how often keywords occur together, revealing clusters of related concepts and new research areas (Mejia et al., 2021, Alreahi et al., 2023).

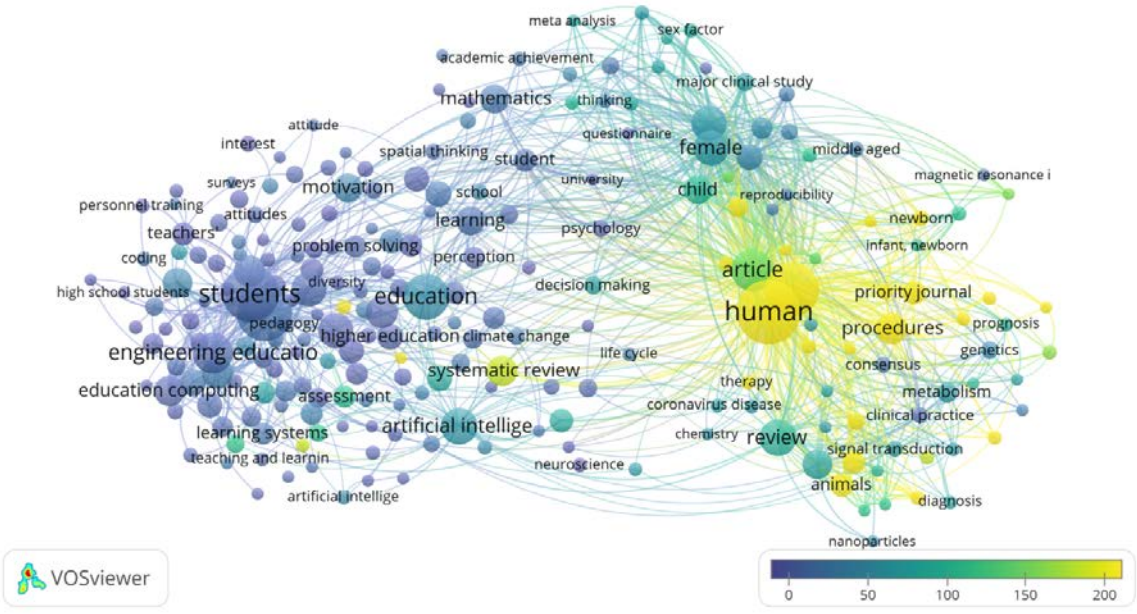

Fig. 5. Network visualization map by author's keywords

Analysis of keyword coincidences demonstrated high coherence in the research area, where the key cores were concepts related to humans, learning, computational thinking, and STEM education. The co-occurrence of terms identified four notional clusters (Figure 6).

(1) Pedagogical and Anthropological
(2) Technological and methodological aspects
(3) Empirical and Educational
(4) Organizational and programming

This structure emphasizes the interdisciplinary nature and conceptual maturity of the research area.

To identify key research areas in the fields of STEAM, elementary education, and technical thinking, we analyzed the frequency of keywords using the VOSviewer software. Only terms that occurred at least 10 times in a sample of 1364 articles were included in the analysis. This resulted in a structured topic map with four clusters, each representing a specific research area.

Visualization: Keyword frequency map

Cluster 1 (red): STEAM approach to education.

Keywords: STEAM, STEM, Education, Course of Study, Pedagogy, Project-based Learning, Integration.

The focus was on the methods of implementing STEAM in primary education, curriculum development, and project-based learning.

Cluster 2 (green): Technical thinking and cognitive development

Keywords: technical thinking, problem solving, creativity, cognitive skills, critical thinking.

Cluster 3 (blue): Information technology and digital tools

Keywords: Technology, Digital Tools, Robotics, Coding, ICT, Educational Software.

This strand relates to the incorporation of digital tools (robotics, coding, etc.) into STEAM education.

Cluster 4 (yellow): Teacher training and professional development

Keywords: Teacher training, professional development, teacher education, educational design.

The main focus was on analyzing the preparation of teachers to work in the STEAM environment and the formation of methodological approaches.

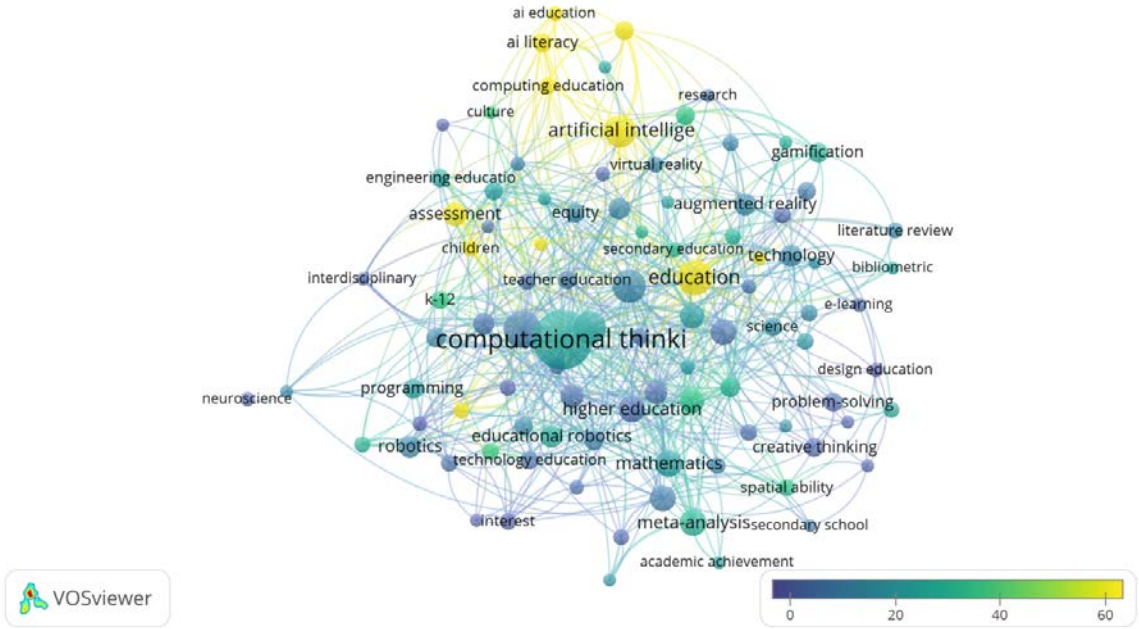

Fig. 6. VOSviewer Visualis creates term-matching networks based on header and abstraction (binary counting) fields

Table 9 presents an analysis of the scientific influence of countries based on the number of publications, total citations, total citation strength, average citations per publication, and integral coherence index. These metrics allow us to assess not only the volume of publication activity but also its qualitative characteristics at the level of an individual country.

The United States of America is the leader in terms of both the number of papers (476) and total number of citations (16,056), accounting for 35.16 % of all publications. However, in terms of citations per publication (33.73), the United States lagged behind several European countries, indicating the prevalence of large rather than score-based highly cited contributions.

Countries with fewer publications showed the most impressive citation averages, but quality weights:

1. Russian Federation: 8 publications, 1968 citations (246 citations per article).
2. Egypt: 8 publications, 1761 citations (220.12 citations per publication).
3. Greece: 22 publications, 3494 citations (158.82 per publication).
4. United Arab Emirates: 13 publications, 1869 citations (143.77 per publication).

These figures demonstrate the focused participation of research groups in highly cited projects, often in collaboration with other authors.

Total Link Strength (TLS) shows the intensity of network links between countries and other participants in the publication process. The United States remains the leader in this indicator (TLS = 332), but Belgium (7.53), Egypt (7.0), and Russia (6.0) show the highest TLS per publication, indicating that these countries are significantly integrated into international research networks.

The data indicate two different types of scientific impacts:

– Highly stable contributions (USA, UK, and China) are characterized by high impact and medium citation rates.

– High Impact Score Contributions (Russia, Egypt, Greece, United Arab Emirates) are characterized by a small number of publications but extremely high citation and network activity.

This configuration emphasizes the importance of international cooperation and strategic publications in journals with high impact factors, as a means of scientifically positioning countries with a limited number of authors.

Table 9. Comparative analysis of countries by total number of publications and citations

Country	Documents	Citations	Total Link Strength	% publications	Citation to the publication of	TLS for publication
United States	476	16056	332	35.16	33,73	0,7
United Kingdom	132	6905	284	9,75	52,31	2,15
Germany	73	5797	228	5,39	79.41	3,12
Italy	40	4173	197	2,95	104,32	4,92
Australia	80	3605	180	5,91	45,06	2,25
Netherlands	46	3079	168	3,4	66,93	3,65
France	27	1562	161	1,99	57,85	5.96
Sweden	24	2868	154	1.77	119,5	6.42
Canada	55	4288	153	4,06	77,96	2.78
Belgium	19	2641	143	1,4	139	7.53
Spain	49	2691	130	3,62	54,92	2.65
China	97	3699	128	7,16	38,13	1.32
Japan	26	2424	123	1,92	93,23	4,73
Switzerland	20	806	88	1.48	40,3	4,4
Brazil	17	731	83	1,26	43	4.88
Israel	19	943	77	1,4	49,63	4,05
Austria	19	2110	75	1,4	111,05	3,95
United Arab Emirates	13	1869	63	0,96	143,77	4.85
India	36	2126	59	2.66	59,06	1.64
Portugal	15	405	57	1,11	27	3,8
Egypt	8	1761	56	0,59	220,12	7
Finland	17	863	56	1,26	50,76	3,29
Greece	22	3494	54	1,62	158,82	2.45
South Korea	16	1764	52	1.18	110,25	3,25
Russian Federation	8	1968	48	0,59	246	6

As part of the bibliometric analysis of publications indexed in the Scopus database, the keywords "STEAM", "elementary school" and "technic think" were used. The analysis was conducted with the help of VOSviewer software, which allowed not only to identify publication activity, but also to assess the level of international cooperation between countries on the basis of Total Link Strength.

The Total Link Strength allows us to determine not only the quantitative involvement of a country in research activities, but also the quality and scale of international cooperation. This is especially true in the context of interdisciplinary topics such as STEAM, where collaboration between countries and disciplines plays a key role in the development of research approaches.

The journal Computers and Education (Elsevier Ltd) also has the highest citation rate with 1264 citations with nine publications, indicating the exceptionally high quality and resonance of the published papers. This journal also has the highest CiteScore (19.8), SJR (3.682), and SNIP (5.21) among the submitted sources (Table 10).

– Education and Information Technologies (Springer): 25 publications, 437 citations, bite score = 10.

– Educational Psychology Review (Springer Nature): High citation rate (415 with eight articles) and highest SNIP (5.38)

– Sustainability (Switzerland): 14 articles and moderate citations (256) reflecting a sustained interest in environmental sustainability and education.

ACM journals reflect the contribution of technical and computational science in shaping STEAM discourse, although their metrics (especially SNIP and SJR) are somewhat lower than pedagogical publications, which are typical of conference proceedings and highly specialized journals.

Source analysis showed that publications in the area of STEAM education and technical thinking were concentrated in journals at the intersection of pedagogy, cognitive science, and technology. Elsevier and Springer journals are key venues for the dissemination of research findings, providing both high coverage and academic impact. Separately, sources demonstrating a high quality-to-quantity ratio, such as Computers and Education and Educational Psychology Reviews, confirm the trend of growing scholarly attention to the digital and cognitive aspects of education.

Table 10. Leading scientific journals in the field of STEAM education and technical thinking

Source Title	TP	TC	Publisher	CiteScore	SJR	SNIP
Thinking skills and creativity	51	815	Elsevier Ltd	7,3	1.162	2,17
Education and information technologies	25	437	Springer	10	1.301	2,31
Frontiers in education	16	121	Frontiers Media SA	2,9	0.64	1,34
Education sciences	15	42	Multidisciplinary Digital Publishing Institute (MDPI)	4,8	0.669	1,32
Sustainability (Switzerland)	14	256	Mary Ann Liebert	6,8	0.672	1,09
International journal of technology and design education	13	167	Springer Science and Business Media B.V.	5,3	0.812	1,54
ACM international conference proceeding series	13	52	Association for Computing Machinery	1,5	0.253	0,23
Computers and education	9	1264	Elsevier Ltd	19,8	3.682	5,21
Educational psychology review	8	415	Springer Nature	15,7	4,32	5,38
ACM transactions on computing education	7	44	Association for Computing Machinery	6,5	1.083	1,91

Notes: TP = total number of publications; TC = total citations.

Table 11 presents the integral bibliometric indicators describing the publication and citation activity of 1364 scientific publications on the topic under consideration for the period 2014–2025.

During the 11 years, 46258 citations were recorded, which is an average of 4205.27 citations per year. The average number of citations per publication was 34.09, indicating steady interest in the scientific community on the topic. The index of citations per author was 13256.56, with an

average number of authors per publication of 3.25, which corresponds to the international trend towards the interdisciplinary and collective nature of scientific work.

High values of the Hirsch index (h-index = 80) and g-index (199) confirm the presence of a core of highly cited publications and the stable scientific reputation of the research field. The average number of publications per author, 632.26, is an aggregate statistic that indicates authors' contribution to collective research.

Aggregate metrics demonstrate a high level of scientific productivity and significant number of citations in a publication corpus. These indicators indicate the maturity and relevance of the research area, confirming the active involvement of the international community and the presence of highly cited studies that form the core of this subject. The stable correlation between the number of authors and publications emphasizes the collaborative nature of the research characteristics of interdisciplinary areas such as STEAM and educational technologies.

Table 11. Cumulative publication citation metrics for 2014–2025

Metrics	Data
Publication years	2014–2025
Citation years	11
Papers	1364
Citations	46258
Cites/ years	4205,27
Cites/paper	34,09
Cites/author	13256,56
Papers/author	632,26
Author/paper	3,25
h-index	80
g-index	199

The data in Table 12 reveal key trends in STEM/STEAM education research. The leading position of the publication by Sawyer & Henriksen (2023) in both total citations (1,131) and annual citation rate (565.5) indicates the emergence of a new paradigm that places creativity at the core of the STEAM approach. Similarly, the high annual citation rates of research on artificial intelligence in education (Holmes, Tuomi, 2022: 95.33; Long, Magerko, 2020: 178) reflect the rapid institutionalization of this field.

Table 12. Top-cited publications within the STEM/STEAM education domain

No.	Authors	Title	Year	Cites	Citesper Year
1	R.K. Sawyer, D. Henriksen	Explaining creativity: The science of human innovation	2023	1131	565.5
2	D. Long, B. Magerko	What is AI Literacy? Competencies and Design Considerations	2020	890	178
3	M.A. Runco	Creativity: Theories and Themes: Research, Development, and Practice	2014	521	47.36
4	X. Tang, Y. Yin, Q. Lin, R. Hadad, X. Zhai	Assessing computational thinking: A systematic review of empirical studies	2020	417	83.4
5	W. Holmes, I. Tuomi	State of the art and practice in AI in education	2022	286	95.33

The enduring influence of foundational studies (Runco, 2014: 521) confirms the continuing importance of theoretical frameworks for creativity. Concurrently, there is a growing impact in applied areas such as AI literacy and computational thinking, which demonstrate not only scholarly interest but also practical implementation as measurable educational outcomes.

The predominance of review and conceptual articles among the most-cited publications is characteristic of a consolidation phase in the research field. Monographs contribute to theoretical development, whereas systematic reviews facilitate the transfer of research findings into teaching practices.

The combination of two metrics, the total citation count and annual citation rate, helps distinguish "classical" works with long-term influence from emerging publications that shape current research trends. The identified patterns confirm a shift toward measurable digital and creative competencies, reflecting the field's general orientation toward validated educational outcomes and practice-oriented development.

Thus, the core of contemporary research is formed by three interconnected domains: the theoretical foundations of creativity, the development of AI literacy, and the cultivation of computational thinking as operationalizable educational outcomes for primary schools. These areas collectively represent the evolving research priorities in STEM/STEAM education.

Table 13 shows the distribution of the number of authors per publication in a sample of 1,364 research papers covering STEAM, technical thinking, and elementary education. This parameter allows us to assess the nature of research collaborations, intensity of scholarly interaction, and trends towards individual or team research productivity.

The most common were publications with one (22.4 %) and two (23.26 %) authors, which together accounted for almost half of all the papers (45.7 %). This may indicate a significant share of individual or small-group research, especially in pedagogical and theoretical-methodological directions.

Simultaneously, approximately 18.6 % of the publications had three authors, and the share further decreased as the number of co-authors increased. Nevertheless, publications with large author teams (from 11 to 100 authors) are also represented: seven publications have 100 authors each, and another eight have between 41 and 66 co-authors. These studies are likely based on large-scale international studies, meta-analyses, or global-level projects.

The category with zero authors (1.8 %) was notable, probably due to metadata errors or unstructured information in the database.

The distribution of the number of authors per publication indicated the predominance of individual and small-group research activities in STEAM and education. However, the presence of multi-authored teams indicates a growing trend towards internationalization and interdisciplinarity of research, especially in topics related to global challenges and the integration of technological approaches. This diversity in author formats reflects the flexibility of the research environment and opportunities for both local and large-scale academic collaborations.

Table 13. Number of authors (co-authors) for publication in research

Author Count	Total Publications (TP)	Percentage (%)
1	305	22,4
2	316	23,26
3	254	18,6
4	162	11,9
5	114	8,4
6	53	3,9
7	39	2,9
8	15	1,1
9	11	0,8
10	8	0,6
11–20	31	2,3
21–30	10	0,7
31–40	6	0,4
41–66	8	0,6
100	7	0,5
*	25	1,8
Total	**1364**	**100,0**

* No author is listed.

Table 14 presents data on the key sponsors that provided funding for scientific publications on the subject. Funding reflects not only financial, but also strategic support for the subject by scientific and political institutions, which makes this indicator an important element of bibliometric analysis.

The leader in the number of funded publications was the US National Science Foundation (NSF), with 81 papers (11.4 % of the total number of funded studies). This emphasizes the importance of the STEAM direction in US science policy, particularly in the context of primary and technology-oriented education.

Second, the European Commission (30 publications, 4.2 %) plays a key role in transnational support for research initiatives under *Horizon 2020* and *Horizon Europe* programs. Also making significant contributions are Chinese agencies, the National Natural Science Foundation of China (NSFC) and the Ministry of Science and Technology of the People's Republic of China, which have funded 25–26 publications each, reflecting the active development of digital education initiatives in China.

Other major funding sources include the US National Institutes of Health (NIH), UK Research and Innovation (UKRI), and Ministry of Education and Science of several countries (Germany, Japan, and Australia). This demonstrates the global nature of interest in STEAM topics and their cross-sectoral importance from education to health and technological development.

Funding for publications in the fields of STEAM education and technical thinking is provided by both national scientific foundations and international programmes. The leaders are the USA, European Union, and China, forming the strategic core of global support for innovative education. There is a steady trend towards internationalization of funding, which promotes the development of interdisciplinary and transnational research consortia.

