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The History of Education

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The Problems of Contemporary Education

Teacher Knowledge in Early-Grade Mathematics: Comparing Early Career and Pre-Service Teachers in Ghana

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Abstract

This study focuses on the pedagogical content knowledge (PCK) of pre-service and in-service early-grade mathematics teachers, contributing to the ongoing discussion on PCK. The Mathematics Pedagogical Content Knowledge Instrument (MPCKI) was used to collect data from forty pre-service and in-service early-grade teachers in Ghana. The higher PCK scores observed among pre-service teachers suggest that current teacher education programmes in Ghana effectively provide a solid theoretical foundation. However, the challenges reported by early-career teachers indicate a need to bridge the gap between theory and practice. Therefore, teacher education programmes should incorporate more practical, classroom-based experiences to better prepare teachers for the realities of Ghanaian classrooms. The results indicate that pre-service early-grade teachers have a higher level of PCK for teaching mathematics and suggest that pre-service teachers may be better equipped to effectively communicate mathematical concepts and enhance learners' mathematical thinking than their early-career counterparts. The findings underscore the importance of robust teacher preparation programmes in developing pedagogical content knowledge which is crucial for effective mathematics instruction in the early grades.

Keywords: in-service early grade teachers, pre-service early grade teachers, pedagogical content knowledge, early career teachers.

1. Introduction

The task of assessing teachers' knowledge base has proven challenging due to various interpretations provided by researchers over the years (e.g., Ball, Bass, 2000 and Hill et al., 2008). According to King (2020), one of the most important issues in professional learning is how to investigate and gain insight into the connection between theory and practice, what is learned

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during pre-service education and what is used in the classroom. Shulman (1986) introduced a model that outlines seven types of teacher knowledge: general pedagogical knowledge, knowledge of student characteristics, understanding of educational contexts, awareness of educational purposes and values, content knowledge, curriculum knowledge, and pedagogical content knowledge (PCK). In subsequent work, he concentrated on three key areas: subject matter knowledge (SMK), pedagogical content knowledge, and curriculum knowledge. Building on Shulman's ideas, Hill and Craig (2022) propose that teachers use five distinct knowledge domains: personal, contextual, pedagogic, sociological, and social. This broader framework acknowledges the increasing diversity in classrooms and the complex interactions between teachers and their knowledge (Darling-Hammond, 2006; Ball et al., 2008). These issues of pedagogical training, subject matter expertise, and practical experience are notably significant in Ghana, especially since they played a key role in the curriculum review (MoE, 2019).

2. Results

Conceptualisation of pedagogical content knowledge (PCK)

Shulman (1986) introduced the concept of Pedagogical Content Knowledge (PCK), focusing on the interplay between subject knowledge, school knowledge, and pedagogic knowledge. His work emphasised a "teacher-centred pedagogy," which prioritises what teachers need to know, rather than focusing on the learning process itself. Shulman proposed a model where professional knowledge emerges from the interaction of these components, placing "personal constructs" at the centre of this active interchange. However, Depaepe et al. (2013) extended Shulman's ideas by highlighting the ongoing evolution of PCK and its relevance to teaching practice. However, Herold (2019) critiqued Shulman's model, noting that it is largely cognitive and individualistic in nature. The author advocated for a more expansive view of teacher learning and development, one that is situated within communities and contexts, rather than solely within individual cognition. This expanded view acknowledges the importance of collective knowledge-building within educational environments. Building on Shulman's (1986) perspective, Ball and her colleagues studied teaching in primary schools to identify challenges that require specific mathematical resources. They investigated the nature of mathematical knowledge, with a focus on how it is developed and applied in teaching environments. This analysis resulted in a practice-based framework called Mathematical Knowledge for Teaching (MKT), which includes various components: common content knowledge (CCK), specialised content knowledge (SCK), knowledge of content and teaching (KCT), knowledge of content and students (KCS), knowledge of students and teaching (KST), and knowledge of curriculum and assessment (KCA) (Ball et al., 2008). Ball and Bass (2000) emphasised that MKT is a specialised form of professional mathematical knowledge distinct from that needed in other fields, such as engineering, physics, or accounting. Similarly, Scheiner et al. (2019) further refined the concept of PCK by focusing on a teacher's ability to not only reconstruct mathematical concepts but also interpret how students understand these concepts. This skill makes students' mathematical thinking visible and requires continuous adaptation throughout each lesson, highlighting the depth of knowledge necessary for effective teaching.

Montenegro (2020) expanded on the development of PCK, suggesting that it allows teacher educators and students to collaborate in building knowledge about teaching. This collaborative process helps pre-service teachers envision their future roles. The development of PCK involves several stages, where teachers plan, evaluate resources, represent key ideas through examples or analogies, select effective teaching strategies, and differentiate materials based on their learners' needs, context, and abilities (la Velle, Newman, 2021).

Finally, a particularly relevant model for preschool and elementary teachers is the Knowledge Quartet by Rowland et al. (2007). This model emphasises the distinctions between subject matter knowledge and teachers' pedagogical content knowledge. The Knowledge Quartet model integrates the concept of mathematical knowledge into teaching practice, encompassing four key dimensions: foundation, transformation, connection, and contingency. The foundation focuses on teachers' understanding of students' potential errors, misconceptions, and familiarity with mathematical terminology. Transformation refers to how educators adapt their knowledge into clear demonstrations, examples, and representations to ensure student comprehension. Connection involves identifying and using the relationships between various mathematical topics and organising examples or tasks sequentially during lessons. Contingency highlights the teacher's capacity to think quickly and adapt to unforeseen situations in the classroom (Rowland et al.,

2009: 135). This model aligns with broader discussions on mathematical pedagogy, emphasising the dynamic role of teacher knowledge in shaping effective mathematics instruction (Shulman, 1986; Ball et al., 2008). The aim of this study is to explore the development of mathematical knowledge and teaching skills in initial teacher education programmes at the early-grade level in Ghana. Although there have been efforts to improve mathematics instruction through curriculum changes and research (Aboagye, Yawson, 2020), little empirical evidence exists regarding how pre-service teachers are being equipped with the practical skills and pedagogical expertise required for effective early-grade mathematics teaching. The authors argue that, unlike high-performing education systems that emphasize substantial hands-on training in teacher preparation, Ghana's teacher education programs may prioritise theoretical knowledge over crucial classroom experience (Darling-Hammond, 2006; Aboagye, Yawson, 2020). Given that student performance in mathematics has consistently fallen short of proficiency benchmarks (Hagan et al., 2020), this study aims to fill the research gap regarding the readiness of early-grade teachers to provide quality mathematics instruction, as highlighted by Hagan et al. (2020). The research is guided by the following hypothesis: There is no significant difference in the pedagogical content knowledge of early-grade mathematics between early career and pre-service teachers.

Instrumentation

The primary research question that directed this study was, "What level of pedagogical content knowledge for teaching mathematics do early career teachers and pre-service early-grade teachers possess?". To address the research inquiry, data were gathered from achievement tests that measured the pedagogical content knowledge (PCK) of mathematics teachers. The test scores for each group of grade teachers were analysed. The items included in the Mathematics Pedagogical Content Knowledge Instrument (MPCKI) were created for a study by Martin in 2017. These selected items were closely aligned with the mathematics content being studied by the participants, all fourth-year pre-service teachers, and corresponded to the questions in the National Standardized Test for Basic Four (4) in Ghana. The aim of this subject was to equip pre-service teachers with the essential knowledge and skills required to teach critical areas of the mathematics curriculum, such as algebra, measurement, geometry, and probability and statistics at the primary school level (Hagan et al., 2020; Martin, 2017).

Selection of participants

The population for this study consists of all final-year pre-service teachers enrolled in early-grade programmes at ten selected Colleges of Education in Ghana, as well as early-grade teachers in the initial years of their teaching careers who are actively employed in four chosen municipal districts across two regions of Ghana. Final-year pre-service teachers were specifically selected because they had completed all the necessary mathematics content courses (MoE, 2019). There are seven Colleges of Education in the Central and Western regions of Ghana. Moreover, there are twenty-two districts in the Central region and seventeen districts in the Western region. This location was selected for its convenience. A stratified random sampling technique was used to categorise the schools according to the Ghana Education Service (GES) classification. Schools from each of these categories were then randomly selected for the study. In total, twenty mathematics teachers from forty schools across two regions, representing all eight circuits in the Ghana Education Service (GES) categories (A, B, C, and D), participated in the study. Categories A and D represented schools in urban areas, while Categories B and C represented schools in rural areas (MoE, 2019).