Table 14. The main organizations that sponsor research in the field of STEAM education

No.	Sponsoring organizations	Documents	Percentage (%)
1	National Science Foundation	81	11,4
2	European Commission	30	4,2
3	National Natural Science Foundation of China	26	3,7
4	National Institutes of Health	25	3,5
5	Ministry of Science and Technology of the People's Republic of China	25	3,5
6	UK Research and Innovation	23	3,2
7	U.S. Department of Health and Human Services	22	3,1
8	Horizon 2020 Framework Programme	21	3,0
9	Ministry of Education of the People's Republic of China	12	1,7
10	U.S. Department of Education	11	1,5
11	Bundesministerium für Bildung und Forschung	11	1,5
12	Deutsche Forschungsgemeinschaft	10	1,4
13	Japan Society for the Promotion of Science	10	1,4
14	Australian Research Council	10	1,4
15	Department of Education and Training	10	1,4
	Total sponsors	**711**	**100,0**

5. Discussion

The findings confirm a rapid acceleration of interest in STEAM at the primary-school level. The dataset comprised 1,364 publications for 2014–2025 (after deduplication), with consolidated influence metrics (h = 80; g = 199; 46,258 citations; 34.09 citations per article), indicating a mature and cohesive research core. The 2020 citation peak – despite only 101 publications – likely reflects the pandemic's exogenous push toward digitalization and the subsequent visibility of EdTech research (14,414 citations; 28.54 per paper). The uneven h/g dynamics across 2021–2023 are consistent with citation lag and thematic consolidation captured by our thematic evolution maps, where isolated pedagogical studies increasingly converge with interdisciplinary models.

Geographically, output and impact concentrated rate in settings with robust research infrastructure. The United States leads both by volume and influence, while Germany achieves high

citation density with a moderate output, suggesting a smaller but methodologically strong corpus. This center-periphery pattern is broadly consistent with prior bibliometric overviews in STE(A)M education and EdTech, which also reported growth in international collaboration and cross-disciplinary venues (Marín et al., 2021).

Source analysis highlights journals at the intersection of pedagogy and digital technology as major drivers of discourse. Computers & Education exhibits exceptional citation returns (e.g., 1,264 citations across nine papers in our set), while Educational Psychology Review shows the best SNIP performance with fewer items. Together, these venues appear to set evidentiary standards for primary-level STEAM by bridging cognitive psychology and technology-enhanced learning (TEL).

Semantic analysis revealed a stable four-cluster architecture coupling (a) technical thinking/engineering competencies, (b) digital tools, (c) STEAM pedagogical strategies, and (d) cognitive development in early years. The prominence of "teacher training" among highly connected keywords indicates that teacher preparation is not merely contextual but is a topic in its own right. This aligns with cumulative evidence on teacher professional development (PD): the most effective PD integrates content knowledge with techno-pedagogical design (e.g., TPACK), builds in co-planning and reflective cycles, and is associated with more durable classroom uptake (Huang et al., 2022; Surahman, Wang, 2023; Fabian et al., 2024). Attitudinal factors – teachers' trust in and perceived usefulness of digital and AI-supported tools – also shape actual classroom integration at the primary level (Ayanwale et al., 2024). In parallel, early years practice frameworks underscore age-appropriate design-as-play approaches for engineering concepts in the primary grades (Fleer, 2020).

Simultaneously, our journal-topic profiles surface a tension between cognitive effectiveness and operational feasibility. High-frequency terms, such as human, student, and computational thinking, signal a shift toward measurable learning outcomes and learner-centered designs. However, the "digital tools" cluster (robotics, coding, ICT) presupposes infrastructure that primary schools secure unevenly. As noted in policy-level syntheses, inequities in access can amplify pre-existing gaps unless schools employ realistic low-tech→high-tech trajectories (paper engineering and 2D→3D modeling before visual programming and robotics), flexible provisioning models (e.g., BYOD), and compensatory measures to mitigate the digital divide (UNESCO, 2023; OECD, 2023; McLean, 2016; Schmitz et al., 2024). In this light, the visibility of the "tech cluster" within our maps suggests that access strategies are moving from background constraints to mainstream research.

Two differences stand out compared with earlier bibliometric studies. First, a primary school focus magnifies learner-centered and pedagogical-method components (e.g., teacher training and curriculum design), which is unsurprising given age-specific demands for safety, didactics, and assessment. Second, the share of digital topics (robotics, coding, AI in education) is higher, consistent with a post-pandemic "digital normal" and institutionalization of EdTech in early grades.

Methodological considerations. The presence of highly cited but thematically distant review articles among "top cites" likely reflects broad search settings and a common bibliometric trade-off between recall and topical precision in the literature. Future iterations should refine field restrictions (e.g., education-domain filters; TITLE-ABS-KEY tuning) to curb cross-domain bleed-throughs. Year-by-year shifts should also account for citation lags and exogenous shocks, which can inflate specific periods and topical nodes.

Practical implications for primary schools are discussed. Teacher readiness is an independent driver of sustainable STEAM integration. PD should explicitly link content and techno-pedagogical lesson design, supported by mentoring and collaborative reflection (Huang et al., 2022; Surahman, Wang, 2023; Fabian et al., 2024; Fleer, 2020). Technology access should be treated as a designed trajectory rather than a fixed state: low-tech 2D→3D solutions scaling to high-tech robotics/coding under budgetary, maintenance, and regulatory constraints (UNESCO, 2023; OECD, 2023; McLean, 2016; Schmitz et al., 2024). Finally, credible evaluation of technical and spatial thinking requires validated measurement instruments; current empirical work remains uneven, which helps explain why review- and method-oriented publications dominate the highly cited core.

Limitations and future directions. The reliance on a single index (Scopus), English-language emphasis, and specific query fields constrain coverage and may shape the top-cited set. Promising next steps include (a) reruns with more precise education-domain filters, (b) triangulation with systematic reviews on PD and infrastructure in primary schools, and (c) stratification by school type/region to examine technology access as a moderator of outcomes.

6. Research gaps and future research directions

Recent studies have highlighted the increasing emphasis on computational thinking and artificial intelligence in primary STEAM education. This trend signifies a broader acknowledgment of the need to equip young learners with the competencies required to navigate increasingly digital and automated environments (Saputra, 2025). Educators are incorporating coding, algorithmic thinking, and problem-solving activities into early curricula to cultivate logical reasoning and creativity (Juškevičienė et al., 2020; Asunda et al., 2023: 51).

Tools such as blk-based programming platforms and AI-powered educational applications are being used to render abstract concepts more accessible and engaging for children. These initiatives aim to establish foundational competencies that support lifelong learning and adaptability in a rapidly evolving technological landscape (Mamaeva et al., 2020; Dohn et al., 2022). Looking ahead, future directions in primary STEAM education are likely to emphasize interdisciplinary learning environments that blend digital literacy with the ethical and societal considerations of technology. As artificial intelligence has become increasingly embedded in daily life, there is a growing need to introduce age-appropriate discussions on data privacy, algorithmic bias, and responsible technology use.

In addition, personalized learning powered by AI is expected to gain traction by offering tailored educational experiences that address individual students' needs and learning styles. These developments suggest a continued evolution of STEAM education towards more holistic, inclusive, and forward thinking.

7. Conclusion

A bibliometric analysis of publications in the Scopus database for 2014-2025 has revealed key trends, research priorities, and the dynamics of scientific activity in the fields of STEAM education, primary school, and technical thinking. In the context of rapid technological development and the emphasis on preparing students for the challenges of the 21st century, the STEAM approach is becoming increasingly relevant, starting from the primary level of education.

This study focused on the integration of interdisciplinary approaches, digital technologies, and cognitive development of primary school students. Simultaneously, there is growing interest in the formation of technical thinking, especially through project activities, robotics, and the use of digital educational resources.

Despite these positive dynamics, questions remain regarding the uneven development of research in different countries, lack of systematic reviews, and poor presentation of empirical studies aimed at measuring the actual impact of STEAM on students' thinking and learning outcomes.

Highlights

Bibliometric analysis of 1,364 publications on STEAM education and technical thinking from 2014 to 2025.

The United States, United Kingdom, and China are the most productive countries in STEAM research.

Arizona State University, University of Hong Kong, and the University of Canberra are influential institutions.

Keyword analysis revealed four research clusters: pedagogical, technological, empirical, and organizational.

Computational thinking and AI are becoming increasingly important in primary STEAM education.

Future research should focus on theoretical models, effectiveness evaluations, and inclusive approaches.

Interdisciplinary learning environments that blend digital literacy with ethics are crucial for STEAM education.

Prospects for future research

Based on this analysis, we identified several promising areas for further research.

1) Development of theoretical models of technical thinking in the context of STEAM education, especially for younger students.

2) The effectiveness of the STEAM approach was evaluated through experimental and longitudinal studies (e.g., using cognitive tests and thinking scales).

3) Impact of digital and gaming technologies on the development of creativity and engineering thinking.

4) Cross-cultural comparative studies on STEAM implementation in countries with different levels of educational development.

5) Integrating gender perspectives and inclusive approaches into the business practices of primary education.

6) Barriers to preparing primary school teachers to implement STEAM programs and develop effective models of professional development.

Ethical Approval

This study did not involve any research involving human participants, identifiable human data, human biological materials, or animals. As such, ethical approval from an institutional review board or ethics committee is not required. This study adhered to the accepted guidelines for non-intervention and desk-based research, involving publicly available secondary data.

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Motivational Readiness of Teaching Staff to Carry Out Professional Activities in the General Education System

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Abstract

A teacher's motivational readiness has a significant impact on the quality of education. The article presents the results of an analysis of the motivational readiness of school teachers in Russia for their professional activities. The work is drawing on psychological and pedagogical research analyzing the characteristics of professional motivation among general education specialists, as well as the socio-pedagogical and psychological factors contributing to its development. The study interprets the results of a large-scale electronic survey covering more than 26,000 teachers from 71 constituent entities of the Russian Federation. Particular attention is paid to examining the value-motivational sphere of teachers in the context of current issues and challenges posed by the modern educational landscape. Teacher satisfaction and self-efficacy, the psychological climate in schools, and other predictors of professional motivation are analyzed. The interpretation of the results and conclusions of the study serves as foundational material for building a system to manage the motivation of teaching staff, optimizing management processes aimed at enhancing the effectiveness of teachers' professional activities, and for creating and implementing organizational scenarios, including scenarios for professional self-realization. The findings of the study add a new dimension to understanding the mechanisms for managing professional motivation and job satisfaction among teaching staff in general education institutions and underscore the importance of an interdisciplinary approach to addressing motivation-related issues in general education. The practical significance of the research lies in the potential application of its results for managing teacher motivation.

Keywords: management of professional motivation, motivational readiness, teaching staff, diagnostic complex, value orientations.

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1. Introduction

The close attention paid by educational management bodies to the mechanisms for developing staff motivation stems from several reasons, including a shortage of qualified teaching staff in the country's schools and the need for educators with a stable positive attitude towards their profession and a level of professionalism that meets the demands of modern society and the labor market. Numerous studies have proven that fostering motivation, both for individual teachers and for teaching teams as a whole, significantly influences all aspects of the educational and upbringing process and substantially enhances the overall effectiveness of an educational institution (Kaitov, 2022).

From the standpoint of a comprehensive psychological-pedagogical approach, significant attention to the problem of the formation and structure of professional activity motives has been paid by A.A. Bodalev, E.N. Bogdanov, A.A. Derkach, N.V. Kuzmina, A.K. Markova, L.M. Mitina, A.A. Rean, and other scholars. Summarizing these studies, we can conclude that professional motivation is commonly viewed as an open, dynamic system that evolves throughout one's professional career and serves as a system-forming factor in the development of professional pedagogical activity.

S.G. Vershlovsky defines motivation for pedagogical activity as "the various urges for which a person chooses the teaching profession: motives, needs, interests, aspirations, ideals..." (Vershlovsky, 2002). It is known that in the andragogical model, an adult independently directs and directs their learning process. This determines the driving forces of learning, which primarily include intrinsic internal motivation (goals, desire for self-development, increased self-esteem). At the same time, external stimuli are not decisive in the learning process. This position was further developed by Yu.N. Kulyutkin (Kulyutkin, 1985), who argued that although the motivation for learning in the andragogical model involves an adult's response to certain external motivators, it is primarily focused on internal motivators. In this context, he repeatedly emphasized the adult's primary focus on what is happening "inside".

This assumption is confirmed by Self-Determination Theory, developed by American psychologists as a model for understanding human motivation (Deci, Ryan, 2012). The theory is based on the premise that people have a basic drive for personal growth, and this drive is underpinned by innate psychological needs for autonomy, competence, and relatedness. Deci, Ryan (Deci, 2012; Ryan, 2020), as well as Koestner, McClelland (Koestner, McClelland, 1990), formulated general principles regarding fostering intrinsically motivated behavior.

Recent studies on academic motivation are of interest.

Important for understanding motivation in enhancing teacher professionalism is V.M. Slastenin's substantiation of the dialectics of the formation of their professional activity. It occurs through a movement initially determined by the force of external motivation, leading towards motivation governed by internal regulators (Slastenin, 2008). According to the scholar, the formation of an integrated system of internal self-regulation can be posited when external regulators in the process of professional activity facilitate the development of internal ones. These internal regulators, in turn, prompt the teacher to re-evaluate the values of external regulators (through axiological analysis), leading to a reconstruction of the system of external regulators as an integrated whole.

Thus, the problem of motivation is interdisciplinary in nature; various fields of scientific knowledge (psychology, pedagogy, sociology, andragogy, etc.) contribute to its resolution, each from its own perspective (Mukhlaeva, 2025).

2. Research methodology

The study employed the method of analyzing empirical data obtained using a developed diagnostic complex for assessing the motivational readiness of teaching staff for professional activity. Diagnostics of the level of motivational readiness among teachers using this diagnostic complex were conducted from September 19 to October 10, 2025, in the form of an electronic survey. Over 26,000 teaching staff residing in 71 constituent entities of the Russian Federation participated in the survey. The survey was conducted anonymously, which allowed for obtaining the most objective results and the most comprehensive view of the processes and trends characterizing motivational readiness. Only essential general information necessary for a comprehensive analysis of the results was requested: gender, position, constituent entity of the Russian Federation, work experience, age, workload (in full-time equivalents), participation in

professional skills competitions, methodological associations, and work as a mentor. The diagnostic complex included the following structural components:

1. Value-Meaning Component, encompassing the system of pedagogical values and professional meanings, including the characteristics of the motivational and value-meaning spheres that constitute the internal potential of a teacher's personality and determine their professional activity. Motives for *full immersion* into the profession were considered: attitude towards the profession, assessment of its social status, awareness of the usefulness and importance of the profession and the teaching process.

2. Goal-Oriented Component, defining the ability to set and achieve professional goals, reflecting processes of professional planning and goal-setting, and establishing goal priorities.

3. Emotional-Volitional Component, assessing emotional attitude towards the profession, stability of the emotional-volitional sphere, and volitional regulation. This component is also related to professional flexibility and response to stress factors.

4. Reflective Component, identifying the capacity for self-analysis and professional self-reflection.

Diagnostics were carried out using 4 complementary methods:

– Questionnaire "Professional Motivation of a Teacher" (PMT) – 60 questions in 6 blocks;
– Methodology "Professional Values of a Teacher" (PVT) – ranking of 18 values;
– Questionnaire "Motivational Profile of a Teacher" (MPT) – 20 questions;
– Projective methodology "Situations" – analysis of 10 professional situations (Figure 1).

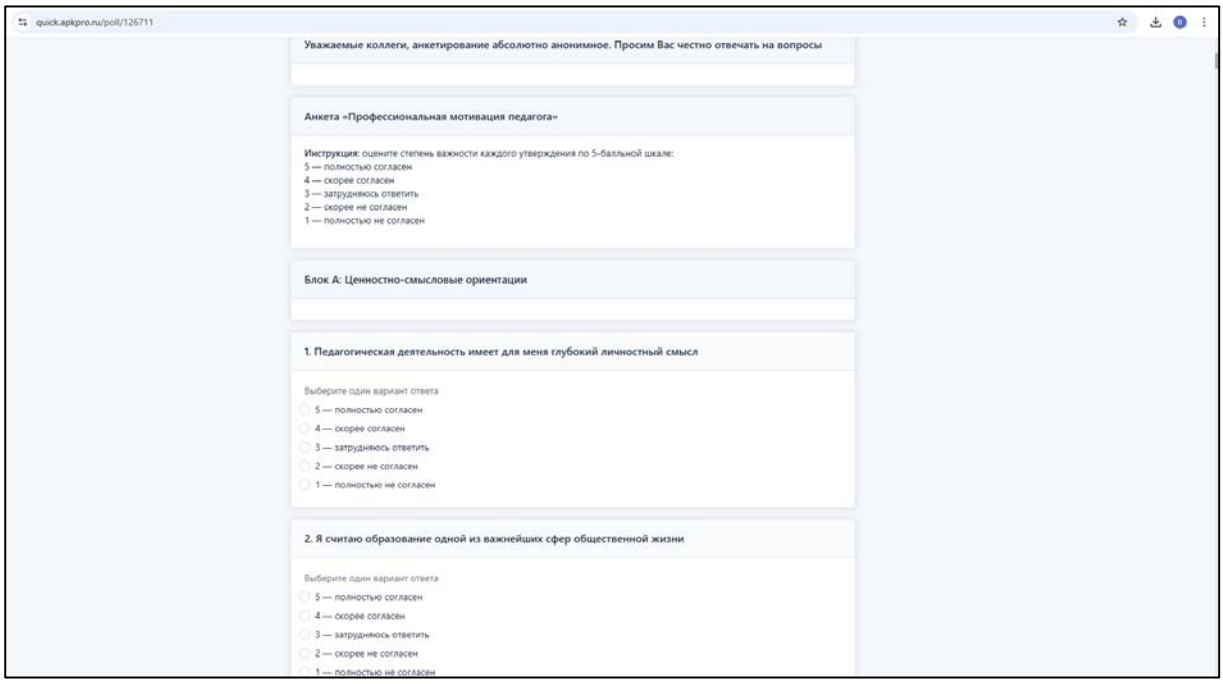

Fig. 1. Questionnaire "Diagnostics of the level of motivational readiness of teachers"

3. Results

Here are the results obtained from the analysis of the diagnostic data.

A total of 25,219 women (93.9 %) and 1,641 men (6.1 %) participated in the survey. The distribution of respondents by age and work experience is presented in Figure 2.

The distribution by teaching experience is as follows:

Up to 3 years: 2,533 individuals (9.4 %);
3-5 years: 1,853 individuals (6.9 %);
5-20 years: 8,136 individuals (30.3 %);
More than 20 years: 14,338 individuals (53.4 %).