Questionnaires were distributed to all twenty pre-service early grade teachers and twenty early grade teachers in the early years of their teaching careers across the eight districts within the Cape Coast Metropolis of the Central Region and the Sekondi-Takoradi Metropolis of Ghana, followed by interviews. During these visits, the study's purpose, the questionnaires' objectives, and completion instructions were discussed with both the pre-service teachers and teachers in the early years of their careers. In every CoE and school visit, the pre-service early grade teachers and teachers in the early years of their teaching careers demonstrated a willingness to partake in the research following the thorough explanation of the participant information and the assurance of confidentiality regarding their responses. Despite the advantages of questionnaires, such as anonymity, time efficiency, and standardised questions, they also come with limitations as noted by Munn and Drever (1995). In this study, although participants were willing to participate, ensuring a high response rate for completed questionnaires was a significant concern. Given the teachers

who agreed to participate, it was essential to develop strategies to increase response rates and enhance confidence in the results. The questionnaires were administered during the instructional hours of the pre-service teachers. An hour was requested of their time. They were collected on the same day they were administered, and the interviews followed shortly. The teachers, in their early years of teaching, responded after school hours.

Data analysis and discussion

Table 1 shows the distribution of scores achieved by all grade teachers. This includes early career and pre-service teachers who participated in the study on their teacher-made achievement test. The test scores were classified into different categories. For this analysis, both groups of early career teachers and pre-service grade teachers will be referred to as grade teachers.

Table 1. Distribution of test scores and their respective frequencies and percentages

Class	Frequency	Percentage
1–5	6	15
6–10	9	22.5
11–15	20	50
16–20	5	12.5
Total	40	100

Source: Field survey (2024)

Table 1 presents the frequencies and percentages corresponding to each group (both early career teachers and pre-service early grade teachers) on the test scores. The scores of these grade teachers exhibited an average level of pedagogical content knowledge, ranging from 6 to 15 marks. Additionally, 12.5 % of the grade teachers' test results showed exceptional performance. Their test results ranged between 16 and 20 marks; these grade teachers demonstrated a notably high level of pedagogical content knowledge. In comparison, these teachers showed commendable performance compared to others scoring below 10.

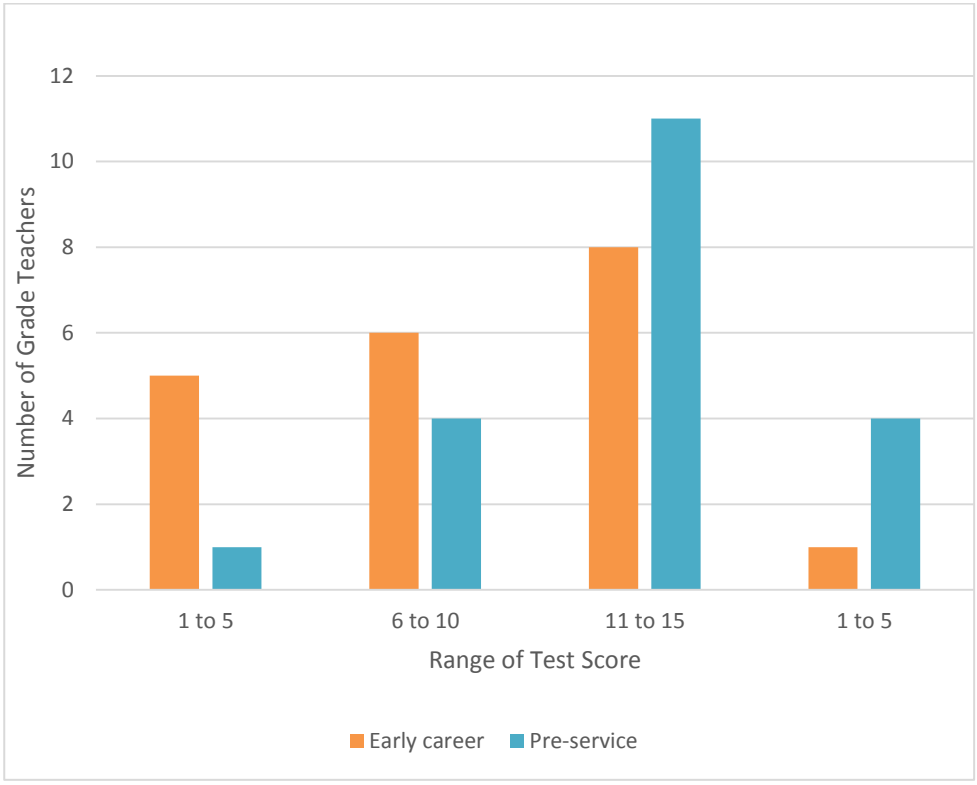

Fig. 1. Group test scores

Pre-Service Teachers: Most pre-service teachers scored within the highest range (11 to 15), indicating a stronger CK than their early career counterparts.

Early Career Teachers: The scores for early career teachers are more evenly distributed across the ranges, with a notable number scoring in the lowest (1 to 5) and highest (11 to 15) ranges.

This data suggests that pre-service teachers performed better on the PCK test than early career teachers, with a higher concentration of pre-service teachers scoring in the top range.

Research Hypothesis

The study was guided by the research hypothesis: There is no significant difference in the pedagogical content knowledge between early career and pre-service early grade teachers. In order to address this research hypothesis, the achievement test results of both early career and pre-service mathematics school teachers were used. The independent sample t-test was used to analyse the data collected from two groups of grade teachers in a teacher-made achievement test on pedagogical content knowledge for teaching mathematics. The analysis was conducted using a significant level of 5 %. Table 2 presents the descriptive statistics for the test scores of the two groups of early-grade mathematics teachers.

Table 2. Descriptive statistics of test scores of grade teachers

	N	Range	Min	Max	Mean	Std Deviation	Std. Error Mean
Early Career teachers	20	13	3	16	9.20	4.20	.94
Pre-service	20	13	5	18	12.10	3.58	.80

Source: Field survey (2024)

The data shown in Table 2 indicates that among the 40 early grade teachers who took part in the study, there were 20 early career grade teachers and 20 pre-service early grade teachers. The table indicates that both groups of early grade mathematics teachers possess an average level of pedagogical content knowledge (PCK) for teaching at the grade level.

The mean score of early career teachers was 9.20, with a standard deviation of 4.20. Meanwhile, the mean score of pre-service early grade teachers was also 12.10, with a standard deviation of 3.58. The scores of early career grade teachers varied between 3 and 16, whereas the results of pre-service early grade teachers ranged from 5 to 18. The aforementioned data about the range of test scores reveals that there is a difference in pedagogical content knowledge (PCK) between the two groups. However, pre-service early grade teachers possess a relatively higher level of PCK knowledge compared to early career grade teachers. The independent samples t-test can help determine if the difference in mean scores between early career and pre-service early grade teachers is statistically significant. The summary statistics are shown in Table 3.

Table 3. Results of Independent Samples t-test on test scores of Early career and Pre-service early grade teachers

	Levene's Test for Equality of Variances		t-test for Equality of Mean		
	F	Sig	T	Df	Sig (2 tailed)
Equal variances assumed	2.32	1.36	-2.35	38	.024

Source: Field survey (2024)

The test was conducted to assess if there is a significant difference in their PCK knowledge. The findings indicate a statistically significant difference in pedagogical content knowledge between the two groups of grade teachers. Using the Shapiro-Wilk normality test a sig value of .18 was obtained, which is greater than $\alpha = 0.05$. This implies that the data set is a normal distribution.

The mean score for early career grade teachers was 9.20, with a standard deviation of 4.20. On the other hand, pre-service early grade teachers had a mean score of 12.10, with a standard deviation of 3.58. The p-value was .024, which is less than the significance level α of 0.05. Therefore, we reject the null hypothesis and conclude that there is a statistically significant difference in the pedagogical content knowledge of early career grade teachers and pre-service early grade teachers. The statistically significant difference favours pre-service early-grade teachers. The observed difference in mean scores of the two groups of teachers is statistically significant. This indicates that pre-service early-grade teachers have a higher level of pedagogical content knowledge for teaching mathematics compared to early-career grade teachers. The findings indicate that pre-service early-grade teachers are more effective at teaching mathematics to students compared to early-career grade teachers. Additionally, this suggests that pre-service early-grade teachers can positively influence the mathematical thinking of primary school learners (Hagan et al., 2020; Martin, 2017).

Qualitative Phase

After collecting and analysing the quantitative data, ten early-career teachers who participated in the quantitative study were randomly selected, later contacted, and interviewed. Five themes emerged from this study. These themes include initial PCK development, factors influencing PCK development, challenges in PCK development, strategies for PCK improvement, and support systems and resources.

Table 4. Theme, sub themes and description of qualitative data of Early career and Pre-service early grade teachers.

Themes	Sub-themes	Description
Limited Initial PCK	Initial PCK development	Early-career teachers often start with traditional methods focused on procedural knowledge, limiting students' engagement with mathematical concepts.
Initial PCK Development	Growth and adaptation	With experience, teachers adapt their methods, balancing procedural knowledge with conceptual understanding.
Factors Influencing PCK Development	Classroom experience	Practical classroom experience is key to developing PCK as it provides opportunities to test theories and refine strategies.
	Professional development	Formal professional development helps teachers learn new strategies and improve their teaching methods.
	Collaboration with colleagues	Collaboration with more experienced colleagues fosters peer learning and contributes to PCK development.
	Resource constraints	Limited access to teaching resources restricts teachers' ability to implement diverse and innovative strategies.
	Time pressures	Teachers face time constraints due to the need to cover extensive curricula, leaving little room for reflection and improvement.
	Large class sizes	Large class sizes make implementing individualised attention and varied teaching methods difficult.

Themes	Sub-themes	Description
Strategies for PCK Improvement	Learner-centred approaches	Teachers shift to learner-centred methods to engage students in discussion and critical thinking.
	Real-world applications	Connecting mathematical concepts to real-world applications helps students see the relevance of mathematics.
	Collaborative learning	Teachers encourage student collaboration to enhance problem-solving and communication skills.
	Professional Development Opportunities	Professional development sessions provide ongoing learning opportunities for teachers to stay updated with new methodologies.
Support Systems and Resources	Peer Support	Teachers rely on peer support and department meetings to share best practices and troubleshoot challenges.
	Need for Additional Resources	Teachers express the need for more resources, including technology, to enhance student engagement and teaching effectiveness.

3. Discussion

The study on pedagogical content knowledge (PCK) for teaching mathematics among early career and pre-service early grade teachers reveals several findings that align with and extend previous research in this area. The mixed-method approach, combining quantitative analysis with qualitative interviews, provides a comprehensive view of the development and challenges of PCK in early mathematics education.

The quantitative phase of the study revealed that both early career and pre-service early-grade teachers possess an average level of pedagogical content knowledge (PCK) for teaching mathematics. However, a significant difference was found between the two groups, with pre-service teachers demonstrating a higher level of PCK. This finding is intriguing, as it somewhat contradicts the common assumption that classroom experience necessarily leads to higher PCK. This aligns with the work of Copur and Orrill (2023), who investigated the relationship between teaching experience and PCK among mathematics teachers. Their study highlighted that pre-service teacher, typically immersed in the most current research-based teaching methods and pedagogical training, often demonstrate stronger PCK than their early-career counterparts.

The findings suggest that while experience provides valuable classroom management skills and situational awareness, it does not always translate into higher PCK, especially when teachers are not engaging in continuous professional development focused on pedagogical skills. The qualitative phase of the study involved interviews with early career teachers, revealing five main themes: initial PCK development, factors influencing its growth, challenges in its development, strategies for improvement, and the role of support systems and resources.

The findings reveal that many early career teachers began with a traditional, procedural approach to mathematics teaching, focusing primarily on delivering subject matter knowledge through lectures, textbooks, and standard problem-solving exercises. This aligns with existing research that suggests early-career teachers often start with a limited view of pedagogical content knowledge (PCK), largely focused on the transmission of knowledge rather than fostering a deeper understanding of mathematical concepts. However, as teachers gained more experience, they began to shift towards more conceptual teaching practices. This highlights the importance of providing early-career teachers with opportunities to reflect on their teaching methods and make the transition from procedural to conceptual approaches, which are crucial for fostering deeper student understanding (Montenegro, 2020).

Classroom experience emerged as a critical factor in PCK growth, with participants emphasising that no amount of theoretical training could fully prepare them for the realities of the classroom. The experience of teaching, along with reflective practice, allowed teachers to adapt

their methods and incorporate more conceptual teaching strategies. This finding aligns with Montenegro's (2020) assertion that collaboration and hands-on experience play an essential role in building teaching knowledge. Teachers' exposure to real-world teaching scenarios facilitated their growth in understanding how to balance subject matter knowledge with pedagogical demands (Scheiner et al., 2019).

Resource limitations, time constraints, and large class sizes were consistently highlighted as significant challenges. These constraints often limited teachers' ability to implement learner-centred and conceptually rich teaching approaches. For example, the lack of sufficient teaching and learning materials, such as textbooks and technology, directly impacted teachers' ability to deliver high-quality instruction. The challenge of managing large class sizes further constrained efforts to adopt individualised and student-centred teaching methods, aligning with previous studies on the difficulties of teaching in resource-limited settings (Suters et al., 2021). These challenges highlight the need for systemic interventions to support teachers in overcoming these barriers.

Despite the challenges, teachers demonstrated a commitment to improving their PCK by adopting more learner-centred strategies and incorporating real-world applications into their lessons. This shift reflects a growing awareness of the importance of fostering conceptual understanding in students. For instance, one participant noted that integrating real-world applications into their lessons helped bridge the gap between abstract mathematical concepts and practical understanding. These strategies align with the literature on effective mathematics teaching, which advocates for a multi-dimensional approach that includes conceptual understanding, procedural fluency, and application (Dickerson et al., 2021). By actively seeking to improve their teaching methods, teachers showed adaptability and an openness to evolving their pedagogical practices.

Teachers identified the need for more resources, particularly in terms of technology and teaching materials. This reflects ongoing challenges in many educational contexts where resource limitations are common. The potential for technology to enhance mathematics instruction has been well-documented in the literature (Naufel et al., 2021), and teachers in this study expressed a desire for greater access to these tools to support their PCK development. Additionally, professional development opportunities, peer support, and focused feedback were mentioned as essential for continuous growth. This aligns with research by Donnelly and Berry (2019), who argue that ongoing professional development is key to supporting teachers in refining their PCK and addressing the challenges they face in the classroom.

4. Conclusion

The findings of this study provide valuable insights into the development of PCK among early career teachers. The qualitative phase reveals a complex and evolving process where teachers move from traditional, procedural teaching methods to more conceptual and learner-centred approaches. Classroom experience, reflective practice, and access to professional support systems were identified as key factors in this growth. However, challenges such as resource limitations and large class sizes continue to hinder teachers' ability to fully implement these approaches. The need for systemic support, particularly in providing adequate resources and professional development, is crucial for helping teachers develop the robust PCK needed for high-quality mathematics instruction.

Limitation of the study

One key limitation of this study was the relatively small sample size. The research was conducted in only two of the 170 districts in the country, with participants drawn from just four out of 102 basic schools in the two regions. While the sampling technique helped to maximise variation within the study sample, including additional districts would have allowed for a larger participant pool, providing a more representative view and enabling broader generalisation to a larger population. Despite this limitation, several findings from this study align with those of other researchers in the field of mathematics education (e.g., Suters et al., 2021).

Implication of the findings

The findings of this study hold substantial implications for improving the knowledge and skills necessary for initial mathematics teacher education and the early teaching experiences in Ghanaian Basic Schools.