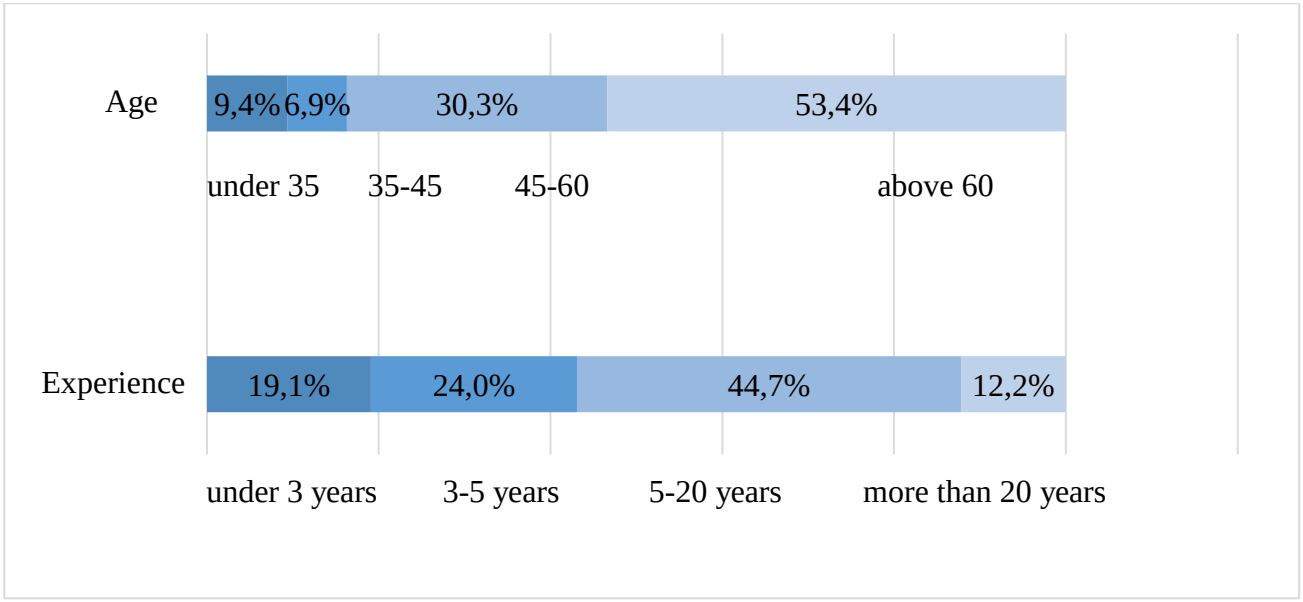

Fig. 2. Distribution by age and length of service

Regarding professional characteristics, it is important to note that the survey included 21,690 teachers (80.7 %), 620 educational psychologists (2.3 %), 447 educational organizers (1.7 %), 394 social educators (1.5 %), and 3,709 individuals who indicated their position as "other" (13.8 %).

Among them, 8,494 individuals (31.6 %) have participated in federal or regional professional skills competitions, indicating that one-third of the audience is initially quite proactive, paying great attention to self-development and improving professional competencies. From the total number of respondents, 7,157 individuals (26.6 %) have ever acted as mentors, which also speaks to the high professional skills of the respondents.

One question was related to teaching workload, and the following distribution was obtained, indicating that the majority of respondents are fully occupied:

– Less than 0.5 full-time equivalent (FTE): 306 individuals (1.1 %);
– 0.5 FTE: 784 individuals (2.9 %);
– 0.5-1 FTE: 1,466 individuals (5.5 %);
– 1 FTE: 9,441 individuals (35.1 %);
– 1-1.4 FTE: 7,315 individuals (27.2%);
– more than 1.4 FTE: 7,548 individuals (28.1 %).

The distribution of participants in the pilot diagnostics by federal districts of the Russian Federation is presented in Figure 3.

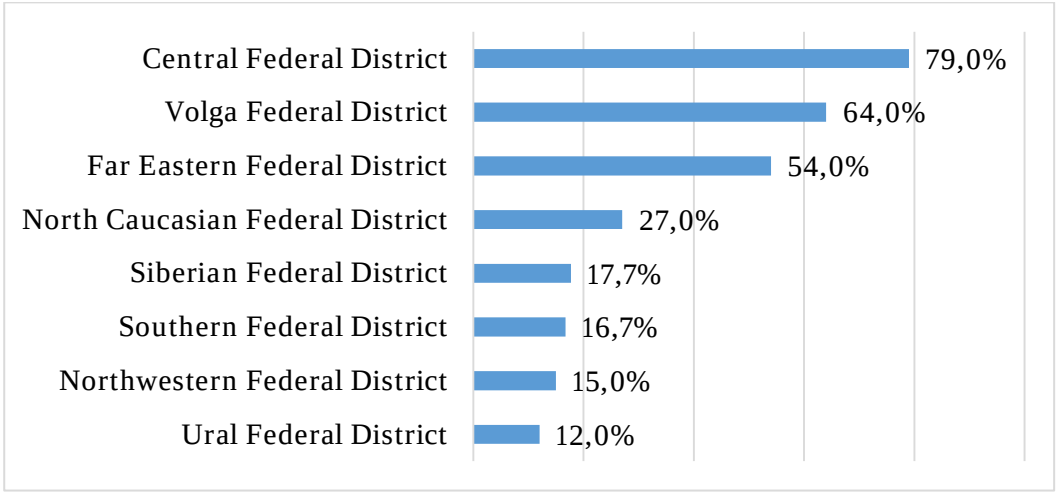

Fig. 3. Distribution of participants in the pilot diagnostics by federal districts of the Russian Federation

Value-Meaning Orientations of Teachers

First and foremost, studying the motivational readiness of teachers requires focusing on their value orientations. There is no doubt that determining the quality of education must take into account that pedagogy is not value-neutral (Koroleva, Mukhlaeva, 2023).

Based on the results of analyzing responses to questions aimed at identifying value-meaning orientations, the highest scores received the statements characterizing the social significance of the teaching profession (Figure 4):

– I consider education one of the most important spheres of public life (82.3 % – completely agree).

– I believe in the possibility of positively influencing the future through education (62.6 % – completely agree; 36.8 % – partially agree).

– I consider my work socially significant (72.9 % – completely agree).

More than half of the respondents feel pride in belonging to the teaching community (51.5 % completely agree; 36.6 % partially agree).

92 % of teaching staff responded positively to the statement that pedagogical activity holds deep personal meaning for them. The obtained statistics indicate that awareness of the social significance of the profession becomes a stimulus for personal development as well. It should be noted that even under conditions of low prestige of the teaching profession, social motivation can remain sufficiently high, giving meaning to the chosen profession and also serving as a means of enhancing one's own significance in the process of pedagogical work (Hall, 2001).

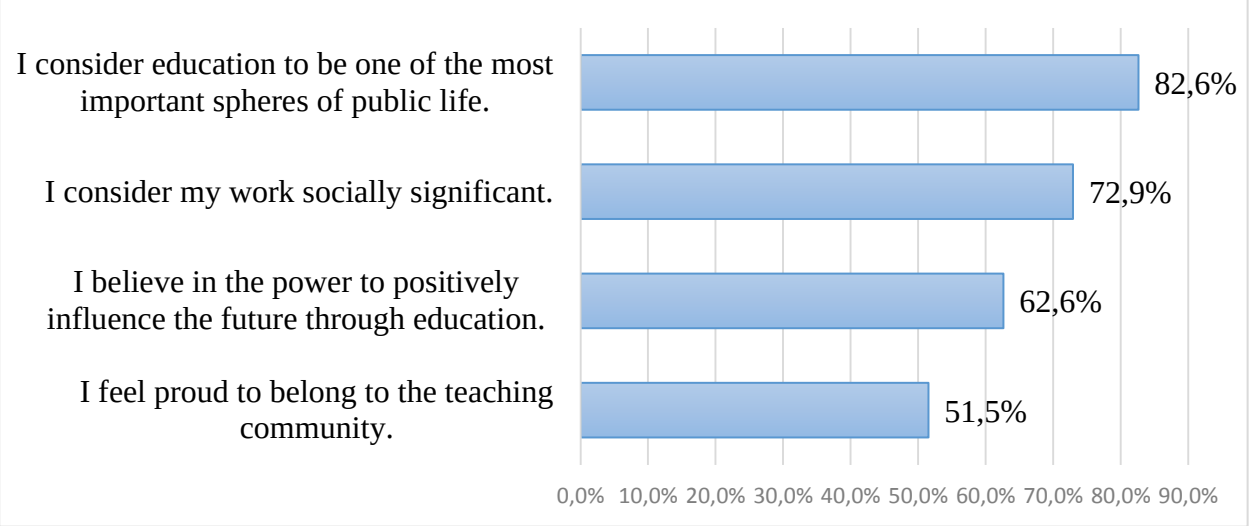

Fig. 4. Assessing the social significance of the teaching profession

As the data show, the value-meaning orientations also reveal an intrapersonal context. The profession facilitates the realization of value-based ideas and is a source of creative and professional growth. 79.2 % of teachers note that the profession allows them to realize their life values. 92.9 % see their mission in developing the learner's personality. 81.8 % affirm that the teaching profession corresponds to their ideas of their calling. Approximately half of the respondents consider professional development more important than material well-being.

An important psychological characteristic is readiness as a state of awareness of needs and motives. More than half of the respondents (53 %) are willing to sacrifice personal time for the sake of fulfilling professional tasks.

Creativity and the opportunity for self-realization appear to be the most important value components of the profession. Thus, 98 % of teachers state that they are attracted by the creative nature of the activity.

Regarding teacher-student interaction, it is considered one of the most rewarding aspects of the teaching profession, serving as a vital source of self-development, a means of understanding societal processes, and, in some cases, a wellspring of energy and emotional support. Almost half of the respondents (49.9 %) note that working with children brings emotional satisfaction. 38.6 % rather agree with this statement. 56.4 % see their mission in developing the learner's personality;

36.9 % express partial agreement. 73.8 % are ready to be a role model for their students. Nearly 60 % of teachers consider students' professional achievements to be their main reward (Figure 5).

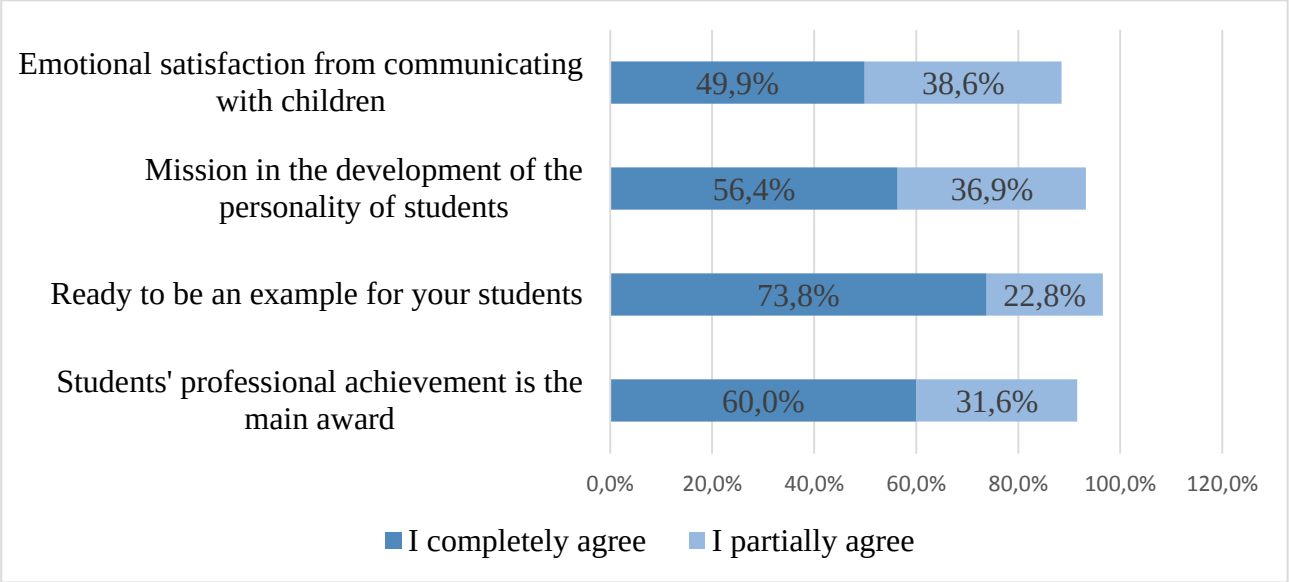

Fig. 5. Communication with students

Thus, the responses of the surveyed teachers indicate a dominance of social motivation, present in their assessment of the profession's social status, and the significance of its key components for them: development of the learner's personality (92 %), creative nature (98 %), and opportunity for self-realization (79 %) (Figure 6).

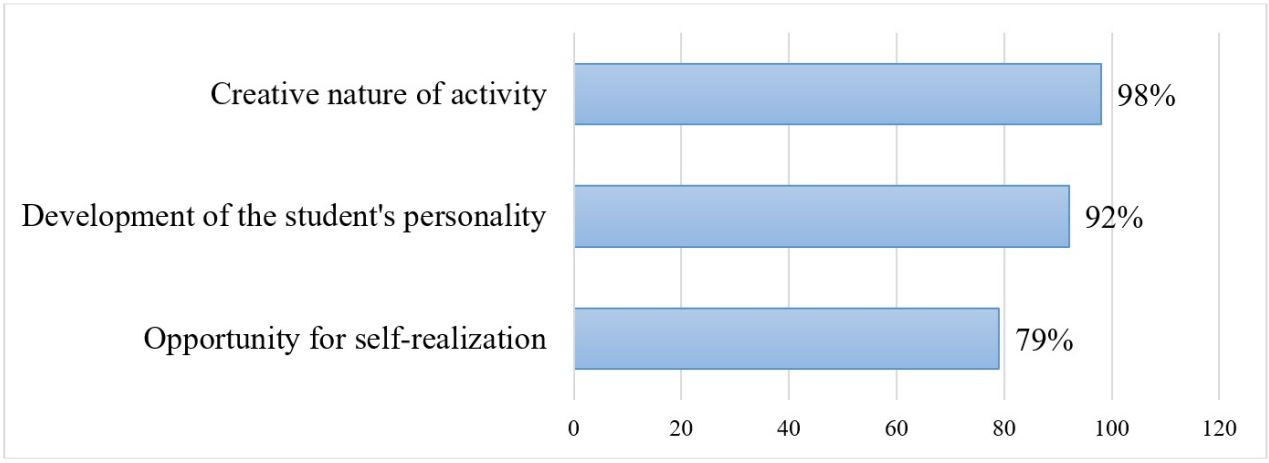

Fig. 6. Dominance of social motivation

Goal Setting and Planning

In a socially oriented profession like teaching, goal setting plays an exceptionally important role. The main characteristics of goal setting are directionality, awareness, and effectiveness. In the process of goal formation, its personal meaning and subjectivity typically intensify. Goal setting serves as a criterion for professional self-awareness and is closely linked to the motivational sphere. In formulating questions for teachers, we, in particular, relied on research proving that the level of goal-setting development is determined not so much by teaching experience and qualifications, but rather is correlated with the level of personal maturity. Accordingly, we assume a connection between goal setting and high motivation (Mezentseva, 2011). The overwhelming majority of surveyed teaching staff (over 80 %) answered that they set specific professional goals for themselves, can plan their professional development, and regularly analyze the achievement of the set tasks. Notably, goal setting is not rigid. Almost 90 % (42.1 % completely agree and 48.1 %

partially agree) of respondents are ready to adjust goals depending on circumstances. More than half of the respondents, to varying degrees, link their personal goals with the goals of the educational organization, indicating a sufficiently high cohesion of teaching teams and a high degree of self-organization.

Emotional-Volitional Sphere

The teaching profession, due to its specific nature, is associated with the manifestation of various emotions, both positive and negative. Important components of pedagogical work are a sense of duty and heightened responsibility. A wide spectrum of emotions is involved in a teacher's activity: communicative, humanistic, aesthetic, etc. The teaching profession is one of the most stress-inducing, which can lead to chronic stress and, ultimately, professional burnout. The survey data showed that the vast majority of surveyed teachers, to varying degrees, experience positive emotions from their profession (40.9 % completely agree and 43 % partially agree). They are also ready to overcome difficulties in the professional sphere (33.8 % completely agree and 46.7 % partially agree) and maintain optimism even when problems arise (28.1% completely agree and 44.9 % partially agree).

An important characteristic of a teacher's emotional-volitional sphere is emotional stability, indicating a high level of its development. The survey data indicate a sufficiently high level of emotional stability development. Most respondents believe they can manage their emotions in difficult situations (34.1 % completely agree and 48.6 % partially agree). Half of the surveyed respondents can mobilize their resources in stressful situations and emphasize that it is relatively easy for them to recover from professional failures (18.4 % completely agree and 33.1 % partially agree). However, a quarter of teachers emphasize that recovering from professional failures is not easy for them (Figure 7).

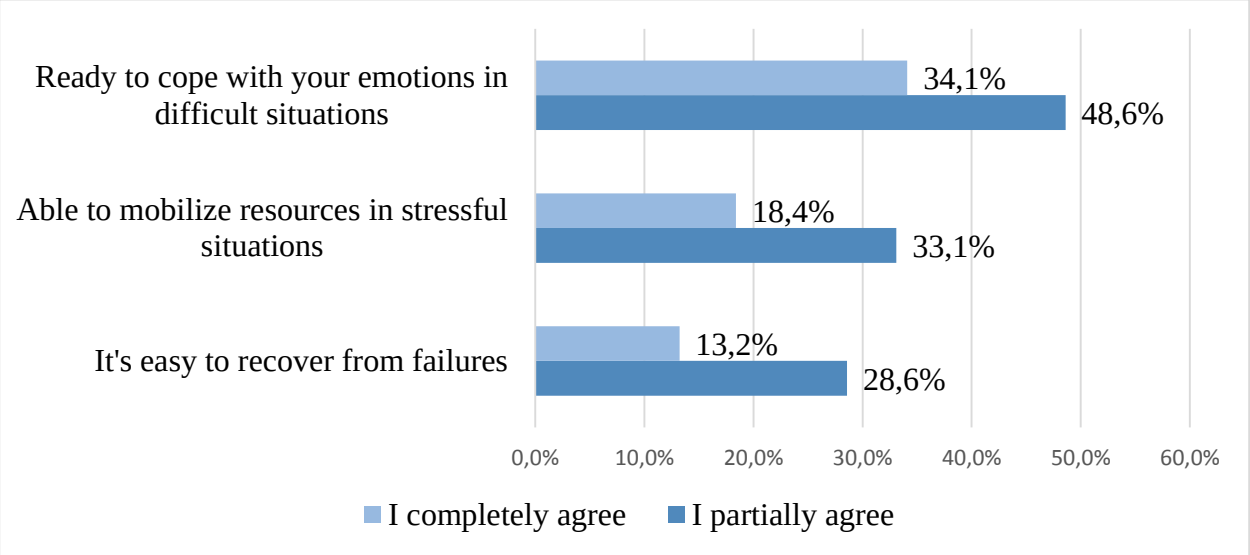

Fig. 7. The emotional-volitional sphere of the teacher

The stable ability to overcome difficulties in the professional sphere is evidenced by the readiness of 80 % of teachers, and 77 % are able to maintain a personal working mode in any situation. At the same time, half of them (51 %) note that their resources are mobilized in a stressful situation, while 29 % found it difficult to answer this question.

Professional Reflection

An important place among psychological processes is occupied by a teacher's professional reflection, which allows for analyzing and rethinking professional experience, finding opportunities for professional growth, and building strategic planning. Professional reflection characterizes both an individual's overall success and the effectiveness of their activity. It is significantly linked to the development of creative thinking and the enhancement of professional mastery. Undoubtedly, the higher the level of personal and professional reflection, the more consciously an educator approaches task resolution and assesses their strengths and weaknesses. This self-awareness, in turn, enables advancement along the professional career ladder (Zhurko, 2012). When developing

the diagnostic complex, we also assumed that high professional motivation in a teacher stimulates the capacity for self-reflection.

The survey also showed a sufficiently high level of professional reflection among the respondents. For instance, the overwhelming majority of respondents, to varying degrees, regularly analyze the results of their work (36 % completely agree and 49.1 % partially agree). 90 % of teachers note that they are capable of critically evaluating their professional actions (41.3 % completely agree and 48.1 % partially agree). Teachers strive to understand the motives behind their professional actions (43.3 % completely agree and 46 % partially agree) (Figure 8).

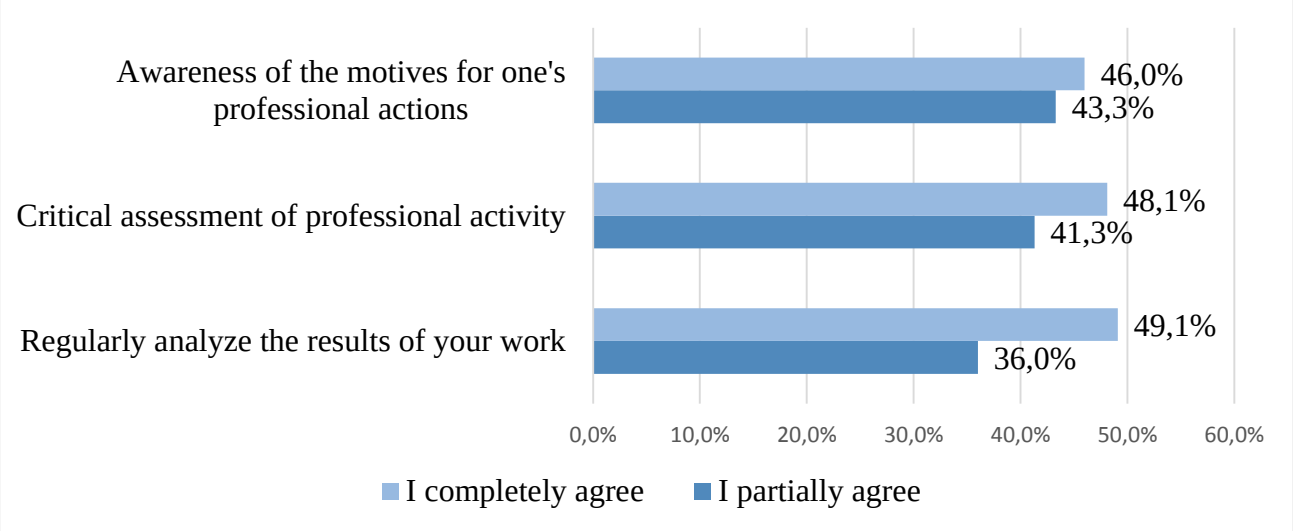

Fig. 8. Professional reflection

The diagnostic complex also included a separate block titled "***Motivational Profile of a Teacher***", dedicated to examining components of internal and external motivation, reflecting motives for self-affirmation and self-realization in the profession, the significance of personal involvement in teaching and upbringing processes, the striving for personal and professional growth, as well as the influence of external economic and social stimuli.

The block of questions in the "Motivational Profile of a Teacher" aimed to examine professional motivation as a system of interrelated motives in a certain way, illustrating teachers' preferences in choosing values and goals, their conscious determination of the direction of behavior and professional activity.

It is known that professional motivation is closely linked to job satisfaction, as "it is a reflection of the relationship between a teacher's demands regarding the content and conditions of work, on the one hand, and the assessment of opportunities to realize their claims, on the other. At the same time, it is important to distinguish between satisfaction with the profession and satisfaction with the job" (Uchitel'..., 1994). This idea, articulated by S.G. Vershlovsky, aligns with the theory of F. Herzberg, the author of the two-factor model of motivation. In his study of motivation among industrial professionals, Herzberg concluded that there are specific conditions and factors that create a high level of motivation. Moreover, their absence does not, in itself, lead to dissatisfaction (Herzberg et al., 2007).

Teachers' responses to questions in this block showed that despite 73 % of them believing their salary is insufficient, nevertheless, 82 % experience satisfaction from their professional activity.

Let's examine the obtained results regarding the assessment of the orientation of internal motivation.

One of the most significant criteria for a teacher's professional successes and achievements is the need for professional growth and self-development. Almost all respondents, to varying degrees, strive to constantly improve their professional skills (48 % – completely agree and 44 % – partially agree). For most teachers, professional growth is an internal need (36.7 % – completely agree; 43.3 % – partially agree). Approximately 75 % of respondents, to varying degrees, strive to enhance their professional competence and improve in their profession. Another important indicator of internal motivation can be noted as the desire for innovation and experimentation with new

pedagogical methods, which demonstrates openness to new things and readiness to apply innovations (31 % – completely agree and 46 % – partially agree) enjoy experimenting with new professional methods; 48 % and 44 % strive for constant improvement of their skills; 29.6 % and 44 % derive satisfaction from solving complex pedagogical tasks; 39 % and 47 % are ready to apply innovations in their work).

Regarding external motivation, as its predictor we primarily considered the need for social recognition, which appears to be a very important condition for the growth of professional motivation and job satisfaction. Note that the problem of defining and studying the social status of a teacher has not lost its relevance throughout the existence of this profession. At the same time, a contradiction in the system of social status persists between the declared high evaluation of a teacher's work and the real institutional means (primarily economic) supporting this evaluation. Analyzing a teacher's assessment of their own professional status provides insight into their self-esteem, professional priorities, and prospects for remaining in the profession. Almost 90 % of respondents emphasized the significance of their professional status, positively marking the statement "I am proud to belong to the teaching community" and noted the importance of recognition from colleagues (78 %). Approximately the same number of teachers acknowledge the significance of evaluation from students' parents. Meanwhile, evaluation in line with administration expectations proved less significant (23.5 % – completely agree and 38.4 % – partially agree). Career advancement opportunities within school conditions are very limited. At the same time, more than half of the respondents strive for career growth in the professional sphere (24.8 % completely agree and 33.1 % partially agree).

Statistics, as expected, indicate the significance of material incentives for motivational readiness as another factor of external motivation; it influences not only economic well-being but also serves as a source of increased self-esteem. 84 % of teachers note the positive impact of material rewards on their activity.

Overall, analyzing which motives stimulate teachers in their professional activity, the diagnostic results show an undeniable dominance of internal motivation factors. Teachers ranked the striving for self-development first (81.3 %). At the same time, working conditions act as a significant incentive in enhancing professional motivation. Also, the majority of surveyed teachers (70 %) affirmatively noted the importance of ensuring good working conditions.

Responses to the block's final question: "What motivates you the most in your professional activity?" illustrate the dominance of internal motivation factors in the sphere of professional self-realization (influence on personality formation and interest in the subject area) (Figure 9).

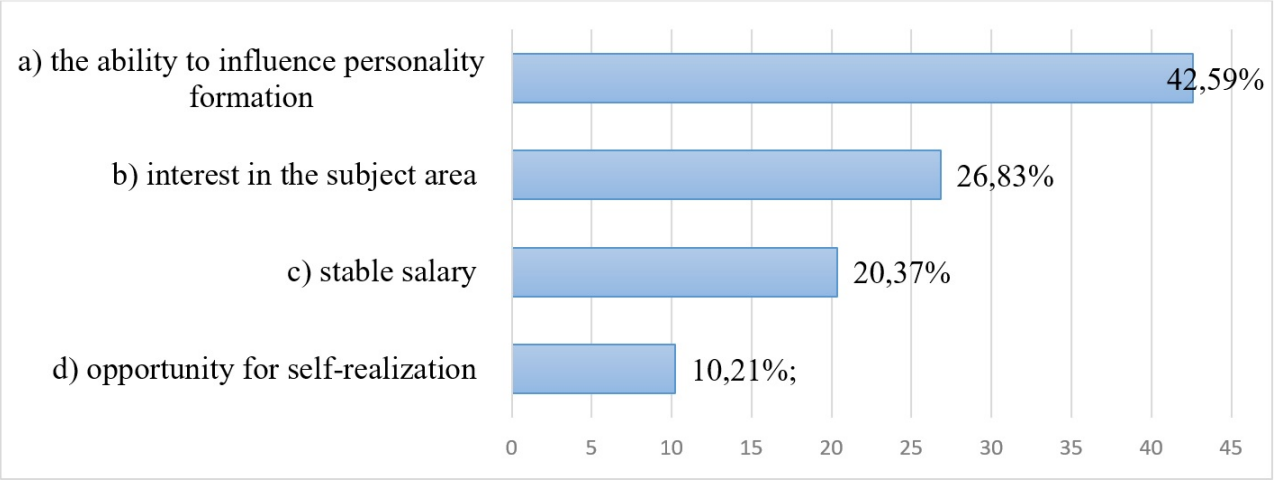

Fig. 9. Factors influencing professional motivation

A teacher's work is associated with the need for constant self-development in the profession and improvement of professional skills.

Teachers' engagement in professional development programs shows a positive correlation with their level of job satisfaction. This underscores the role of professional development as a motivational factor for continued professional activity, precisely by fostering this sense of satisfaction (Kraft et al., 2016). However, this relationship may also be reciprocal; it is logical that

teachers who are more satisfied with their work exhibit a stronger inclination to participate in such programs (Nir, Bogler, 2008).

Let's examine the results of responses to questions in the block concerning attitudes toward professional development. The overwhelming majority of respondents view professional development positively as a form of professional and personal growth (Figure 10).

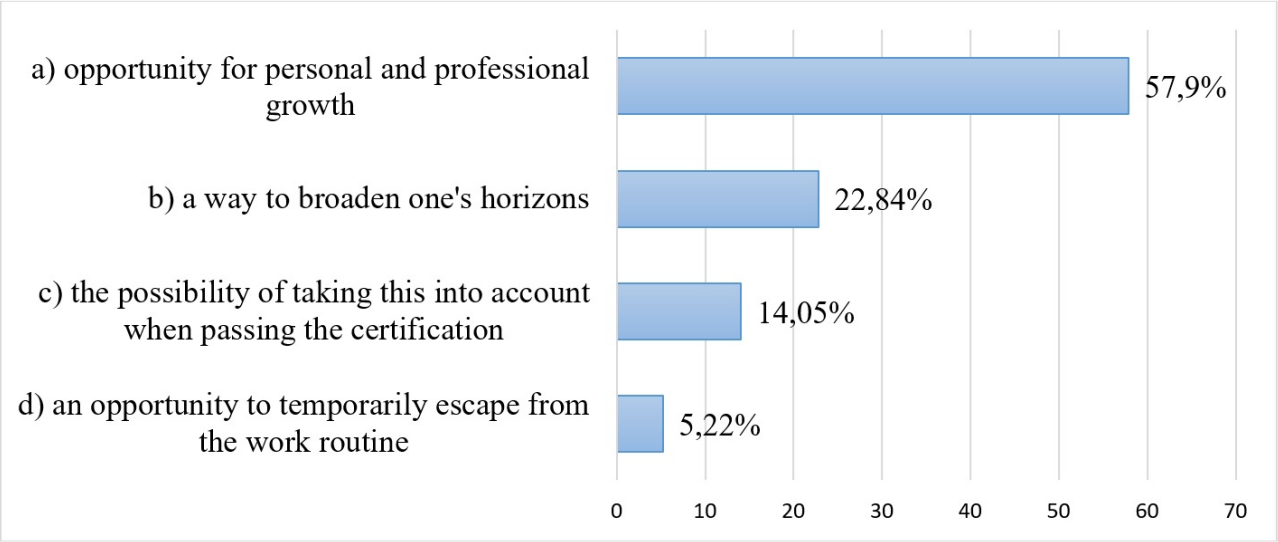

Fig. 10. Attitude towards additional professional education

Over 70 % of teachers evaluate corporate training positively; however, teachers' opinions diverged depending on the motivation factor. For 43 %, it is an excellent way for teamwork, while for 37 %, it is a way to test their abilities. More than half of the respondents (62 %) highly value the opportunity to participate in scientific-methodological work as a source for improving professional skills. More than a third of respondents consider expert activity attractive, as it provides an opportunity to learn from other teachers' experiences. 84 % of respondents regularly study literature on new teaching and upbringing technologies and strive to apply the acquired knowledge in their work. Thus, a sufficiently high level of teachers' orientation towards improving their professional knowledge can be noted.

4. Discussion

The analysis of teachers' motivational readiness allowed for identifying a number of discussion points. Within this discussion, we consider it relevant to review a series of predictors of motivation and job satisfaction, also reflected in the diagnostic complex, such as individual beliefs in one's own effectiveness (self-efficacy) and the perception of school climate.

Self-efficacy is defined as people's beliefs about their ability to successfully perform a specific course of action, a person's belief in their own capability to devise and implement the sequence of actions required to produce a given result (Bandura, 1997). It is known that this concept is central to social-cognitive theory. Self-efficacy beliefs constitute a key attribute of human activity. They determine how individuals perceive and are oriented toward overcoming difficulties and failures (ibid.). Teacher self-efficacy has been conceptualized as an educator's judgment or belief in their capabilities to engage students in the learning process, manage their behavior, and implement instructional strategies overall (Tschannen-Moran, Hoy, 2001). Teacher self-efficacy is regarded as a significant factor determining job satisfaction (Malmström, Öqvist, 2025; Caprara et al., 2006). Teachers with higher self-efficacy in teaching tend to report greater levels of job satisfaction and demonstrate higher professional motivation (Toropova et al, 2020; Kim Yeoun et al., 2023).

This relationship is likely reciprocal; undoubtedly, a stronger sense of self-efficacy is fostered to a significant degree by recognizing one's own positive professional stances (Bandura, 1997).

Teacher self-efficacy, while correlating with these attitudes and job satisfaction, also influences teacher enthusiasm – a state in which educators typically experience inspiration and enjoyment from their professional duties (Kunter et al., 2008). In this way, self-efficacy mediates the relationship between positive emotions and teacher enthusiasm (Buric, Moè, 2002). A higher

level of teachers' belief in their self-efficacy is also associated not only with higher job satisfaction but is logically determined by lower levels of intentions leading to staff turnover (Skaalvik, Skaalvik, 2014).

Another aspect of self-efficacy in the context of our study is the fact that, being a key attribute of human activity, self-efficacy beliefs determine how people perceive and cope with difficulties (Bandura, 1997). Research on factors determining teacher job satisfaction and professional motivation has revealed a consistent mitigating effect of teachers' self-efficacy beliefs on the stressful work environment in schools, e.g., Collie et al. (Collie et al, 2012).

Moreover, Klassen and Chiu (2010) contend that teacher self-efficacy mitigates the impact of occupational stress on professional motivation. This view is corroborated by other researchers (Collie et al., 2012), who, in their study of the interrelationship between teacher stress, self-efficacy, and job satisfaction, confirmed that when stressful working conditions are coupled with a pronounced sense of self-efficacy, they tend to be perceived as surmountable challenges and consequently do not exert a negative influence on job satisfaction.

Researchers pay particular attention to studying the indicator of teachers' perception of the school climate. It has been noted that the support of teacher enthusiasm by colleagues and the leadership of the educational organization correlates with job satisfaction and professional motivation; these factors are regarded as key resources for ensuring the quality of professional activity (Toropova et al., 2020; Yetiş, 2025). Conversely, conflict situations arising during interactions with colleagues act as negative predictors of job satisfaction and pose an obstacle to teachers' effective work.

The teaching profession presupposes a sufficiently high level of development of communicative competencies, including the ability to build constructive dialogue with other participants in the pedagogical process, avoid aggression, make quick decisions in conflict situations, and strive to understand students and colleagues (Teledahl, 2024). Analysis of teachers' responses to questions aimed at understanding the importance of interaction with other participants in the pedagogical process and the nature of the psychological microclimate showed that 50 % of teachers view their colleagues' achievements positively and are ready to use their experience in their own work. Also, 50 % of respondents note the presence of healthy competition in the team as a positive fact. For 15 %, the healthy competition acts as a significant incentive.

In the course of their work, a teacher often encounters conflict situations. Avoiding conflicts in the school environment is practically impossible. The teacher's stance towards a conflict situation and their motives for overcoming them are important. As a positive fact, it should be noted that the majority of respondents strive to avoid conflicts and criticism (44.3 % – completely agree and 44.4 % – partially agree).

Thus, collegial enthusiasm can be viewed as an indirect source of motivation. It assists teachers, particularly those with external motivation, in finding meaning and value in their work. Conversely, although the organizational climate undoubtedly plays a significant role even for teachers who chose their profession for more intrinsic reasons, they largely derive satisfaction from personal self-realization and a passion for the act of teaching itself. Consequently, this somewhat diminishes the relative importance of collegial enthusiasm for this group (Fernet et al., 2008). Undoubtedly, to most effectively enhance job satisfaction among all teachers, regardless of their initial career motivations, it is crucial to create an environment that fosters both high morale and strong professional commitment.

5. Conclusion

As a result of the study, components of teacher motivation in value-based, goal-oriented, emotional-volitional, and reflective aspects were identified, the most significant and insignificant motives were outlined, and their comparative analysis was conducted. The dominance of internal motivation factors over external motivation was convincingly confirmed. The role of teachers' self-efficacy and their perception of school climate as leading predictors of motivation and satisfaction with their professional activity was analyzed. The conducted research enables conclusions to be drawn that are significant for implementing targeted measures within personnel policy. These include fostering motivation among education workers and developing approaches to effectively manage their professional development. This, in turn, constitutes one of the essential conditions for achieving high-quality education and enhancing the prestige of the teaching profession.

6. Acknowledgements

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Fostering a Positive School Climate through Spiritual Leadership in High Schools

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Abstract

This study investigated the relationship between Spiritual Leadership Practices (SLP) and Positive School Climate (PSC) of 38 student leaders enrolled in the Polytechnic University of the Philippines Laboratory High School during SY 2024–2025. A researcher-made questionnaire was employed to gather data on spiritual leadership dimensions – vision and purpose, hope and faith, altruistic love, and meaning and belonging – along with perceptions of positive school climate, these were analyzed through Pearson's correlation analysis and Spearman's rank-order correlation analysis to ensure result reliability. A weak but statistically significant positive correlation between SLP and PSC was found, suggesting that stronger spiritual leadership practices are associated with a more supportive, collaborative, and inclusive school environment. Spearman correlation indicated a similar positive direction but did not reach statistical significance. Both tests supports the conclusion that spiritual leadership practices positively relate to perceptions of a positive school climate. It is recommended that schools provide spiritual leadership development programs for student leaders to further enhance positive school climate, promote cooperation, and foster holistic student growth.

Keywords: spiritual leadership, positive school climate, student leadership development, high school education, leadership traits.

1. Introduction

The development of leadership in high school students is an important part of an education as it molds the future leaders into individuals with the values and skills that enable them to become successful in their lives. In addition, student leadership fosters students for societal issues and builds civil responsibility. The study of Li (2024) emphasizes the importance of cultivating leadership behavior, which is crucial for community engagement, thru student-centered learning. In relation to societal and community. With respect to the social and community Naheed et al.

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(2023) noted the important power of student leadership in higher education for addressing social problems such as poverty, healthcare, and sustainability through collaboration. In addition to overall leadership, the involvement of Student leaders in decision-making and management of discipline also contributes to better school climate because it builds accountability and responsibility within students as explained in the study of Umurisa et al. (2024).