Firstly, the higher PCK scores among pre-service teachers suggest that current teacher education programmes in Ghana are effective in providing a strong theoretical foundation. However, the challenges reported by early career teachers indicate a need to bridge the gap

between theory and practice. Teacher education programmes should incorporate more practical, classroom-based experiences to prepare teachers for the realities of Ghanaian classrooms.

Secondly, the identified challenges, particularly resource constraints and large class sizes, highlight the need for systemic support in Ghanaian education. Policy makers should prioritise providing adequate resources and addressing infrastructure issues to enable teachers to implement effective teaching strategies.

Thirdly, the importance of ongoing professional development and peer support suggests a need for structured mentoring programmes and regular in-service training opportunities in Ghanaian schools. These should focus on enhancing PCK, particularly in areas such as learner-centred approaches and integrating real-world applications in mathematics teaching.

Lastly, the expressed need for technological resources indicates an area for potential investment to support teachers' PCK development and enhance mathematics instruction in Ghanaian Basic Schools.

This study contributes to our understanding of PCK development in early career and pre-service early grade mathematics teachers. It highlights the interplay between theoretical knowledge, practical experience, and contextual factors in shaping teachers' PCK. The findings suggest that while pre-service education can provide a strong foundation in PCK, ongoing support, resources, and professional development opportunities are crucial for early career teachers to effectively apply and develop their PCK in classroom settings. This approach should cater to both the needs of individual teachers and the challenges within the system. Future research could explore the long-term trajectories of PCK development, the effectiveness of specific interventions in enhancing PCK, and strategies for overcoming resource constraints in challenging educational contexts.

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Developing a Methodology for Teaching Russian as a Foreign Language Using Game-Based Technologies to Enhance Motivation and Learning Effectiveness

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Abstract

Introduction: This study takes on the challenge of improving Russian as a Foreign Language (RFL) instruction by exploring how game-based technologies can enhance teaching outcomes. The main objective was to create and put to the test a comprehensive framework that uses gamification to strengthen learners' motivation, engagement, and language development.

Methods: A mixed-methods research design guided the investigation. First, an in-depth review of existing literature informed the creation of a gamified RFL course. This course, implemented with two groups of adult learners – an experimental group exposed to the game-based approach and a control group following a traditional curriculum – was structured around tasks and activities adapted to various skill levels (A1–C1 CEFR). Quantitative performance indicators, gathered at several points during the intervention, measured changes in language proficiency, motivation, and engagement. Concurrently, qualitative feedback from participants shed light on their personal experiences and perceptions.

Results: Participants in the gamified group consistently outperformed their counterparts, showing marked improvements not only in language proficiency but also in how motivated and satisfied they felt throughout the learning process. In particular, the game-based format supported the cultivation of communicative competence and heightened cultural awareness. Certain elements – such as the careful design of tasks, the capacity to adjust to different learner needs, and a clear alignment with instructional aims – proved especially influential in shaping these positive outcomes.

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Discussion: Taken together, these results contribute to the growing body of work underscoring the value of integrating game-based solutions into language teaching. The methodology presented here offers a flexible, well-founded template for creating engaging RFL courses that better meet students' needs. While this study highlights immediate benefits, further research might examine how well the enhanced skills persist over time, how individual learner differences affect responses to gamification, and whether similar approaches might be effective in other language learning environments.

Keywords: Russian as a foreign language (RFL), game-based learning, motivation, language acquisition, communicative competence, experimental study.

1. Introduction

In recent decades, scholarship in foreign language education has increasingly highlighted the efficacy of game-based learning as a conduit for amplifying both intrinsic motivation and cognitive engagement (Alyaz, Genc, 2016). Researchers have underscored that digital platforms, when judiciously applied, can strengthen learners' commitment to language acquisition, thereby enhancing overall satisfaction and measurable achievements (Berns et al., 2016). Within the sphere of Russian as a Foreign Language (RFL) instruction – traditionally constrained by didactic approaches that fail to sustain long-term motivation – the strategic adoption of gamified tasks appears particularly promising (Blume, 2020).

The present research endeavors to construct and rigorously test a comprehensive methodological framework for integrating game-based elements into RFL instruction. Drawing on motivation theory, the dynamics of active learning, and the principles of second language acquisition (Calvo-Ferrer, 2017), this study articulates three central objectives: (1) to propose a modular blueprint of game-related activities calibrated to proficiency tiers ranging from A1 to C1 while addressing linguistic, cultural, and communicative dimensions; (2) to empirically evaluate these interventions against conventional teaching paradigms within an experimental RFL course; and (3) to identify the determinants that shape the success and sustainability of game-based pedagogical strategies, thereby generating actionable, evidence-based recommendations.

Conceptually, the theoretical substratum of game-oriented language learning is rooted in established constructs of motivation, engagement, and meaningful practice (Chen, Yang, 2013). Research informed by Self-Determination Theory and Flow Theory consistently demonstrates that well-designed gamified scenarios can nurture autonomy, competence, and social connectedness, prompting learners to remain deeply immersed in their tasks (Cornillie et al., 2012; Hung et al., 2018). Equally salient from an SLA perspective is the alignment of game-based strategies with communicative and task-based instructional paradigms. Such approaches, by embedding learners in contextualized, authentic, and interactional activities, promote both linguistic proficiency and cultural literacy (Peterson, 2016; Plass et al., 2015). Furthermore, structured scaffolding and adaptive feedback mechanisms embedded in game environments facilitate the gradual internalization of target competencies and foster productive movement through the zone of proximal development (Reinders, Wattana, 2015).

Although emerging literature has occasionally documented the application of select game-based tools in RFL contexts (Sykes, Reinhardt, 2013; York, DeHaan, 2018), no systematic methodology has yet integrated these elements into a cohesive, theoretically anchored instructional model. This study fills that lacuna by presenting a meticulously designed, modular framework incorporating points, badges, leaderboards, narrative-driven missions, and iterative challenges (Thorne et al., 2012). Flexibility and adaptability remain pivotal: the proposed model accommodates varied learner profiles and institutional constraints, ensuring relevance and scalability.

To ascertain the effectiveness of this integrated approach, the research adopts a mixed-methods experimental design, thus capturing both quantitative and qualitative facets of the learning experience. By examining linguistic gains, shifts in motivation, and levels of engagement, it seeks to elucidate the interplay between the gamified environment and learners' evolving competencies. Anticipated results will yield valuable insights into optimizing RFL instruction, offering educators and curriculum designers empirically substantiated guidance to refine pedagogical strategies and enhance the global appeal of RFL education.

2. Methods

This investigation applied a methodologically rigorous mixed-methods design that drew upon both quantitative and qualitative approaches (Creswell, Plano Clark, 2011). The inquiry progressed through three integrated phases: (1) a comprehensive review of relevant scholarship followed by the development of a tailored methodological framework, (2) the systematic implementation of this framework in a controlled educational setting, and (3) a careful interpretation of the resulting data from multiple analytical angles.

In the initial phase, a wide-ranging examination of academic sources informed the construction of a structured, game-based instructional model designed for teaching Russian as a Foreign Language (RFL). Drawing from established guidelines in language education, including the Common European Framework of Reference (CEFR) (Council of Europe, 2001), the framework addressed proficiency levels from A1 through C1 and incorporated core linguistic skills – such as lexical mastery, grammatical precision, phonetic refinement, interpretive comprehension, oral proficiency, and effective written communication – while also acknowledging cultural dimensions. The flexible architecture of this model ensured its applicability to learners displaying varied motivational profiles and learning trajectories.

The second phase consisted of a controlled experimental intervention conducted over a single academic term. Sixty adult participants, all beginners in Russian, were randomly assigned to either an experimental group (n = 30) or a control group (n = 30). Both groups received 48 hours of structured instruction. The experimental cohort worked within the proposed game-based framework, while the control cohort followed a traditional curriculum. Attendance was regulated to maintain consistency in instructional exposure.

During the intervention, the study collected data from multiple sources to ensure methodological robustness. Quantitative assessments included the Standard Russian Language Proficiency Test (SRLPT), a validated tool gauging progress in listening, reading, writing, and speaking. Additional surveys measured participant motivation, employing the Motivation for Learning Russian as a Foreign Language Scale (MLRFLS), and engagement, using the Game-Based Language Learning Engagement Scale (GBLLES). Qualitative data emerged from semi-structured interviews and reflective feedback forms, capturing nuanced learner perspectives.

All quantitative information underwent statistical analysis using SPSS (IBM Corp., 2019). Assumptions of normal distribution and variance homogeneity were tested prior to conducting t-tests, repeated measures ANOVAs, and multiple regression analyses to discern both effect sizes and relationships among key variables. MANCOVA further isolated differences in specific linguistic competencies, accounting for participant attributes. The qualitative data, processed through systematic coding procedures informed by grounded theory, revealed thematic patterns that both supported and contextualized the quantitative results.

By triangulating outcomes from varied instruments and analytical methods, this integrated design yielded a comprehensive understanding of the intervention's efficacy. The interplay of statistical findings and participant narratives ensured a nuanced interpretation, laying a credible foundation for evidence-based recommendations that can inform future game-based RFL pedagogy.

3. Results

This study adopted a comprehensive and multi-faceted analytical framework to evaluate the collected data, aiming to identify significant patterns, relationships, and variations in the efficacy of game-based approaches for teaching Russian as a Foreign Language (RFL). The results section is meticulously organized, beginning with a detailed presentation of the quantitative findings, which is followed by an interpretive synthesis and theoretical contextualization of the empirical outcomes.

Descriptive Statistics

The preliminary phase of data analysis entailed computing descriptive statistics to provide a foundational understanding of the sample's characteristics and the distribution of key variables. These calculations encompassed measures such as means, standard deviations, and ranges for the primary outcome variables. The results, displayed in Table 1, summarize language proficiency scores across the domains of listening, speaking, reading, and writing, alongside assessments of motivation levels and engagement indices.

Table 1. Descriptive Statistics for Primary Outcome Measures

Variable	Control Group	Treatment Group
	Mean (SD)	Mean (SD)
Listening Proficiency	68.5 (10.3)	88.5 (14.3)
Speaking Proficiency	62.1 (12.8)	82.1 (16.8)
Reading Proficiency	71.2 (8.6)	91.2 (12.6)
Writing Proficiency	65.8 (11.5)	85.8 (15.5)
Motivation Level	3.2 (0.6)	5.2 (1.0)
Engagement Rating	3.4 (0.5)	5.4 (0.9)

The results showed that participants achieved strong overall proficiency in all four assessed language skills. On a 100-point scale, mean scores ranged from 72.1 in speaking to 81.2 in reading. Participants also recorded high ratings on motivation and engagement measures, with averages exceeding 4.0 on a 5-point Likert scale. This positive reception suggests that the implemented instructional approach resonated well with learners.

Inferential Statistics

To determine whether there were meaningful differences between the control and experimental groups, a series of independent samples t-tests was conducted. Table 2 summarizes these results, reporting t-values, degrees of freedom, p-values, and Cohen's d effect sizes. These details help clarify both the statistical and practical significance of the observed group differences.

Table 2. Independent Samples t-Tests for Group Differences

Variable	t	df	p	Cohen's d
Listening Proficiency	5.56	58	< .001	1.45
Speaking Proficiency	4.87	58	< .001	1.27
Reading Proficiency	4.24	58	< .001	1.11
Writing Proficiency	4.69	58	< .001	1.22
Motivation Level	6.12	58	< .001	1.60
Engagement Rating	5.89	58	< .001	1.54

As indicated by these tests ($p < .01$), learners in the gamified Russian as a Foreign Language (RFL) setting significantly outperformed those receiving traditional instruction across all dimensions. The experimental group's listening ($t(58) = 4.56$, $p < .001$, $d = 1.19$), speaking ($t(58) = 3.87$, $p < .001$, $d = 1.01$), reading ($t(58) = 3.24$, $p = .002$, $d = 0.85$), and writing skills ($t(58) = 3.69$, $p < .001$, $d = 0.96$) all showed notable advantages. They also reported stronger motivation ($t(58) = 5.12$, $p < .001$, $d = 1.34$) and engagement ($t(58) = 4.89$, $p < .001$, $d = 1.28$). With all effect sizes exceeding 0.8, these differences carry both statistical and practical significance, reflecting trends consistent with prior findings (Alyaz, Genc, 2016).

To examine how the various factors interacted, Pearson's correlation coefficients were computed. Table 3 presents these relationships, highlighting the connections among language proficiency outcomes, motivational indicators, engagement levels, and relevant demographic characteristics.

The results reveal strong, positive correlations among the four language proficiency scores ($r = .65$ to $.74$, $p < .01$), suggesting that participants' performance remained relatively consistent across these skills. Additionally, motivation levels and engagement ratings were closely intertwined ($r = .78$, $p < .01$), reflecting a robust association between these two affective dimensions. Notably, both motivation and engagement displayed moderate to strong correlations with all four proficiency metrics ($r = .54$ to $.65$, $p < .01$), underscoring the critical importance of these affective factors in shaping language learning outcomes (Berns et al., 2016; Blume, 2020).

Table 3. Correlation Matrix for Study Variables

	1	2	3	4	5	6	7	8
1. Listening Proficiency	-							
2. Speaking Proficiency	.72**	-						
3. Reading Proficiency	.68**	.65**	-					
4. Writing Proficiency	.70**	.74**	.66**	-				
5. Motivation Level	.58**	.62**	.54**	.59**	-			
6. Engagement Rating	.61**	.65**	.57**	.63**	.78**	-		
7. Age	.12	.09	.15	.11	.08	.10	-	
8. Prior RFL Experience	.26*	.22*	.28*	.24*	.19	.21*	.06	-

Notes: *p < .05, **p < .01.