Spiritual leadership greatly influences the leadership experiences of students. The study of Allen et al. (2023) provided an in-depth analysis of the importance of spirituality in facing life's challenges and empowering leadership of black male college students. It also highlights the need for inclusive approaches to integrating spirituality in students' leadership development. Prabhu and Mehta (2023) underscored the importance of spiritual values in fostering holistic student growth by identifying eight attributes of Spiritual Intelligence (SI) that influences student leadership development in higher education, providing a framework for applying spirituality to their academic lives, regardless of personal beliefs.

In this study, spiritual leadership is not defined by specific religious or spiritual traditions, but as a leadership model based on universal values – such as hope, vision, altruistic love, and a sense of meaning and belonging – that contribute to a positive and inclusive school climate (Fry et al., 2017; Zaharris et al., 2017). Therefore, the focus is on the enactment of these values by student leaders, rather than on their personal or religious spiritual beliefs.

The relevance of measuring spiritual leadership among students in schools extends globally, addressing critical issues in character development, moral education, and academic performance. Spiritual leadership helps develop values like honesty and tolerance, as well as cooperation, which are essential for the creation of ethical and supportive schools. For example, students' active participation in spiritual activities such as congregational prayers and Quran recitation of students at SMK Islam Al Fadhila Demak, Indonesia resulted in stronger character development and improvement of vocational education quality (Maulidin, 2024). Moreover, when it comes to schools run by the Seventh-Day Adventist (SDA) faith in Zimbabwe, student-led initiatives for spiritual leadership have been instrumental in promoting discipline and high academic standards in these schools, highlighting how spiritual leadership can address moral decline and train individuals to become holistic humans (Ngwenya, Nyakora, 2024). Spiritual leadership working on promoting universally accepted concept values, such as hope, faith and altruistic love, can foster a positive school culture whereby students experience ongoing personal growth and, in turn, academic success (Zaharris et al., 2017). This emphasis on student spiritual leadership underscores the global importance of nurturing students who are ethical, motivated, and socially responsible leaders who can give back to their communities, serving as an invaluable addition to the educational systems in nations worldwide. Thus, this study contributes to international discourse by exploring spiritual leadership in the context of a Philippine secondary school providing localized insights with global implications.

Although there is a depth of research done on spiritual leadership with adults especially in higher education (Allen et al., 2023; Prabhu, Mehta, 2023), it can be noted that little attention has been focused on adolescent leaders at the high school level, resulting in a lack of knowledge around how adolescent leaders experience spiritual leadership and the impact it has on them in high school settings. This is a noticeable gap and indicates where more exploration of spirituality in adolescent leadership is needed.

This research gap should be addressed, as the current study will thus provide insight into the influences linking spiritual leadership to the development of adolescent leaders and a positive school environment. It will also help teachers and administrators develop a more holistic leadership programs, which foster responsible, empathetic leaders in high schools. Such an exploration is critical for promoting leadership practices that advance spiritual values in the secondary school context. To achieve these objectives, the study adopts a quantitative research approach. This method enables the examination of the relationship between spiritual leadership practices and school climate using measurable data and statistical tools. It promotes objectivity and supports the study's goal of identifying whether significant correlations exist among the variables.

Specifically, this study aims to answer the following questions:

1. To what extent do high school student leaders agree or disagree with the practice of spiritual leadership?
2. To what extent do high school student leaders' responses reflect a positive school climate in their schools?

3. Is there a significant relationship between the perception of spiritual leadership practices and the perception of a positive school climate in high schools?

Review of Related Literature

Leadership in High Schools

For most individuals, school serves as the first formal organizational experiences that shapes our early understanding of organizational culture and roles. School is often perceived as the most significant organizational experience during childhood and adolescence (Montgomery, Kehoe, 2015). In addition, Murphy (2012) posited that behaviors in adult organizational settings are deeply influenced by experiences in school as individuals spend an extensive time in school, an average of 12 years or approximately 15,000 hours, making it a central institution in formative years.

Schools have the greatest influence on the leadership development of young people due to the unique set of both formal and informal opportunities they provide. Research shows that student leadership not only motivates and boosts the confidence of learners but it also solves trust issues between students and teachers thus developing even sturdier relationships (Lavery, Hine, 2013). Student leaders are also key actors of discipline within schools, by their activities such as controlling the behavior, organizing events, and maintaining order that boosts a positive school environment (Kirea, 2015; Njue, 2014). For instance, prefects act as the main link between students and the school communication administration and therefore they can carry out disciplinary duties with ease as well as supervise the entire operation of the school (Kirea, 2015). On the other hand, leadership training like the one discussed by Lau (2004) prefects are awarded practical skills that help them develop personally and equally support the flawless operations of their institutions. The prefect system of Botswana, analyzed by Morapedi and Jotia (2011), moves further as it even shows the role of student leadership in teaching civic responsibility and engaging with the democratic cause. These studies point out that student leadership has a huge impact in increasing discipline in the school community, helping individual and groups to grow, and even building up the personal and collective levels of thereof.

Spiritual Leadership

Researchers and scholars have been describing the concept of spiritual leadership in various ways by concentrating on two main aspects which are spirituality and leadership. The term spirituality, as defined by Hindmarsh (2018), is an animating principle of existence that gives the living a sense of purpose and precious meaning. This means that spirituality is something that influences an individual's behavior and how they perceive the meaning of their actions. While on the other hand, a leader is one who exerts influence, inspires, and motivates the others to the accomplishment of specific goals or the following of particular values (Frost, 2019; Smith et al., 2018; Wang et al., 2019). Thus a leader's function is the influence of followers' behavior as well as their guidance toward mutual goals. When including spirituality into the actual practice of leadership, it means that leaders advise their followers to have a more profound and intimate engagement with their work. Furthermore, spiritual leadership makes it possible for followers to understand that their work has a bigger meaning and therefore get more attached to their job, thereby bringing out the best of them in what they do (Gjorevska, 2021; Siddiqi et al., 2017). This means of leadership underpins the need to create a sense of purpose and attachment to organizational duties which are significant and this finally translates to a more engaging and motivating experience.

Spiritual leadership refers to the process of inspiring and motivating others by guiding them through spiritual values that reflect one's beliefs about the meaning of life. These values include concepts such as love, compassion, justice, and equality. Spiritual leaders use these values to influence their followers positively and foster a sense of purpose and community. This form of leadership is applicable across various sectors, including education, where leaders inspire students and staff to connect with their work on a deeper, more meaningful level (Rafsanjani, 2017).

Theoretical Framework

Transformational leadership theory which was defined by Burns (1985) and later elaborated by Bass comes with the concepts of inspiring followers to reach their potential. Leadership based on spiritual values and transformational leadership have common elements which include the ability to inspire and motivate followers through core value-based leadership. Transformational

leaders are the ones who wield the idealized influence to spur on the employees to aspire to the highest levels of performance, impart the necessary motivation to the employees to pursue the goals, encourage the employees to think out of the box, and be in the connections with the employees as well (Bass, 1985; Northouse, 2018). In the same vein, the spiritual leadership that values the principles of love, compassion, and justice is the kind of leadership that will help the followers to find the deeper meaning and purpose in their work (Rafsanjani, 2017).

Meanwhile, both of them focus on forming a common goal and promoting ethics which could be specifically positive in school settings. For high school student leaders, integrating spiritual and transformational leadership principles can help cultivate leaders who are not only motivated by academic goals but also by a sense of personal and communal growth, enhancing their leadership qualities and connection to others.

2. Methodology

This study used a quantitative research design to analyse the relationship between spiritual leadership characteristics, and the school climate perception of student leaders. The sample of the study were 38 student leaders which include homeroom presidents, homeroom vice presidents, organization presidents and organization vice presidents from the Polytechnic University of the Philippines Laboratory High School. Respondents were intentionally sampled using purposive (criteria) sampling (i.e., chosen based on leadership level, with the assumption that they possessed traits likely to be relevant to the study). While there are only 38 student leaders in the sample, this number is adequate for correlational analysis of the small and organic population of student leaders within the school. In general a minimum sample size of 30 is required to detect medium sized relationships (Cohen, 1992). In addition, the study aimed at representativeness across the organization and not generalizability.

A researcher-made survey questionnaire with two sections was developed for the study: Section I focused on spiritual leadership practices that included vision and purpose, hope and faith, altruistic love, meaning and belonging whilst Section II assessed student leaders' perceptions of positive school climate. The instrument underwent content validation by two experts who rated each item on a four-point scale: 1 – Not Relevant, 2 – Somewhat Relevant, 3 – Quite Relevant and 4 – Highly Relevant. The S-CVI was 0.95, which reflects excellent content validity. Finally, a pilot test was performed on student leaders with profiles similar to those that participated in the study. Its (0.75) calculated Cronbach's alpha coefficient also showed an acceptable internal consistency reliability of the tool for its application in data collection of the study.

The assumption of Pearson correlation coefficient was verified prior to the analysis. The two variables – spiritual leadership practices and perceived positive school climate – were continuous constructs in this study and assessed separately. Normality of the data was evaluated by Shapiro-Wilk test and Q–Q plots. Analysis results spiritual leadership practices ($W = 0.939$, $p =. 039$) was somewhat less than normal, and found that perceived positive school climate ($W = 0.957$, $p =. 156$) was normally distributed. The Q–Q plots of both the variables in visually appeared to be closely lying on the diagonal line representing approximate normality. Linearity and homoscedasticity were tested with a scatterplot that showed an overall positive linear association between the two variables, no large outliers, and an equivalent spreading of data. Based on these results, the conditions required for Pearson correlation were assumed to have been met and Pearson correlation was accepted as a valid test for examining the relationship between spiritual leadership and school climate (Ghasemi, Zahediasl, 2012). Nonetheless, since the spiritual leadership practices deviated a bit from normality, Spearman rank-order correlation was also calculated to supplement Pearson analysis. Both tests were incorporated in order to corroborate the reliability and sound methodological relationship between spiritual leadership and perceived school climate.

The study has been performed in compliance with the policy of Polytechnic University of the Philippines and after obtaining ethical clearance. Informed consent was obtained from all subjects, and confidentiality of the participants' responses was strictly maintained to ensure their privacy.

3. Results

As shown in Table 1, the Vision and Purpose factor has a grand average of 4.58 (SD =.51), which is an indicator of great agreement among the leaders' students. This means that they maintain a clear direction and strong commitment to the school's mission and values. The item with the highest mean – "I emphasize the importance of individual contributions to the school's

success (M = 4.74, SD = 0.45) – indicates a high acknowledgement of teamwork and collective responsibility. In the meantime, the item that received the lowest score – "I articulate a compelling vision that inspires others to contribute" – although it remained high, suggests a need for its further improvement in communicating vision with more inspiration. The total SD (0.51) points to a similar response pattern, common perceptions shared with student leaders in terms of vision- and purpose-driven leadership.

Table 1. Vision and Purpose Scale

Statement	Mean	SD
I articulate a compelling vision that inspires others to contribute.	4.42	0.50
I encourage a focus on long-term goals aligned with the school's mission.	4.58	0.55
I provide clear direction for achieving our shared objectives.	4.61	0.46
I emphasize the importance of individual contributions to the school's success.	4.74	0.45
I consistently align my actions with the school's core values and vision.	4.53	0.60
Grand Mean and SD	**4.58**	**0.51**

Table 2. Hope and Faith Scale

Statement	Mean	SD
I inspire confidence in achieving our school's goals, even in challenging times.	4.50	0.56
I model optimism and a positive outlook for the school community.	4.47	0.60
I encourage resilience and perseverance among staff and students.	4.58	0.64
I instill hope by recognizing and celebrating small achievements.	4.79	0.47
I trust in the potential of others to overcome obstacles and grow.	4.82	0.39
Grand Mean and SD	**4.63**	**0.53**

Table 2 presents the results for the Hope and Faith dimension. A grand mean of 4.63 (SD =.53) demonstrates significant overall agreement across student leaders. This reveals how they are optimists, who have faith and the ability to lead. The item with the highest mean score – "I trust in the potential of others to overcome obstacles and grow" (M = 4.82, SD = 0.39) – indicates the belief that student leaders have in other people's potential, whereas the item with the lowest mean score I model optimism and a positive outlook for the school community" (M = 4.47, SD = 0.60) – indicates that optimism could vary between respondents even though it was evident among them. The total standard deviation (SD = 0.53) implies rather similar responses that express a common conviction for keeping faith and hope even under trying circumstances.

Table 3. Altruistic Love Scale

Statement	Mean	SD
I create an environment of mutual respect and trust within.	4.61	0.56
I demonstrate genuine concern for the well-being of students.	4.74	0.50
I prioritize empathy and understanding in addressing conflict.	4.71	0.57
I encourage selflessness and service among members of the school community.	4.39	0.72
I value each individual for their unique qualities and contributions.	4.76	0.43
Grand Mean and SD	**4.64**	**0.56**

Table 3 shows that the grand mean of the Altruistic Love dimension was 4.64, (SD = 0.56), which indicated a very high degree of agreement among student leaders. This finding indicates students experience empathy, respect and acts of compassion throughout the school. The item with the highest mean – "I value each individual for their unique qualities and contributions" (M = 4.76, SD = 0.43) – underscores character appreciation, while the lowest-scoring item on the scale – "I encourage selflessness and service among members of the school community" (M = 4.39, SD = 0.72) – suggests that across leaders, degrees of encouraging selflessness may differ slightly.

The overall SD (SD = 0.56) indicates relatively uniform responses across all the items, indicating a general perception in a caring and trusting leadership environment.

Table 4. Meaning and Belonging

Statement	Mean	SD
I help individuals find purpose in their roles within the school.	4.45	0.65
I foster a sense of belonging by promoting inclusivity and community.	4.63	0.49
I encourage meaningful reflection on personal and professional growth.	4.45	0.65
I create opportunities for collaboration that strengthen team bonds.	4.55	0.60
I celebrate achievements to enhance members' sense of purpose and connection.	4.66	0.53
Grand Mean	**4.55**	**0.58**

As presented in Table 4, the Meaning and Belonging factor yielded a grand mean of 4.55 (SD = 0.58) suggesting a high degree of consensus among student leaders. This indicates they work to create a school culture of purpose and inclusivity. The statement with the highest rating – "I celebrate achievements to enhance members' sense of purpose and connection" (M = 4.66, SD = 0.53) (M = 4.66, SD = 0.53) – draws attention to recognition as an aspect of belongingness, while scores for the lowest-rated items – "I help individuals find purpose in their roles within the school" and "I encourage meaningful reflection on personal and professional growth" (M = 4.45, SD = 0.65) – demonstrate opportunities to enhance reflection and individual purpose. The average SD (0.58) suggests some degree of consistency, however there is a small fluctuation in practice according to how student leaders enact meaning and belonging within their position.

Table 5. Positive School Climate Index (PSCI)

Statement	Mean	SD
I feel physically and emotionally safe in our school environment.	3.79	0.84
Our school provides clear rules and guidance to address bullying and conflicts.	3.97	0.86
I know where to go or whom to approach for help when I face challenges.	4.29	0.77
The school fosters a supportive environment where everyone is treated fairly.	4.11	0.92
Teachers and staff ensure that all students feel cared for and valued.	4.34	0.78
My teachers encourage me to actively participate in my learning journey.	4.63	0.54
Classroom lessons are engaging and help me develop critical thinking skills.	4.45	0.69
I receive helpful feedback from my teachers to improve my performance.	4.39	0.68
I have access to resources that support my learning needs.	4.45	0.65
The school recognizes and rewards students for academic and personal growth.	4.11	0.89
Students in our school treat one another with respect and kindness.	3.84	0.86
I feel a strong sense of connection and trust with my teachers.	4.21	0.66
My classmates and I work well together to achieve common goals.	4.45	0.69
I can openly communicate with my teachers and peers when I have concerns.	4.24	0.78
There is a sense of unity and teamwork among the students in our school.	4.32	0.78
Our school celebrates the diversity of its students and their contributions.	4.34	0.75
The facilities and resources available at school create a comfortable learning environment.	4.18	1.04
I feel proud to be part of this school and its positive reputation.	4.50	0.60
The school listens to students' voices and considers our feedback for improvement.	4.03	0.97
Environmental and social responsibility are emphasized in our school activities.	4.50	0.60
Grand Mean and SD	**4.26**	**0.77**

As displayed in Table 5, the Positive School Climate Index (PSCI) garnered a grand mean of 4.26 (SD = 0.77), which suggests strong agreement among student leaders. This indicate that

students feel their school to be supportive, inclusive and welcoming. The highest-rated items, "My teachers encourage me to actively participate in my learning journey" (M = 4.63, SD = 0.54) and "Environmental and social responsibility are emphasized in our school activities" (M = 4.50, SD = 0.60), suggest deep engagement and values-based education. The lowest-rated item, "I feel physically and emotionally safe in our school environment" (M = 3.79, SD = 0.84), suggests that perceptions of safety are positive but less uniform and might warrant further consideration. With an overall standard deviation of approximately 0.77, responses have moderate variation, suggesting that most students perceive a positive school climate while experiencing individual differences with respect to the safety, inclusivity, and support provided by schools.

Table 6. Correlation Matrix

Correlation Table

Variable		SLP	PSC
1. SLP	Pearson's r	—	
	p-value	—	
	Spearman's rho	—	
	p-value	—	
2. PSC	Pearson's r	0.321	—
	p-value	0.050	—
	Spearman's rho	0.301	—
	p-value	0.066	—

The correlation analysis indicated a weak and positive significant relationship between Spiritual Leadership Practices (SLP) and Perceived School Climate (PSC), r(36) =. 321, p =. 050. It appears that greater spiritual leadership amongst student leaders is related to more positive perceptions of the school environment. To check that this result was stable, a Spearman rank-order correlation was further performed, which also gave evidence of a positive relation in the same direction, ρ(36) =. 301, p =. 066. Although the Spearman result was not statistically significant, findings across both tests supports the conclusion that spiritual leadership practices are positively related to perceptions about a positive school climate.

4. Discussion

This study's findings indicate that student leaders demonstrate higher positive spiritual leadership practice by having a clear vision, optimism, empathy, and belonging. These characteristics seem to influence and pattern how they influence others in the school community. Such consistency in their answers seem to indicate that these behaviors are actually embedded nature of their leadership behavior and not mere theoretical or academic rhetoric, reflecting an organizational culture based on sense of purpose and unity. This is in line with some of the previous work on how clarity of vision align collective goals and foster direction among school stakeholders (Penolio, 2022). These practices can be traced back to the community-oriented nature of Philippine schools, in which values like pagkakaisa (unity) and bayanihan (cooperation) are ingrained in the educational environment.

The findings of high hope and faith in student leaders reveals that they manage to stay positive and optimistic despite their adversities. This supports Fry (2003) who believes Spiritual leadership offers vision and faith, persisting through perseverance and commitment. In a secondary school setting, that optimism may help prevent students from succumbing to academic & personal pressures.

Altruistic love appeared to be the dominant aspect of spiritual leadership across all dimensions. It shows that Filipino student leaders conceptualize leadership in terms of empathy, compassion and caring for others. Altruistic love has generally been considered the core of spiritual leadership theory as it underpins ethical decision-making and followers' trust (Martínez-Soto et al., 2024). In the Philippine context, where pakikipagkapwa (shared humanity) is a central value, these behaviors probably flow naturally as acts of caring, and not leaving any one out in school.