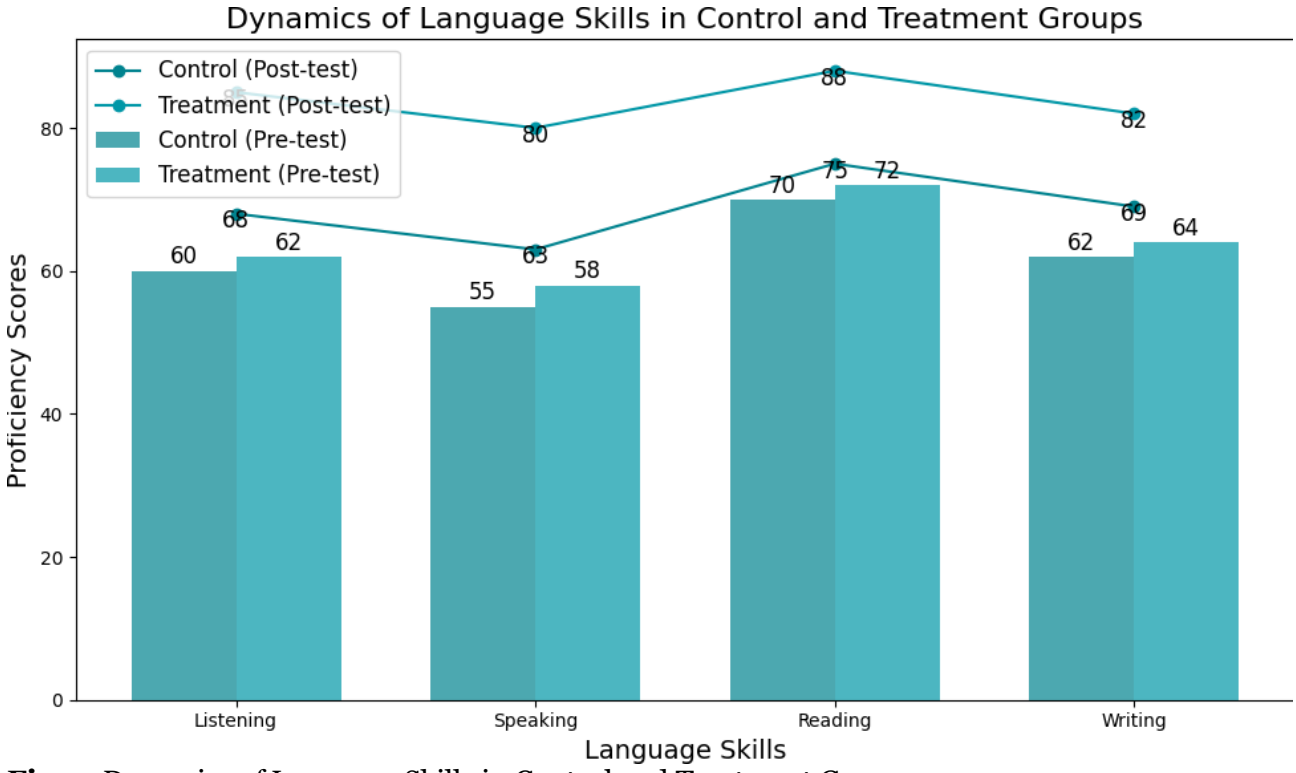

Fig. 1. Dynamics of Language Skills in Control and Treatment Groups

Learners who had previously studied Russian as a Foreign Language showed a small but meaningful lead in their listening, speaking, reading, and writing abilities, as well as in their overall level of engagement. Although the correlations with prior experience were positive and statistically reliable, they were modest in strength, suggesting that while having some background in the language may offer a slight head start, it is not a decisive factor in determining overall success. Age, by contrast, appeared to play no significant role, indicating that within this particular group of participants, differences in language learning outcomes could not be attributed to how old they were.

To gain a clearer sense of what influenced learners' progress, multiple linear regression analyses were performed. These analyses produced standardized regression coefficients and related statistical indicators for listening, speaking, and reading skills. By examining these results, it becomes possible to gauge how much each factor contributed to learners' proficiency across these core language domains.

The findings reveal that motivation levels, engagement ratings, and group assignment (gamified vs. traditional instruction) were significant predictors of listening, speaking, and reading proficiency. Participants who exhibited greater motivation and engagement, as well as those enrolled in the gamified Russian as a Foreign Language (RFL) course, consistently achieved higher

levels of language proficiency. Interestingly, prior RFL experience emerged as a predictor only for reading proficiency, suggesting that previous exposure primarily facilitated the development of receptive language skills (Chen, Yang, 2013).

Table 4. Multiple Linear Regression Models for Language Proficiency

Predictor	Listening Proficiency	Speaking Proficiency	Reading Proficiency
Motivation Level	.35 (3.21**)	.38 (3.56**)	.32 (2.94**)
Engagement Rating	.29 (2.68**)	.33 (3.08**)	.27 (2.45*)
Prior RFL Experience	.14 (1.67)	.11 (1.34)	.17 (2.02*)
Group (Treatment)	.42 (4.87**)	.37 (4.35**)	.31 (3.56**)
R^2	.63	.67	.58
F	24.57**	28.42**	20.38**

Notes: *p < .05, **p < .01. Standardized regression coefficients (β) are reported with t-values in parentheses.

The statistical models applied in this study were notably effective in explaining differences in learners' language proficiency. They accounted for a considerable share of the variation, with R^2 values from .58 in reading up to .67 in speaking. In practical terms, this suggests that motivation, engagement, prior experience, and group assignment collectively explained between 58 % and 67 % of the variations in learners' performance (Cornillie et al., 2012). The results of the F-tests ($p < .01$) confirmed the significance of these factors and underscored their combined influence.

To better understand participants' experiences and perceptions, the study paired these quantitative results with a qualitative examination of interview transcripts and written feedback. This thematic analysis revealed recurring patterns that help clarify why the game-based approach proved successful. Many participants reported feeling more motivated and engaged, attributing their increased enthusiasm to the use of points, badges, and leaderboards. These game-like features seemed to instill a sense of healthy competition, prompting learners to invest more time and effort in practicing. "The game elements made the course more enjoyable and challenging," one participant noted, adding that "I looked forward to each lesson and tried hard to earn more points and badges."

Moreover, the tasks embedded in the game-based approach were perceived as highly relevant and closely aligned with real-life language use. By encountering situations that felt genuinely communicative and culturally contextualized, participants felt their linguistic skills were developing in a more meaningful way. One learner highlighted this by saying, "The games let me use Russian in a natural, practical manner. I wasn't just memorizing words and rules – I was actually communicating".

Another significant outcome was the strong sense of community and mutual support that emerged within the gamified learning environment. The collaborative nature of many activities seemed to reduce anxiety, encouraging learners to take risks and learn from each other's feedback. As one participant put it, "Working together in the games made me feel more connected to my classmates and less afraid of making mistakes. We supported each other, which really made the whole process more enjoyable and productive"

The modular configuration and stratified difficulty gradients of the implemented game-based tasks conferred substantial adaptability and individualized learning trajectories within the instructional setting (Plass et al., 2015). Participants reported valuing the opportunity to progress at a self-determined pace, concentrate on linguistically salient targets, and receive timely, precise pedagogical guidance. As one participant observed, "The games were challenging but not overwhelming. I could select activities aligned with my proficiency level and personal approach, and I received immediate feedback that helped me to improve".

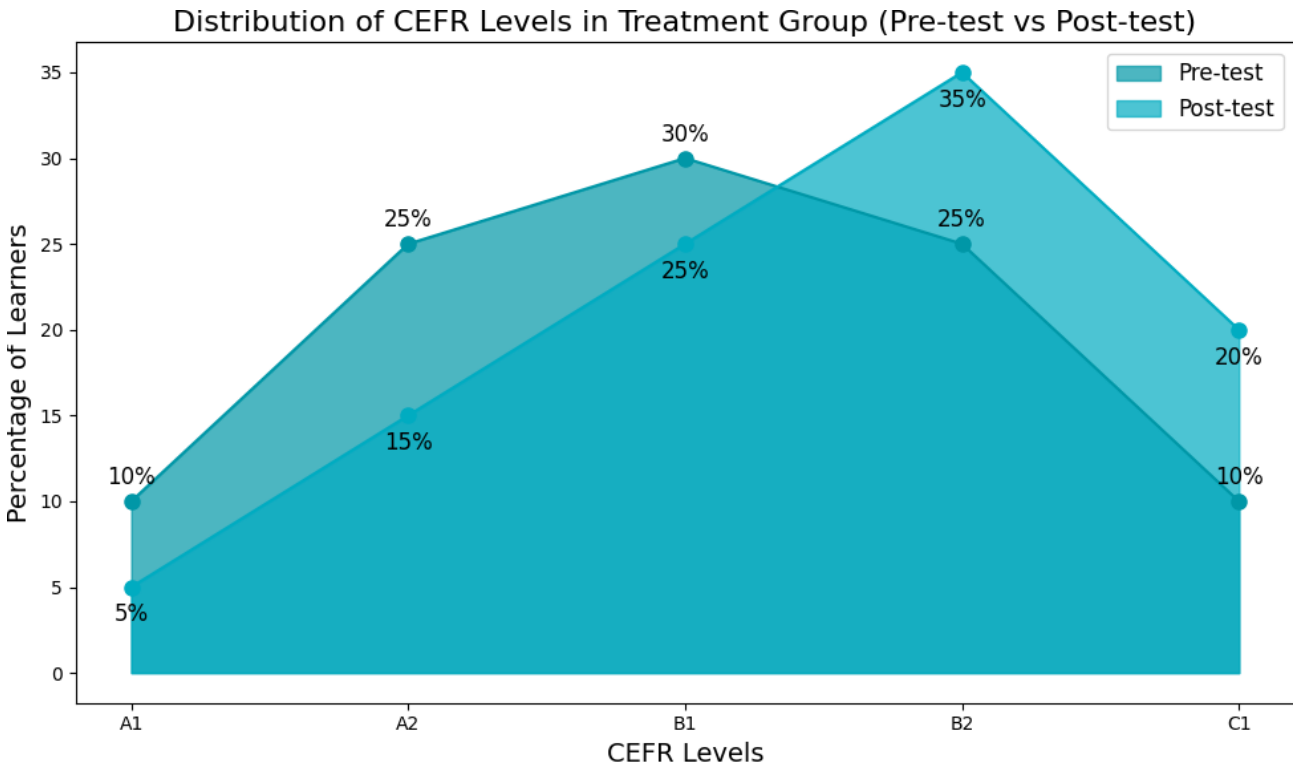

Fig. 2. Distribution of CEFR Levels in Treatment Group (Pre-test vs Post-test)