The dimension of meaning and belonging suggested the student leaders perceives their experience to be meaningful and supportive, although their levels of reflection and personal growth

may differ. This is congruent with previous evidence showing that belonging to school is associated with engagement and well-being (Korpershoek et al., 2020). It implies that, as Philippine schools' common culture generally promotes inclusion, there remains potential for deeper self-reflection and more personalized growth in leadership.

The overall positive rating of school climate shows student leaders feel supported and are able to work together. But there is some variability indicating not all individuals perceived safety and resources the same way. This is consistent with the perception that school climate is multi-faceted, including safety, relationships and support from the institution (Wang, Degol, 2016). These disparities might be accounted for by differences in access and support across lower-resource settings, including certain public secondary schools (Larson et al., 2020).

Finally, the positive association between spiritual leadership practices and positive school climate highlights that values-based leadership behaviors promote a supportive and connected learning environment. As Karadağ (2020) notes, spiritual leadership affects school culture in the sense it enhances common values and trust within the members. This connection could be amplified in the Philippines where cooperation and compassion are considered culturally instilled virtues. This infusion of spiritual values in adolescent leadership seems to create belonging and respect among students, two elements that are vital for the maintenance of a positive school climate. This is consistent with Neal's (2024) assertion that being spiritually aware may increase students' sense of meaning and connection to the school.

The small sample size and single-school setting are limitations to the generalizability of this study. The application of purposive sampling also may lead to selection bias because the participants were selected according to particular leadership positions. Future studies might recruit student leaders from different schools or educational grades to increase the representativeness of samples. Using a mixed-method approach or a longitudinal design could offer even richer understanding of how spiritual leadership plays out in school climate over the years. Overall, the results emphasize the formative potential of spiritual leadership for student leaders. Leveraged with empathy, mission and clear vision, this approach not only reinforces relationships but also helps to build a welcoming and affirming school climate that supports holistic development.

5. Conclusion and Recommendation

The results show that students sense high spiritual to lead in the school. These mean scores, all of which are significantly greater than average, suggest student leadership cultivates trust, collaboration, and a shared sense of purpose. Non-academic data, including qualitative measures such as the Positive School Climate Index, which reflects student perceptions of school conditions as supportive and engaging, though areas of focus such as emotional and physical safety warrant further attention, provide additional context regarding institution environmental factors shaping student achievement. Additionally, correlation analysis reveals a statistically significant but weak positive correlation between spiritual leadership practices and school climate, further implying that while these leadership practices certainly promote a positive school climate, they cannot stand alone as the only driving forces behind students' experiences.

In summary, the findings suggest that the work of developing spiritual leadership practices in schools should continue to be a key area identified by school administrators where attention to the positive school climate can be enhanced and developed even further. Creating a sense of belonging, encouraging hope, and ensuring that actions are consistent with the school's values can help create a supportive environment for staff and students. Also, consider focusing on areas that received lower ratings such as emotional and physical safety, as these improvements can lead to a more inclusive and safe school. Finally, additional research would help examine other influences on school climate, as well as the effect of specific types of leadership behaviors on various educational settings.

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Ways of Professional Socialization of Future Teachers in University Education

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Abstract

The desire of modern youth for individual identity, including in the professional community, the use of predominantly online forms of interaction, the presence of problems of real communication, translates the process of socialization into a continuous process of formation of a person's personality, including during the period of mastering a future profession at a university. The latter presupposes the presence of a flexible strategy for the functioning and construction of the educational process, which involves the adaptation of the university to new trends and needs of subjects. The purpose of the study is to implement and confirm the effectiveness of the conditions for professional socialization of a future teacher in the educational environment of a classical university. The study was conducted in 2019–2024 using theoretical and empirical methods: theoretical analysis, comparison, generalization, specification, adapted questionnaire "Profession – teacher" by A.S. Robotova, methodology for determining socialization by M.I. Rozhkov, motivation test for professional activity by K. Zamfir modified by A. Rean, experiment. At the formative stage of the experiment, a set of conditions was implemented: formation of incentives for self-improvement, self-realization in creative and upcoming professional activities; widespread use of online interaction formats; active involvement of students in the professional pedagogical community. The results obtained using the method of K. Zamfir as modified by A.A. Rean, used to identify the motivation of future teachers for professional and pedagogical activity, indicate a decrease in the number of students with external negative motivation (ENM) and positive dynamics of internal motivation (IM) and external positive motivation (EPM). Positive dynamics of professional socialization was also obtained according to three criteria (motivational-perspective, cognitive-identification, result-activity), which confirmed the effectiveness of the implemented set of conditions and its practical significance. The study was conducted as part of the activities of the Federal Innovation Platform "Model of Innovative Training of Teaching Staff in the Profile of "Organization of Educational Work" in a Classical University".

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1. Introduction

The modern transformation of society, which is primarily digital in nature, involves intensive adjustment of the entire sphere of human activity. Education should be most sensitive to these changes, since not only external characteristics (forms, methods, means) change, but also the subjects of the educational process. Digital technologies enable the implementation of blended and distance learning, as well as the use of active and interactive teaching methods (webinars, online seminars, case studies using digital simulations, and others). Practical teacher training can now take place in virtual classrooms or through digital internships. Competency assessment can also be implemented through the use of digital learning analytics for student progress and early-stage remediation programs, including e-courses or digital portfolios. Students are transformed from passive recipients of knowledge into active designers, using digital platforms and online resources, and as a result, they often independently make decisions about their individual learning paths. However, all these positive factors pose risks to students' professional socialization. For example, contact with teachers and peers is often asynchronous and text-based, reducing the number of face-to-face interactions; interactions between teachers and students become more structured, reducing spontaneous face-to-face dialogues; Professional identity is most often established through digital platforms and professional networks rather than through local personal contacts, while socialization, as the process of developing norms and behavior patterns, occurs online through collaborative activities, observation of experienced teachers, and daily informal interactions. But the main problem remains that in everyday life, the only distinguishing feature of the modern educational revolution is the exclusive use of online forms of interaction, leading to difficulties in communicating with others for the first time in the world. All this translates the process of socialization into a continuous process of formation of a person's personality, including during the period of mastering a future profession at a university. The latter implies the presence of a flexible strategy for the functioning and construction of the educational process in educational institutions of higher education, which involves the adaptation of universities to new trends and needs of subjects.

The specific tasks of higher education are numerous: developing the creative potential of students, forming a set of competencies, ensuring further competitiveness of the individual, etc. Researchers in the field of education have been trying to determine the factors of success in teaching, upbringing and socialization of students in the new educational environment of educational institutions for about two decades and to indicate what changes and transformations should occur in order to ensure high quality education.

The relevance of the study is substantiated by overcoming the following contradictions:

– Between society's need for a teacher capable of creative, continuous reproduction of social values in the era of digitalization, and insufficient readiness of universities to search for new benchmarks for the connection between education and the socio-economic sphere;

– Between the existing socio-cultural and theoretical prerequisites for the creation of a system of early professional socialization of a teacher and their insufficient actualization and implementation in the theory and practice of higher education;

– Between the urgent need for practical transformations in the training of teachers at the university and the lack of knowledge of the conditions of professional socialization of future teachers in the educational environment of the university.

The purpose of the article is to analyze the concept of "professional socialization of a teacher", definition, implementation and confirmation of the effectiveness of the conditions of professional socialization of a future teacher in the educational environment of a classical university.

In the course of socialization, norm, customs, and ideologies are inherited and disseminated, as well as a system of values, skills, and habits is formed. Due to the interdisciplinary nature of this concept, there is no single definition in modern science. In pedagogical science, socialization is considered in close relationship with the concepts of "upbringing" and "education" in the broadest sense of the word.

In a number of works by Russian researchers, professional socialization is defined as the process by which students acquire knowledge, skills and inclinations, and social experience that

make them more or less effective members of their society (Kropotova, Balichieva, 2019; Kropotova, 2020; Lyashevskaya, 2019; Samartseva, 2019).

From the point of view of a number of domestic researchers, socialization involves the study of appropriate behavior and attitudes of society, which is facilitated by entering a social environment, interacting with other people who are an example of the norms of a particular collective (Bahor, 2017; Razuvaev, 2012; Sadyrin, 2013). The individual learns the relevant social norms, behaviors, values, codes, les, habits characteristic of the socio-cultural environment. One of the positive consequences of professional socialization is job satisfaction.

In some studies, professional socialization is defined as a "ritualized process" that involves the transfer of organizational culture through the stage of mutual adaptation of the organization and the specialist. A future specialist at a university can acquire the values, attitudes, norms, knowledge and skills necessary for existence in their chosen profession (El'kina, Lozovan, 2018; Nemudraya, 2018; Tyumaseva i dr., 2018). Students can accept the norms of the university staff that affect their values and relationships, or they can firmly adhere to old beliefs, rejecting the norms of socializing groups and remaining unchanged in their beliefs and values. Co-education with peers is positively associated with self-assessment of university achievements, such as general education, intellectual and personal and interpersonal development.

A number of scientific papers prove that the term "socialization" is used by sociologists, social psychologists, anthropologists, political scientists, and educators to denote a multifaceted process of cognition of one's culture, providing an individual with the resources necessary for action and participation in society, that is, socialization is a means of achieving social and cultural continuity (Solodova, 2018; Tihonova, 2012; Yugfel'd, 2015). The process of socialization helps to form mental traits and personality. These traits are formed as a continuous process, as the generalization and fulfillment of new social roles, the acquisition of new experiences.

Foreign scientists, characterizing this concept, believe that the professional socialization of a future teacher occurs through the selective assimilation of values, attitudes, skills and knowledge of a certain group when a student begins to make independent pedagogical decisions (Balcı, Karabulut, 2019; Hartnett, Brown, 2014; Jong, Kool, 2017). The research notes that professional socialization begins with the learning process and can continue after the student's graduation. The process of socialization of an individual is influenced by his previous education and experience, relationships and interactions, family attitudes and values, intellectual level and motivation level at the beginning of learning (Cerit, Temelli, 2018). The ultimate goal of the professional socialization process is considered as providing an individual with the opportunity to identify themselves with the profession and develop a professional identity through the acquisition of knowledge, skills, norms and values of the profession (Everitt, Tefft, 2018).

2. Materials and methods

The study was conducted using theoretical and empirical research methods. Theoretical methods: theoretical analysis, comparison, generalization, specification. Empirical methods: questionnaire "Profession – teacher" by A.S. Robotova, adapted by the authors, the method of determining socialization by M.I. Rozhkov, the test of motivation for professional activity by K. Zamfir modified by A. Rean, experimental work.

The quasi-experimental study was conducted at the Yelets State University from 2019 to 2024. The total number of subjects was 125 students who during the specified period mastered the teaching profession in the field of training: 44.03.05 Pedagogical education (with two training profiles), and 125 students of 4–5 courses who completed their studies in 2021, 2022. Participants in the experiment were recruited through a targeted selection process, which is most appropriate when a specific group is of interest (in our study, these are future teachers), allowing us to conduct a qualitative study and achieve relevance.

When starting the experimental work, we proceeded from the hypothesis that the professional socialization of a future teacher would be more effective in the implementation of a number of pedagogical conditions:

– Formation of motivations for self-improvement, self-realization in the upcoming professional activity;

– Widespread use of online interaction formats in the university's educational environment;

– Active involvement of students in the professional pedagogical community.

As we noted above, socialization, like upbringing, is a continuous and multifaceted process that continues throughout a person's life, becoming more specific depending on age and the content of education. It is a misconception that the older a person is, the more socialized they are. Diagnostics of the level of socialization of 125 students of 4–5 courses studying in the field of Pedagogical education (with two training profiles), conducted using the methodology of M.I. Rozhkova showed that only 44 % of respondents had a high level of socialization, but more than half of the respondents were at average and even low levels: average – 26.4 %, low – 29.6 %. According to the methodology, students were assigned to a specific level of socialization using the following algorithm: respondents answered questions using one of the following options (4 – always; 3 – almost always; 2 – sometimes; 1 – very rarely; 0 – never); then we calculated the average score a_{cp} as the arithmetic mean of all the points received. If $a_{cp} > 3$, the respondent was assigned to a high level of socialization; if $2 > a_{cp} < 3$, then to an average level; if $a_{cp} < 2$, then to a low level.

At the stage of professional development of a personality, a characteristic feature of the professional socialization of a future teacher is his self-determination, which has a positive effect on the learning process. The latter means the process of maturing a professional, orienting him in the world of professional values, accompanied by the formation of an individual style of pedagogical activity, attitude to the world, society, profession, and the child as a subject of upbringing and training. We consider the pedagogical result of self-determination to be a combination of skills, knowledge and beliefs that allow a person to conduct purposeful, self-regulating, autonomous behavior. The success of his further professional socialization and academic career depends on how close the image of a teacher in the mind of an applicant or a first-year student is to reality, and how much the future teacher realizes not only the importance but also the complexity of pedagogical work.

The criterion-evaluation apparatus of our study is presented in Table 1.

Table 1. Criterion-evaluation apparatus of the study

Criterion	Indicators	Diagnostic Tools
Motivational-perspective	Graduates have plans for professional growth, career prospects and self-actualization in the profession	K. Zamfir's test of professional activity motivation modified by A. Rean (were used in their original form without adaptation, which confirms their reliability and validity)
Cognitive identification	Awareness of the teacher's image, professional self-determination, identification with the profession on the basis of acceptance of the values and norms of the professional community	Questionnaire “Profession of a teacher” (the questionnaire was adapted by the authors)
Result-action	Professional success, activity of future teachers, recognition of the results of their work in the pedagogical environment	Portfolio (The portfolio form was developed by the authors and adapted for this audience of respondents)

At the formative stage of experimental work on the professional socialization of students in the educational environment of a classical university, we implemented a set of conditions to solve the research goal:

– Formation of motivations for self-improvement, self-realization in creative and upcoming professional activities based on the principle of taking into account the individual characteristics of each student through the active involvement of students in diverse social relations, student professional communities: «The Commonwealth of Responsive Hearts», the «Bonus» teaching group, creative associations of various orientations;

– Extensive use of online interaction formats that allow for the complementarity of two educational environments – direct, in which students are physically present, and virtual, which

allows for the development of the professional experience of teachers-practitioners: online inclusion of teachers' lessons in the classroom, online master classes, online participation of teachers-practitioners and senior students who are in practice in educational organizations in educational discussions, round tables, scientific events;

– Active involvement of students in the professional pedagogical community through the involvement of psychological and pedagogical classes for high school students operating at the university, participation in competitive events: the Delphic Games (The Art of Education nomination), contests of creative, scientific and research works of pedagogical orientation, "Student of the Year. Teachers", the Olympiad "I am a professional", etc.

3. Results

Let us present some quantitative and qualitative results of the conducted research. The diagnosis was carried out according to each criterion proposed by us. The results obtained by K. Zamfir's method, modified by A.A. Rean, used by us to identify the motivation of future teachers for professional teaching activities, indicate a decrease in the number of students with external negative motivation (ENM) and positive dynamics of internal motivation (IM) and external positive motivation (EPM) (Figure 1).

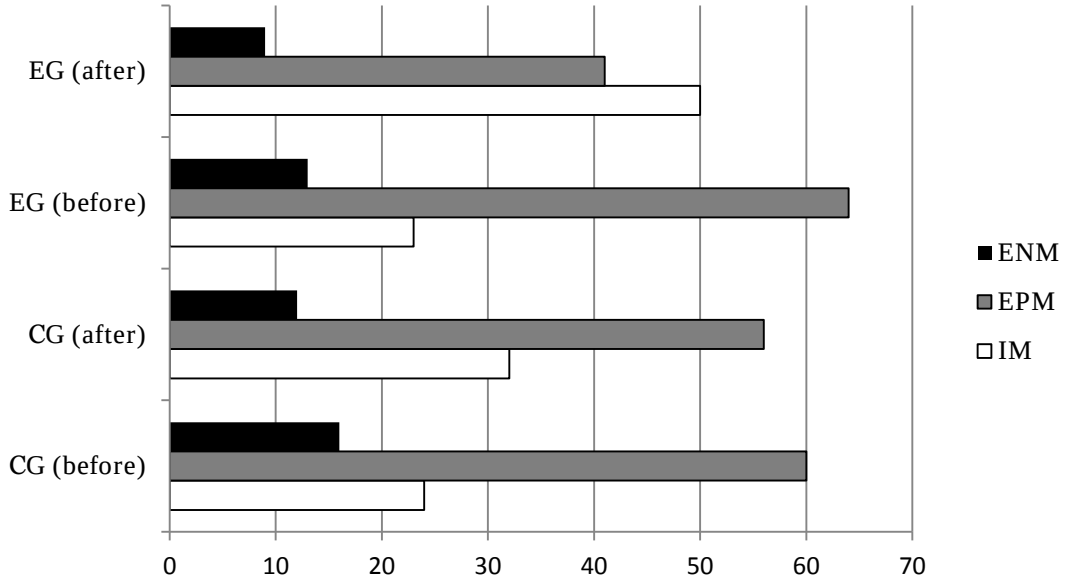

Fig. 1. Dynamics of results by motivational-perspective criterion (percentages are calculated from the number of respondents, %)

For students with a leading intrinsic motivation for senior courses, pedagogical activity itself is of great importance. They are focused on improving their professional skills and achieving desired goals (they want to put their knowledge into practice, learn how to establish contact with students and their parents, participate in competitions, show a desire to communicate with colleagues, and get acquainted with the work experience of teachers).

As part of the diagnosis based on the cognitive identification criterion, the respondents of the experimental and control groups were offered an adapted questionnaire "Profession – teacher". We will present the results of the selected questions in the questionnaire.

Module 1 of the questionnaire "Result-targeted".

The answers to the question about what the teacher transforms and changes in the process of his/her activity were distributed as follows (Figure 2).

In our opinion, the single answers are interesting, in which students answer that the teacher, first of all, transforms himself.

When answering the question about the results of pedagogical activity, the student audience was initially unanimous. 94 % of the respondents consider only the knowledge gained by students, the results of the Unified State Exam, admission to universities, and school victories in Olympiads as the result of a teacher's activity. Only 6 % indicated the level of general development and well-mannered pupils as the result of pedagogical activity. At the control diagnosis in the EG, this ratio became reversed: 18 % – knowledge result, 82 % – personal, in CG the situation has leveled off:

44% – knowledge result, 56 % – personal.