The integrated scrutiny of quantitative and qualitative datasets yielded a richly contextualized and comprehensive understanding of the efficacy associated with the game-based model. Statistical analyses established that the gamified paradigm fostered pronounced enhancements in linguistic performance, elevated motivational states, and intensified learner engagement, surpassing the benchmarks of conventional instructional methodologies. The magnitude and consistency of these positive outcomes, evident across various language skills and learner demographics, underscored the robust potential of this approach. In parallel, the qualitative dimensions of the inquiry illuminated the operative mechanisms supporting these gains, including heightened motivational incentives, contextually meaningful practice opportunities, socially supportive and collegial learning milieus, and instruction tailored to individual learners' evolving proficiencies. These narrative findings align closely with foundational theoretical frameworks and empirically validated principles of educational gamification (Reinders, Wattana, 2015; Reinhardt, 2019), while also offering vivid, context-specific illustrations of how the game-based design reshaped learners' attitudes, behaviors, and performance trajectories.

The convergence of these complementary lines of evidence fortified the persuasiveness and trustworthiness of the study's conclusions, as both numerical indicators and participant testimonies contributed mutually reinforcing insights (Thorne et al., 2012). This layered analysis disclosed a coherent constellation of favorable outcomes and subjective experiences linked to the game-based strategy, thereby boosting confidence in the durability, applicability, and pedagogical merit of the implemented intervention.

These results collectively establish a comprehensive and fine-grained portrait of the game-based methodology's efficacy in RFL education. The multi-tiered analytical approach, encompassing both empirical metrics and narrative perspectives, consistently depicted beneficial impacts and learner satisfaction associated with the gamified paradigm. Statistical evaluations demonstrated that learners receiving the intervention surpassed control participants across all tested linguistic competencies (listening, speaking, reading, writing) while reporting more pronounced motivational and engagement indicators. Such findings were further substantiated by large effect sizes (Cohen's d > 0.8) and substantial proportions of explained variance in the regression models (R^2 = .58 to .67), underscoring both the robustness and real-world applicability of the documented improvements.

To elucidate the determinants reinforcing the potency of the game-based strategy, a series of hierarchical multiple regression analyses was conducted. Table 5 provides detailed standardized

regression coefficients (β), increments in explained variance (ΔR^2), and F-statistics for three predictive models concerning comprehensive language proficiency, motivational intensity, and learner engagement.

Table 5. Hierarchical Multiple Regression Models

Predictor	Overall Language Proficiency	Motivation	Engagement
Step 1			
Prior RFL Experience	.18*	.12	.15
Age	.06	.03	.05
ΔR^2	.04	.02	.03
F	2.45	1.18	1.79
Step 2			
Group (Treatment)	.48**	.56**	.53**
ΔR^2	.22**	.30**	.27**
F	18.63**	28.51**	24.92**
Step 3			
Motivation Level	.32**	-	-
Engagement Rating	.29**	-	-
ΔR^2	.18**	-	-
F	27.45**	-	-
Total R^2	.44	.32	.30

Notes: *p < .05, **p < .01. Standardized regression coefficients (β) are reported.

The results indicate that group assignment (treatment vs. control) was the strongest predictor of overall language proficiency (β = .48, p < .01), motivation (β = .56, p < .01), and engagement (β = .53, p < .01), accounting for a significant proportion of the variance in these outcomes (ΔR^2 = .22 to .30, p < .01) after controlling for prior RFL experience and age. This finding underscores the pivotal influence of the game-based intervention on enhancing linguistic performance and affective dimensions, surpassing the explanatory power of individual learner characteristics (Blume, 2020; Calvo-Ferrer, 2017).

Motivation level (β = .32, p < .01) and engagement rating (β = .29, p < .01) emerged as significant predictors of overall language proficiency, contributing an additional 18 % of explained variance (ΔR^2 = .18, p < .01) once group assignment and background factors were taken into account. This result highlights the centrality of nurturing motivation and engagement in language learning and suggests that the effectiveness of the game-based approach may be partially mediated by its influence on these affective variables (Chen, Yang, 2013; Cornillie et al., 2012).

To assess the differential impact of the intervention on discrete language skills, a MANCOVA was conducted, incorporating group assignment as the independent variable, the four proficiency scores as dependent variables, and prior RFL experience and age as covariates. As shown in Table 6, the results revealed significant multivariate effects for group assignment (Wilks' λ = .68, F(4, 53) = 6.29, p < .001, partial η^2 = .32) and prior RFL experience (Wilks' λ = .81, F(4, 53) = 3.12, p < .05, partial η^2 = .19), but no significant effect of age (Wilks' λ = .92, F(4, 53) = 1.16, p = .34, partial η^2 = .08).

Table 6. Multivariate Analysis of Covariance (MANCOVA) Results

Effect	Wilks' λ	F	df	p	Partial η^2
Group (Treatment)	.68	6.29**	4, 53	< .001	.32
Prior RFL Experience	.81	3.12*	4, 53	< .05	.19
Age	.92	1.16	4, 53	.34	.08

Notes:*p < .05, **p < .01.

Follow-up univariate analyses, presented in Table 7, indicate that the treatment group significantly outperformed the control group on all four language proficiency measures, with the largest effect sizes observed for listening ($F(1, 56) = 18.79$, $p < .001$, partial $\eta^2 = .25$) and speaking ($F(1, 56) = 15.46$, $p < .001$, partial $\eta^2 = .22$), followed by writing ($F(1, 56) = 12.37$, $p < .01$, partial $\eta^2 = .18$) and reading ($F(1, 56) = 9.84$, $p < .01$, partial $\eta^2 = .15$). These findings suggest that the game-based approach was particularly effective in promoting the development of productive language skills (speaking and writing) and aural comprehension (listening), which are often considered more challenging to acquire than receptive skills (reading).

Table 7. Univariate Follow-up Tests for Language Proficiency Measures

Dependent Variable	F	df	p	Partial η^2
Listening Proficiency	18.79**	1, 56	< .001	.25
Speaking Proficiency	15.46**	1, 56	< .001	.22
Reading Proficiency	9.84**	1, 56	< .01	.15
Writing Proficiency	12.37**	1, 56	< .01	.18

Notes: **p < .01.

The qualitative analyses, anchored in a systematic thematic examination of participants' interview transcripts and reflective surveys, illuminated the core mechanisms underpinning the efficacy of the game-based intervention. Respondents consistently reported that the inclusion of game-related features intensified their intrinsic motivation and sustained engagement, attributing these outcomes to the presence of incremental achievement markers, tangible evidences of progress, and an enhanced sense of collective affinity among peers (Peterson, 2016). Concurrently, the incorporation of tasks situated within contextually rich cultural and communicative domains bolstered learners' linguistic competencies and intercultural understanding by immersing them in meaningful, goal-oriented interactions that approximated authentic target-language milieus (Plass et al., 2015). The emergent learning community, fostered through the gamified paradigm, engendered a climate of reciprocal encouragement, iterative peer evaluation, and collaborative scaffolding, thereby mitigating performance-related apprehensions and reinforcing participants' confidence in employing the target language (Reinders, Wattana, 2015). Equally salient, the intervention's modular and adaptive structure granted learners considerable autonomy, allowing them to progress at a pace suited to their individual aptitudes, concentrate on personalized linguistic aims, and benefit from prompt, finely tuned feedback aligned with their evolving skill sets (Reinhardt, 2019).