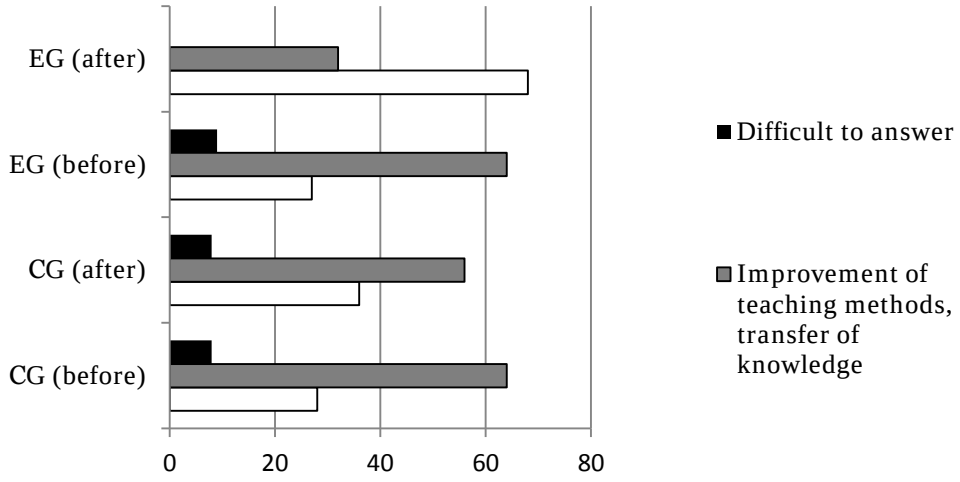

Fig. 2. What does a teacher transform, change in the process of his/her activity? (dynamics, percentages are calculated from the number of respondents, %)

Module 2 of the questionnaire "Conditions of professional activity".

Listing the advantages of the conditions of the teaching profession in comparison with others, future teachers were again divided: the possibility of continuous self-education – 23 %; the availability of free time – 18 %; they find it difficult to answer the question – 47 %. The only answers are: the lack of any advantages in the teaching profession; the ability to influence a person, impose their opinion; the ability to communicate with children.

Module 3 of the questionnaire "Teacher's image".

The next group of questions was aimed at identifying the image of an ideal teacher. It is disappointing that initially only a few people note the obligatory presence of the teacher's love for children. 15% of students found it difficult to answer the question about the professionally significant qualities of the teacher's personality at all.

The collective image of an ideal teacher, presented by us according to the answers of the EG respondents in Figure 3, in our opinion, correlates with the requirements for the personal qualities of a teacher, presented earlier in the general pedagogical professionogram, today – in the professional standard of a teacher.

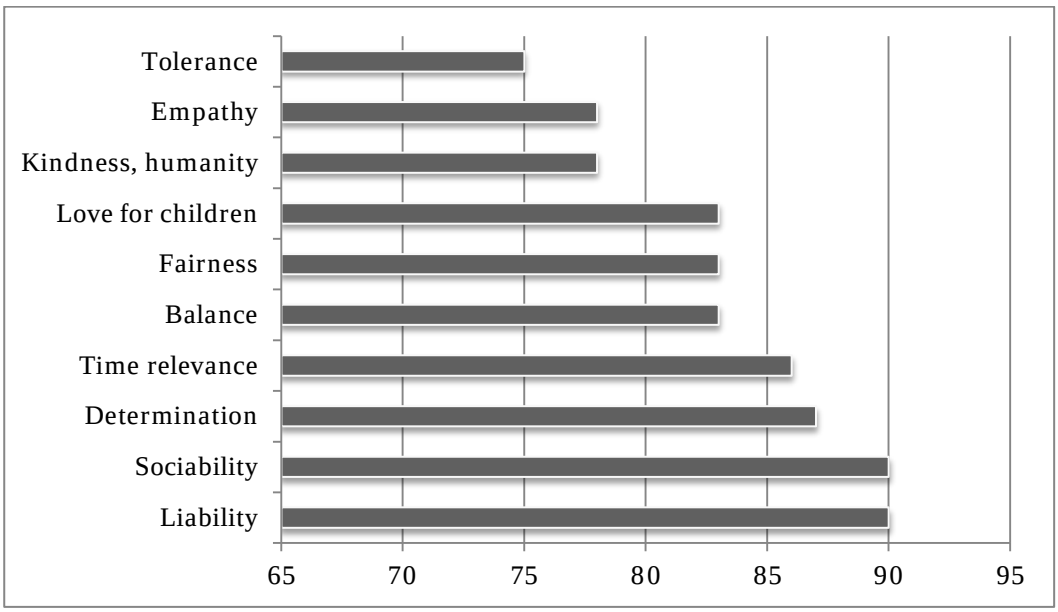

Fig. 3. Image of an ideal teacher (top-10 personal qualities, EG after) (percentages are calculated from the number of respondents, %).

The respondents were also asked to indicate the knowledge, in their opinion, necessary for the teacher. The results are shown in the diagram (Figure 4).

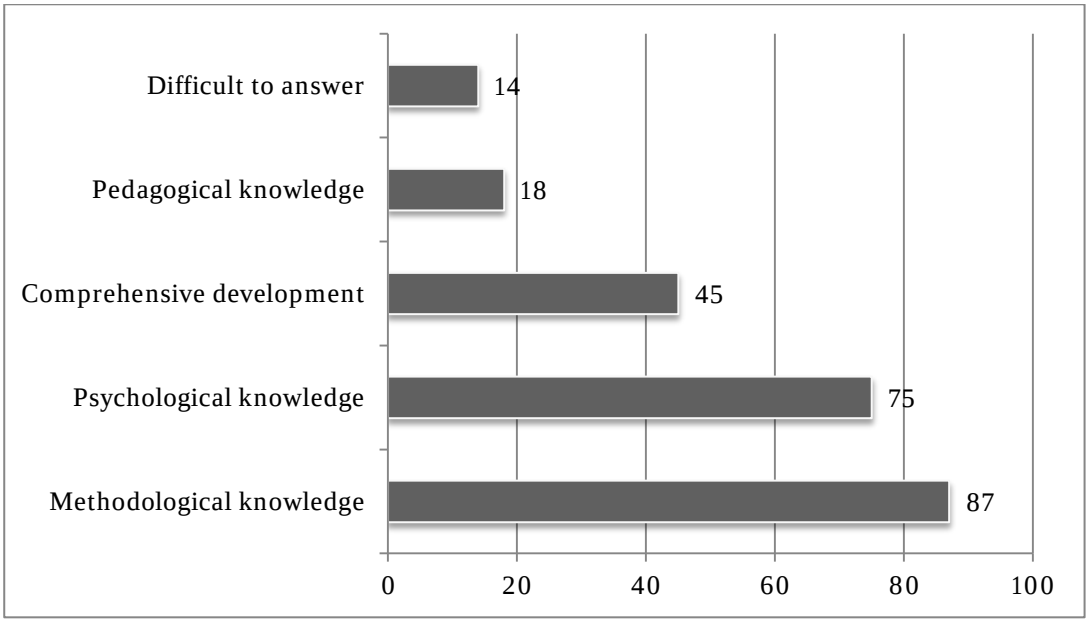

Fig. 4. Knowledge needed by the educator (percentages are calculated from the number of respondents, %).

As can be seen, pedagogical knowledge is present in the answers more indirectly, at the methodological level. The latter means for us that purposeful work is needed, aimed not only at increasing motivation in learning, correcting students' ideas about their future profession, but also at forming their understanding of pedagogy as an independent science, its role in society and its place in teacher training.

According to the performance-activity criterion, the results were tracked twice in the students' portfolios: in the 2nd and 5th year, respectively. The systematic and professionally oriented nature of the activities in which future teachers participated was evaluated. The results are shown in Figure 5.

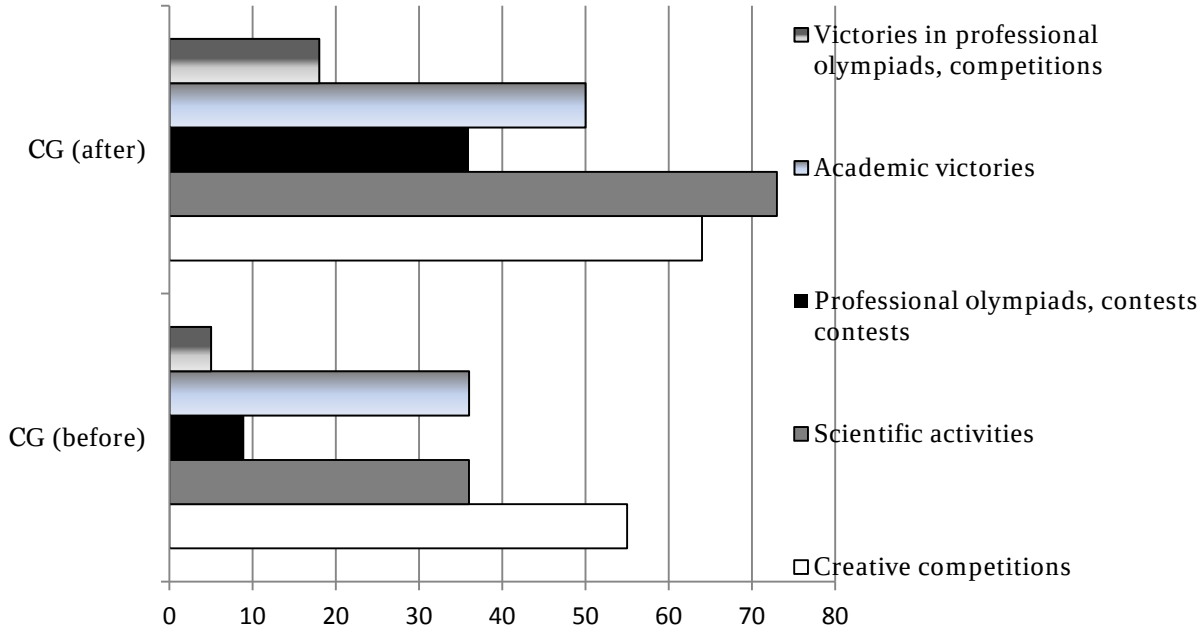

Fig. 5. Dynamics of portfolio assessment (percentages are calculated from the number of respondents, %).

In order to determine the reliability of the results of assessing the performance-activity criterion of students' professional socialization, Student's t-test was calculated for dependent samples (before and after). We present the results for one academic group (profile Primary Education; Social Pedagogy). Sample size $n = 20$. For the above-mentioned portfolio components, students scored points from 0 to 100, which we converted into a series from 0 to 5. As a result of applying Student's t-test, we obtained the following values, calculated for the significance level $p < 0,001$: mean value before $M_1 = 3,11$, after $M_2=3,555$. Average difference in values $M_d = 0,445$. Standard deviation of differences $S_d = 0,338$, t-statistics – 5.888. Effect size Cohen's d = 1,317. Thus, after the quasi-experiment, not only statistical but also pronounced practical significance of the work carried out was achieved.

4. Discussion

During the experimental work, we adhered to the point of view of scientists who consider professional socialization as a process determined by a number of factors and conditions. From the point of view of foreign researchers, these factors can be grouped into three categories: individual, organizational and interaction factors. However, all these factors are not equally important in terms of their impact on the process of socialization, the role of mentors, and role models (Bullen, Morgan, 2011; Dinmohammadi, Peyrovi, 2017; Henslin, 2015; Padilla, Perez, 2003).

The study of the factors determining the entry of students into the world of the profession is also the subject of research by Russian scientists. Traditionally, they represent a system of factors in the interrelation of two groups: external and internal factors (Klimenko, 2012). External factors (economic conditions in the region, the degree of prestige of the future profession, the image and image of the educational institution, the goals and values of the immediate environment, etc.) have an indirect impact on the formation of a future professional. The internal ones (the level of professionalism of the teaching staff, the material and technical equipment of the educational process, the characteristics of the student body and the level of development of the student group, student government, etc.) contain just significant educational potential and can be managed and pedagogized (Popov i dr., 2023). Without detracting from the importance of the factors outlined above, we limited ourselves to investigating the potential of the content and organization of the university's educational environment, which is characterized by variability, plasticity and dynamism. We hope that our research has expanded the above-mentioned research of scientists in the aspect of studying the potential of the group as a factor of professional socialization. We are not considering an academic group, but a professionally oriented student community (the "Commonwealth of Sympathetic Hearts" association, the «Bonus» teaching group) as a significant agent of professional socialization.

A number of scientists emphasize that the main part of the process of student socialization is its orientation towards ideals (Bobohonova, 2019; Gunina, Dudina, 2020; Efimova, 2015). In the context of online communication, connecting to an institutional virtual learning space, students can also interact productively, assimilating a whole system of knowledge, attitudes, skills and moral rules necessary for joining the professional community (Vlasova, 2021; Magomadova, 2017; Morozov et al., 2024; Bashkireva i dr., 2020). However, scientists note that this process has a two-way nature. On the one hand, we are talking about the process of integrating a future or young specialist into a professional environment; on the other hand, we are organizing the process of forming various personality structures of the student. In our study, the teacher's image is a similar structure.

In our opinion, the professional socialization of students learning the teaching profession refers to the process during which students, on the one hand, master a system of professional knowledge, skills, and competencies, on the other hand, they build their own philosophy, worldview, and system of professional values and images. Thus, the professional socialization of a future teacher is the process of acquiring values, attitudes, norms, knowledge, skills and competencies necessary for teaching and implementation in the professional community. However, the issue of determining the criteria and diagnostic basis of the study remains controversial in this case.

The criteria proposed in individual studies: the student's professional competence, readiness for independent professional activity, professional adaptability, the degree of satisfaction of employers and the social partner with the quality of student training (Yugfel'd, 2015) are of a delayed nature and the corresponding diagnostic procedures are limited in the educational process of the university. It was important and significant for us to demonstrate the possibility of identifying the success of professional socialization during the direct development of the future profession.

The theoretical significance of the conducted research is the criterion-evaluation apparatus in the unity of motivational-perspective, cognitive-identification, performance-activity criteria, suggesting the feasibility of evaluating the effectiveness of professional socialization of a future teacher at the university through the diagnosis of students' plans for professional growth, career prospects and self-actualization in the profession, awareness of the teacher's image, identification with the profession, activity of future teachers, their professional performance in the professional community.

The applied value of the research lies in the development of methodological support and diagnostic tools for evaluating the effectiveness of professional socialization of a future teacher at the university.

We see the prospects for research in further research and methodological support for the formation of a certain professional subculture in the student's professionally oriented community and its correlation with educational results in the form of a set of general cultural and professional competencies.

Professional socialization is inextricably linked with a number of processes: adaptation, self-realization, integration of a personality into a professional environment and is determined by many factors, one of which is the development of a future profession in the educational environment of a university.

5. Conclusion

Summarizing the course and results of the conducted research, the following conclusions can be stated:

1. Unfortunately, more than half of the senior students have problems and difficulties entering the world of the profession and are at average and even low levels of socialization.

2. A characteristic feature of the professional socialization of a future teacher is self-determination, accompanied by awareness of the teacher's image and identification of one's own personality with the standard, the formation of an individual style of pedagogical activity.

3. The educational environment of a classical university is characterized by a multiprofessional and, to a greater extent, theoretical nature of training and performs traditional functions: social (ensuring the mastery of socially significant values, the formation of a citizen and a professional), communicative (organizing the mastery of interpersonal communication techniques, including virtual), educational (introducing students to certain types of educational activities, self-education, etc. self-development, organizational support for the assimilation of scientific knowledge, the formation of universal ways of activity), scientific research (production of new scientific knowledge). At the same time, it has a specific potential to ensure the professional socialization of a student – a future teacher.

4. Professional socialization cannot be effectively carried out without involving the future professional himself in various types of activities. The implementation of a set of conditions leads to a positive result of the professional socialization of a future teacher in the educational environment of a classical university: the purposeful, organized formation of motivations for self-improvement, self-realization in the upcoming professional activity.; extensive use of online formats of interaction between students, teachers, and representatives of the professional community, ensuring the development of advanced pedagogical experience; active involvement of students in the work of psychological and pedagogical classes, participation in competitive events.

5. Active involvement of students in competitive events (Delphic Games, contests of creative, scientific and research works of pedagogical orientation, "Student of the Year. Teachers", the Olympiad "I am a professional" and others) It promotes the professional socialization of the future teacher at the stage of mastering the profession at the university, but cannot provide practical professional experience. Therefore, in our opinion, it will be effective to increase the share of practical training in educational programs for teacher training at a classical university. Such an increase implies a mandatory transition to the "core of pedagogical education" not only in pedagogical institutes and universities, whose activities are regulated by the administrative acts of the Ministry of Education, but also in classical universities, founded by the Ministry of Science and Higher Education.

The presented version of the professional socialization of a future teacher in the educational environment of a classical university in the unity of objectives, implemented content conditions and a criterion-assessment apparatus represents a new practice of professional education and can contribute to the methodology of professional development of a teacher.

Contribution of the authors

The authors contributed equally to the collection and processing of empirical data, as well as to the writing of the manuscript.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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The History of Education

Sir Alfred Constantine Barry (1815–1888): Minister, Educator, Mason

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Abstract

This work represents a biography of A. Constantine Barry (1815–1888), an American minister and prominent public figure, who at the height of his career served as the 4th Superintendent of Public Instruction of the state of Wisconsin.

The study's source base incorporated the following three groups: 1) collections of published documents; 2) museum items; 3) sources of private origin.

The findings revealed that, a dedicated missionary minister all his life, A.C. Barry preached in eight different localities within the state of New York and four localities within the state of Wisconsin. His life can be divided into two distinct time periods – (1) before 1857 and (2) after 1857.

During the first period, beginning in 1836, he engaged in missionary work and served as a Mason, and, following his relocation to Racine, WI, in 1846, he engaged in promoting the temperance cause and championed the idea of enacting prohibition in the state of Wisconsin, supervised public education in Racine, was active as a Mason, engaged in research work, was a member of several scientific societies, and served as the 4th Superintendent of Public Instruction of Wisconsin in 1856–1857.

In 1857, A.C. Barry was a guest at the inauguration of President James Buchanan. During his visit to Washington, DC, he was one of several dozen guests stricken by the "National Hotel disease" – which some suspected was an attempted poisoning – and would suffer from its after-effects for the rest of his life. The disease is likely to have been behind his not running for another term as Superintendent of Public Instruction of Wisconsin. There was also a sharp drop in his activity as a Mason. He opted to focus on missionary work. However, the Civil War would change his plans, with him going off to serve as a chaplain – which he did for about 2 years. During that

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period, he also engaged in volunteer recruitment work and served one term in the Wisconsin State Assembly. After the war, A.C. Barry continued his missionary service; he established a church in Elkhorn, WI. That was the height of his activity in the postwar period.

Keywords: Alfred Constantine Barry (1815–1888), 4th Wisconsin Infantry Regiment, chaplain, Reverend, Civil War, Union Army, Mason, Racine Lodge No. 18, Superintendent of Public Instruction of Wisconsin, National Hotel disease.

1. Introduction

Alfred Constantine Barry (July 15, 1815 – March 5, 1888) was an American educator, politician, Universalist minister, and Wisconsin pioneer. Born at Walton, Delaware County, NY, he moved with his parents to Victor, Ontario County, NY, when he was a child. He was raised there and acquired a good education under private tutors, with his preceptor being the Rev. Jacob Chase, of Geneva, Ontario County, NY (Butterfield, 1880: 989). He was ordained a Universalist minister in 1836 and pastored for 10 years at various locations around New York (Gaines, Orleans County; Homer, Cortland County; Fort Plain, Montgomery County). During that period, he became a member of a Masonic lodge under the jurisdiction of the Grand Lodge of New York. In 1846, he moved to Racine, WI, where he would reside for 18 years. He remained a resident of the state of Wisconsin up until his passing.

2. Materials and methods

The study's source base incorporated the following three groups: 1) collections of published documents; 2) museum items; 3) sources of private origin.

In considering the first group, primary mention has to be given to the two-volume work 'Roster of Wisconsin Volunteers, War of the Rebellion, 1861–1865' (Roster of Wisconsin..., 1886; Roster of Wisconsin..., 1886a), which contains material on A.C. Barry's service as chaplain with the 4th Wisconsin Infantry Regiment and the 19th Wisconsin Infantry Regiment. In addition, use was made of the annual *Proceedings of the Grand Annual Communication of the Grand Lodge of Wisconsin* (1848–1855) to gain information on his service with Racine Lodge No. 18 (Proceedings..., 1848; Proceedings..., 1850; Proceedings..., 1851; Proceedings..., 1852; Proceedings..., 1854).

In terms of the second group, central is A.C. Barry's rare Masonic sword, now part of the collection of the Museum of the History of the American Knights Templar at Cherkas Global University (Houston, USA) (Figures 1–4) (MHAKT CGU. Collection 1st. Catalog no. 083/KT072).

Fig. 1. Rare Masonic sword which used to belong to A.C. Barry (MHAKT CGU. Collection 1st. Catalog no. 083/KT072)

The sword appears to date back to when there were no Knights Templar parades yet – the scabbard has no rings to attach it to the belt, which may place it in the 1860s. It is adorned with multiple Masonic ornaments that used to be utilized only by members of the Masonic order of Knights Templar. In fact, the collection of the Museum of the History of the American Knights Templar at Cherkas Global University contains several swords with similar ornaments and inscribed with the names of their owners, and those individuals were doubtless connected with the Masonic order of Knights Templar – e.g., Eugene F. Falconnet (1830–1887) (MHAKT CGU. Collection 1st. Catalog no. 034/KT030), James E. Allonson (1846–1913) (MHAKT CGU. Collection 1st. Catalog no. 046/KT042), and others.

Fig. 2. Sword's hilt and guard

Fig. 3. Sword's scabbard

Fig. 4. Inscription on the sword's hilt – 'A.C. Barry, Wis.'

The sword is marked with two names – W. Clauberg and Virgil Price, NY, which may suggest that it was manufactured between 1859 and 1870 (Hamilton et al., 2008: 208, 210).

The third group of sources is a set of writings published by A.C. Barry in his magazine, *The Old Oaken Bucket* (Barry, 1849).

In terms of methodology, use was primarily made of the retrospective and biographical methods.

3. Discussion

The historiography on A.C. Barry is relatively thin. There is a short biography of him in C.W. Butterfield's 'The History of Columbia County, Wisconsin' (Butterfield, 1880). As a side note, the last place of residence of A.C. Barry's family was the city of Lodi, located in Columbia County. In general, the work is relatively scant biographically, with no information whatsoever on anyone's membership with Masonic organizations. At the same time, it provides a pretty detailed biographical account of the life of A.C. Barry. For instance, it even lists the exact date he was mustered out after the Civil War. Essentially, it may be regarded as a personal autobiography of A.C. Barry (Butterfield, 1880: 989), which doubtless adds to the value of that publication.

The other work that provides an insight into the legacy of A.C. Barry is J. Schafer's 'Prohibition in Early Wisconsin' (Schafer, 1925), which touches upon his active work with the Sons of Temperance society.

4. Results

A. Constantine Barry and the fight for temperance

In 1848, Wisconsin became a state, and that same year there started in the region the fight for temperance, with the Sons of Temperance establishing a Grand Division in Milwaukee. (The Sons of Temperance was a society founded on the east coast with a mission promoting a lifestyle abstinent from alcohol.) The minister A.C. Barry, too, joined the temperance movement. What is more, he would become active as a member of that organization. In addition, in Racine he would found and edit (1849–1852) a temperance magazine known as *The Old Oaken Bucket* (Figure 5). The magazine was made the official organ of the Wisconsin Grand Division Sons of Temperance (Schafer, 1925: 284).

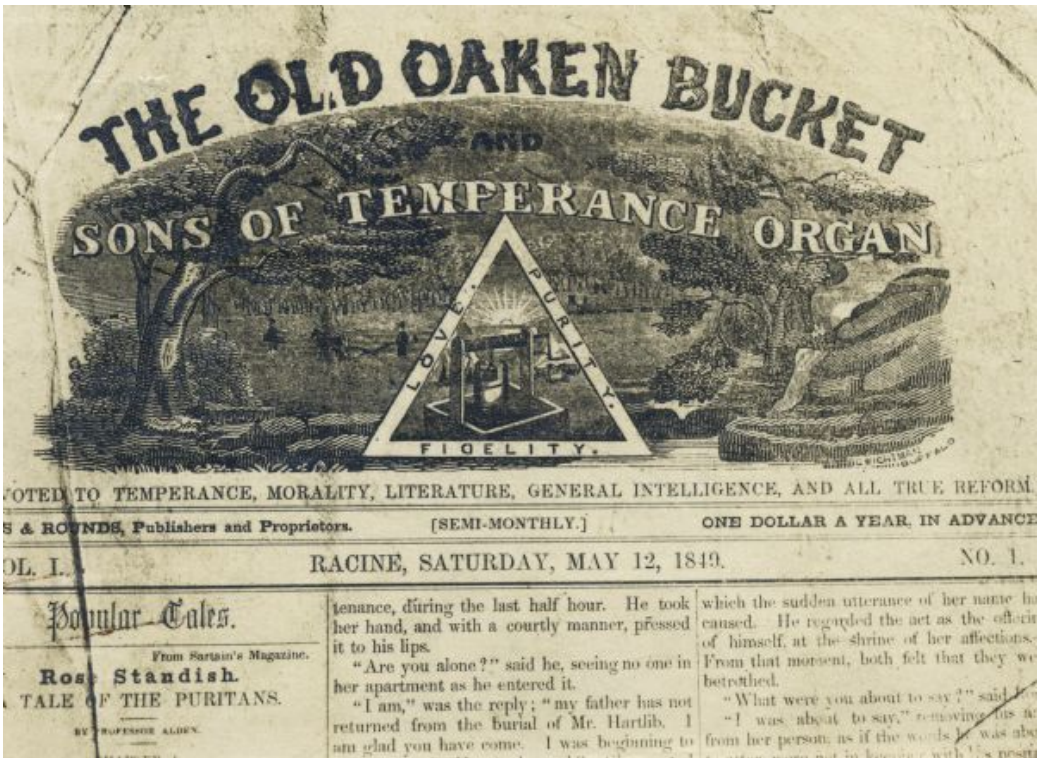
THE OLD OAKEN BUCKET
AND
SONS OF TEMPERANCE ORGAN
LOVE PURITY FIDELITY
OTED TO TEMPERANCE, MORALITY, LITERATURE, GENERAL INTELLIGENCE, AND ALL TRUE REFORM
S & ROUNDS, Publishers and Proprietors. [SEMI-MONTHLY.] ONE DOLLAR A YEAR, IN ADVANCE
OL. I. RACINE, SATURDAY, MAY 12, 1849. NO. 1.
Popular Tales.
From Sartain's Magazine.
Rose Standish.
A TALE OF THE PURITANS.
tenance, during the last half hour. He took her hand, and with a courtly manner, pressed it to his lips.
"Are you alone?" said he, seeing no one in her apartment as he entered it.
"I am," was the reply; "my father has not returned from the burial of Mr. Hartlib. I am glad you have come. I was beginning to
which the sudden utterance of her name h caused. He regarded the act as the offerin of himself, at the shrine of her affections. From that moment, both felt that they we betrothed.
"What were you about to say?" said h
"I was about to say," removing his a from her person, as if the words he was ab

Fig. 5. Front page of *The Old Oaken Bucket* magazine

The Sons of Temperance succeeded in causing a law to be enacted in 1849 requiring vendors to pay a $1,000 bond on which they could be sued for damages caused by customers consuming their liquor. It was viewed as a tentative achievement, with Sons of Temperance member A.C. Barry

having this to say about it in *The Old Oaken Bucket*: "Generally speaking, it will remain a dead letter on the statute books. There is a greater law opposed to it and which renders it a nullity. Unless enlightened public opinion and sentiment go along with a law and sustain it, it is good for nothing" (Barry, 1849: 169).

The law did not suit anyone, with the Sons of Temperance and A.C. Barry insisting on complete prohibition of liquor vis-à-vis those opposed to anti-liquor legislation demanding that liquor be allowed to be sold freely and with no bonds imposed (Schafer, 1925: 288).

As a side note, much opposition to liquor prohibition came from Wisconsin's growing German population, as for those people beer was socially and culturally important and the brewing process was central to communal life. Consequently, in 1851 a new law was adopted requiring a bond of only $500, half of the original required bond. The law's passage was lamented by the Sons, including A.C. Barry, who in *The Old Oaken Bucket* characterized the defeat as an abandonment of Wisconsin's historical temperance pedigree.

The 1851 defeat coincided with a continued rise in the beer-positive German population, with the Sons of Temperance effectively losing their political power by 1855.

A. Constantine Barry as an educator

In 1848, the government of Wisconsin undertook to reform its school system – by replacing a territorial system with centralized governance with a system of independent school districts. Virtually concurrently with his arrival in Racine and engagement in the fight for temperance, A.C. Barry became involved in local education matters.

He was an advocate of the educational theories of Horace Mann, and supported the creation of district normal schools and teacher's institutes, and the consolidation of school districts.

In 1849, Wisconsin introduced a system of free public schools, funded with taxpayer money. A.C. Barry served as the first supervisor of the public schools in Racine from 1849 to 1853. The introduction of the system of free public schools would lead to a sharp drop in the number of private primary schools in Wisconsin.

However, the 1848 school statute was such a jumble that the legislature, recognizing serious deficiencies, established a revision commission to codify and rationalize school law. Eventually, in 1862 a new law forced all school districts in Wisconsin to relinquish their authority to county superintendents.

In 1855, A.C. Barry became the 4th Superintendent of Public Instruction of Wisconsin. He would hold that office until 1857. (Butterfield, 1880: 989).

A member of the Democratic Party, A.C. Barry was a guest at the inauguration of James Buchanan (15th US president) in 1857. He and his wife were among several dozen guests at the National Hotel in Washington, DC, stricken by the so-called "National Hotel disease" (Butterfield, 1880: 989). The serious consequences the poisoning had for A.C. Barry are mentioned in several biographical accounts. As a side note, some regard the National Hotel disease as one of the United States' biggest crime mysteries of the 19th century. President James Buchanan, too, was afflicted, but managed to recover. The disease was peculiar in that the majority of the hotel's guests stricken by it would not be able to recover from and continue to be sick with it for the rest of their lives. For instance, Representative John Montgomery of Pennsylvania died at the age of 51 a month after contracting the disease, with Representative John Quitman of Mississippi passing at the age of 60 a year and 4 months after contracting it and Representative David Robinson of Pennsylvania passing at the age of 43 2 years after doing so.

Due to the after-effects of contracting the disease, A.C. Barry had to substantially limit his public and pedagogical activity. He did not run for re-election as Superintendent in 1857.

A.C. Barry was well-versed in the natural sciences and had been for many years a corresponding member of the Academy of Sciences of Philadelphia, the Boston Natural History Association, and the Buffalo Scientific Association (Butterfield, 1880: 989).

A. Constantine Barry during the Civil War

At the outbreak of the American Civil War, A.C. Barry volunteered for service in the Union Army and was enrolled as chaplain of the 4th Wisconsin Infantry Regiment, serving in that role from June 15, 1861 to June 8, 1862. As a side note, in 1863 the 4th Wisconsin Infantry Regiment was converted to the 4th Wisconsin Cavalry Regiment (Roster of Wisconsin..., 1886: 156-157).

On his return to Wisconsin, he served on the local recruiting board and was engaged in volunteer recruitment work.

In the 1863 general election, he was elected to the Wisconsin State Assembly, representing Kenosha County in the 17th Wisconsin Legislature.

On April 4, 1864, after the end of the legislative session, he returned to active duty as chaplain for the 19th Wisconsin Infantry Regiment, and served 10 months with that regiment (Roster of Wisconsin..., 1886a: 112). On February 9, 1865, A.C. Barry received an appointment from President Abraham Lincoln to serve as chaplain of the United States Hospitals.

He mustered out on August 15, 1865 (Butterfield, 1880: 989).

A.C. Beckwith's 'History of Walworth County, Wisconsin', published in 1912, draws upon the recollections of some of the region's longtime residents. In 1868–1878, A.C. Barry resided in Elkhorn, Walworth County, where he established a church. Of interest is the fact that he and his service as chaplain during the Civil War would be remembered by residents nearly 50 years later, and on top of that they would even quote one of his sayings – "While in military service he said or wrote that he had been preaching universal salvation for many years, but was at last convinced that hell was just then a military necessity" (Beckwith, 1912: 303).

After the war, he was an active member of the Wisconsin Commandery of the Military Order of the Loyal Legion, and served as chaplain of the organization for many years.

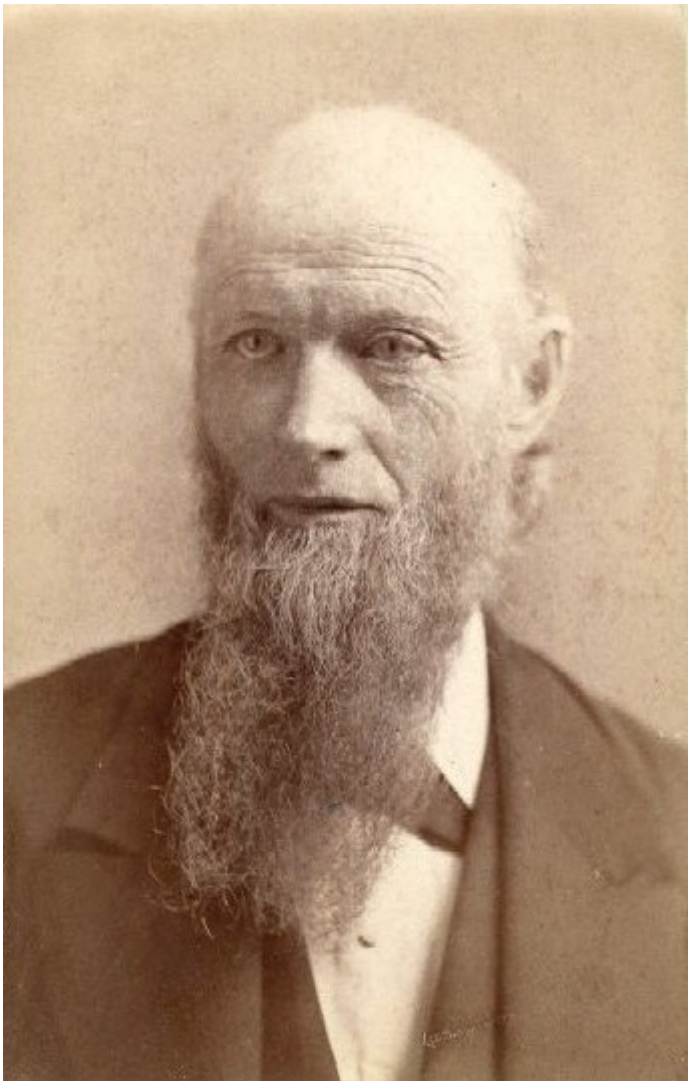

Fig. 6. A. Constantine Barry (photographed between the 1870s and 1880s)

In the spring of 1864, A.C. Barry moved his family to Fond du Lac, WI, where he resided for 4 years. In 1868, he moved to Elkhorn, WI, where he established a church. He finally moved to Lodi, WI, in April 1878, where he resided for the rest of his life (Butterfield, 1880: 989).

A. Constantine Barry as a Mason

In 1846, A.C. Barry moved to Racine, WI. As a side note, on May 29, 1848, an eastern portion of the Territory of Wisconsin, which at the time was an organized and incorporated territory of the United States, was admitted to the Union as the State of Wisconsin, the US's 30th. Interestingly, just shortly before that, in January 1848, Racine became home to Racine Lodge No. 18. The lodge was founded by 10 Master Masons (most of whom were not locals), with A.C. Barry being one of them (Proceedings..., 1848: 75). Back then, a new lodge could be formed by a group of not less than seven Master Masons (Webb, 1816: 84). In 1848, Racine Lodge No. 18 numbered just 14 members – 10 Master Masons (two of them officers), one Fellow Craft, and three Entered Apprentices (Proceedings..., 1848: 75). The following year, 1849, the lodge now had 24 members – nine officers, 14 Master Masons, and one Entered Apprentice (Proceedings..., 1850: 115-116). In 1850, A.C. Barry was installed as Chaplain of Racine Lodge No. 18 (Proceedings..., 1851: 101). While no information of this kind is available for 1851, it is known that in 1852 A.C. Barry was still the lodge's Chaplain (Proceedings..., 1852: 111).

No information on Racine Lodge No. 18 is available for 1853. A.C. Barry is listed among the lodge's Master Masons in the 1854 report (Proceedings..., 1854: 67). There is no mention of him being with Racine Lodge No. 18 in the 1855 report (Proceedings..., 1855: 101-102).

On February 7, 1855, Racine became home to Orient Charter No. 12 of the Grand Chapter of Royal Arch Masons of the State of Wisconsin. No reports are available on the activity of that organization for 1855–1863. However, there is reason to believe that it is in that timeframe that A.C. Barry became a member thereof. This conclusion is based on the fact that A.C. Barry was among the Companions of that Masonic organization in 1864 (Proceedings of the Grand Chapter..., 1864: 62).

In 1865, despite A.C. Barry and his family having left Racine, he continued to be one of the Companions of that Masonic organization (Proceedings of the Grand Chapter..., 1865: 63).

There was a similar situation in 1866–1870 (Proceedings of the Grand Chapter..., 1866: 55; Proceedings of the Grand Chapter..., 1867: 76; Proceedings of the Grand Chapter..., 1868: 92; Proceedings of the Grand Chapter..., 1869: 79; Proceedings of the Grand Chapter..., 1870: 65). It is difficult to say for how long A.C. Barry remained a member of Orient Charter No. 12 of the Grand Chapter of Royal Arch Masons of the State of Wisconsin, but from 1877 the records no longer listed him as a member of that organization.

On January 6, 1866, Racine became home to Racine Commandery No. 7. However, there is no mention of A.C. Barry in the records of the Grand Commandery of Knights Templar for the State of Wisconsin for 1867 and 1873–1878 either as a member of Racine Commandery No. 7 or one of any other commandery. He might have been a member of the Masonic order of Knights Templar for a short period of time, and, while records are yet to be found on his service with the Knights Templar, the only historical reminder of that experience is his Masonic sword.

5. Conclusion

A dedicated missionary minister all his life, A.C. Barry preached in eight different localities within the state of New York and four localities within the state of Wisconsin. His life can be divided into two distinct time periods – (1) before 1857 and (2) after 1857.

During the first period, beginning in 1836, he engaged in missionary work and served as a Mason, and, following his relocation to Racine, WI, in 1846, he engaged in promoting the temperance cause and championed the idea of enacting prohibition in the state of Wisconsin, supervised public education in Racine, was active as a Mason, engaged in research work, was a member of several scientific societies, and served as the 4th Superintendent of Public Instruction of Wisconsin in 1856–1857.

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After the war, A.C. Barry continued his missionary service; he established a church in Elkhorn, WI. That was the height of his activity in the postwar period.

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