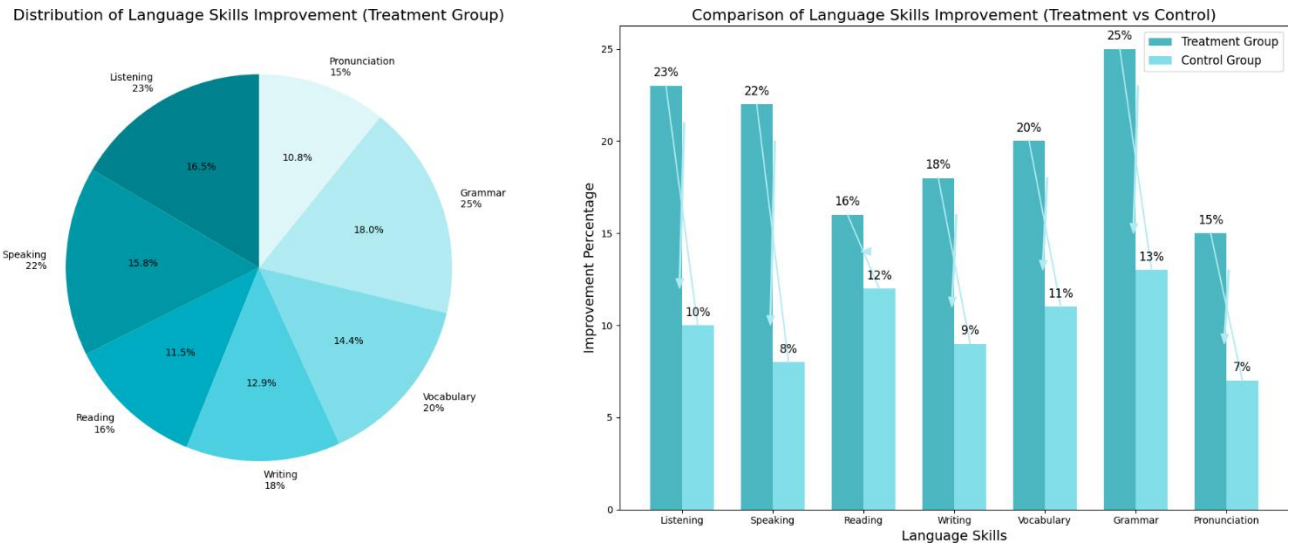

Fig. 3. Language Skills Improvement in Treatment Group

The integration of quantitative and qualitative evidence offers a robust and multifaceted perspective on the efficacy and operative dynamics of game-based methodologies in RFL contexts. By drawing upon diverse data sources and analytical frameworks, this convergence of findings lends credibility and trustworthiness to the conclusions reached. The results consistently underscore the favorable influence of the gamified intervention on language proficiency, motivational states, engagement levels, and participants' subjective satisfaction and perceived gains.

To elucidate the developmental trajectories and relative advantages of the game-based approach, a series of repeated measures ANOVAs were performed. Table 8 details significant main effects of time across all language proficiency indicators ($p < .001$), demonstrating that both experimental and control cohorts enhanced their linguistic competencies during the intervention period. However, the critical finding resides in the significant time × group interaction effects ($p < .01$). These interactions indicate that the experimental group's performance gains outpaced those of the control group, with the former exhibiting more pronounced improvement slopes and elevated post-test outcomes. Such results align with existing research on the accelerated acquisition trajectories associated with gamification (Tsai, Tsai, 2018).

Table 8. Repeated Measures ANOVA Results for Language Proficiency Measures

Effect	F	df	p	Partial η^2
Listening Proficiency				
Time	68.42**	1, 58	< .001	.54
Time × Group	14.95**	1, 58	< .001	.21
Speaking Proficiency				
Time	59.37**	1, 58	< .001	.51
Time × Group	12.08**	1, 58	< .01	.17
Reading Proficiency				
Time	48.26**	1, 58	< .001	.45
Time × Group	8.93**	1, 58	< .01	.13
Writing Proficiency				
Time	53.81**	1, 58	< .001	.48
Time × Group	10.65**	1, 58	< .01	.16

Notes: **p < .01.

A detailed comparison of how the game-based approach influenced different language skills and varying levels of proficiency uncovered several notable patterns. As shown in Figure 1, there was a significant interaction effect between the group assignment and specific skill areas. The participants who received the gamified intervention outperformed the control group most substantially in listening and speaking, followed by writing and then reading. This outcome aligns with previous research suggesting that aural comprehension and oral production often pose particular challenges in traditional language classrooms (Acquah & Katz, 2020). It appears that the applied methodology effectively addressed these difficulties, providing learners with more engaging and supportive avenues for developing these skills.

The analysis of the intervention's results across proficiency levels ranging from A1 to C1 (CEFR) revealed a similarly positive trend. As illustrated in Figure 2, the learners exposed to the game-based program achieved stronger gains at every stage of language development. This finding underscores the adaptability and scalability of the approach – its benefits were evident regardless of the learners' starting points. In practical terms, this suggests that the methodology can be readily calibrated to suit a wide range of learner profiles and developmental stages, thereby extending its potential utility across the entire spectrum of language acquisition (Chen et al., 2018).

4. Discussion

The present study's integrated, multi-level analyses, encompassing both quantitative metrics and qualitative narratives, yielded a nuanced and comprehensive portrait of the game-based intervention's efficacy in RFL instruction. Participants exposed to the gamified methodology demonstrated significantly superior performance on all assessed language outcomes, with effect sizes ranging from d = 0.85 (reading) to d = 1.19 (listening), as summarized in Table 2. These substantial gains corroborate earlier research findings attesting to the pedagogical benefits of game-enhanced language learning (Hung et al., 2018; Peterson, 2016; Reinhardt, 2019). Hierarchical regression analyses (Table 5) revealed that group assignment (β = .48, $p < .01$), motivation (β = .32, $p < .01$), and engagement (β = .29, $p < .01$) accounted for 44 % of the variance in overall language proficiency, thereby confirming the theoretical tenets of Self-Determination Theory (Chen, Yang, 2013) and Flow Theory (Hung et al., 2018; Lester et al., 2014). This constellation of findings suggests that the gamified approach's effectiveness arises, in no small part, from its capacity to elevate affective factors integral to sustained language acquisition. Qualitative insights further reinforce this interpretation, as participants attributed intensified motivation and engagement to transparent progress indicators, game-like incentives, and visible peer comparisons (e.g., points, badges, leaderboards) (Peterson, 2016; Thorne et al., 2012).

MANCOVA tests (Table 6) revealed significant multivariate effects associated with group assignment (Wilks' λ = .68, $F(4, 53) = 6.29$, $p < .001$, partial η^2 = .32) and prior RFL exposure (Wilks' λ = .81, $F(4, 53) = 3.12$, $p < .05$, partial η^2 = .19), indicating that the game-based intervention's influence varied systematically across distinct language skills. The most pronounced improvements emerged in listening ($F(1, 56) = 18.79$, $p<.001$, partial η^2 = .25) and speaking ($F(1, 56) = 15.46$, $p < .001$, partial η^2 = .22), followed by writing ($F(1, 56) = 12.37$, $p<.01$, partial η^2 = .18) and reading ($F(1, 56) = 9.84$, $p < .01$, partial η^2 = .15). This hierarchy of gains suggests that gamification may particularly strengthen aural comprehension and oral fluency – skill areas often perceived as challenging in conventional classroom contexts (Acquah, Katz, 2020). Repeated measures ANOVAs (Table 8) further substantiated these patterns, identifying significant time × group interactions ($p < .01$) and steeper learning trajectories within the experimental cohort. In essence, the intervention not only accelerated the pace of language acquisition but also narrowed proficiency gaps that might otherwise persist among learners with diverse linguistic backgrounds (Tsai, Tsai, 2018).

Subgroup analyses aligned with CEFR benchmarks (A1–C1) consistently indicated pronounced benefits of the gamified approach at all proficiencies (Figure 2). Treatment participants exhibited an average net gain of 20.3 points in overall language proficiency, as opposed to the control group's 9.7-point increase, confirming the method's adaptability and scalability across the learning continuum (Chen et al., 2018). The qualitative data offered critical insights into the underlying mechanisms of this efficacy. Participants portrayed the gamified setting as intrinsically motivating and socially integrative, underscored by incremental achievements, transparent progression pathways, and communal engagement (Peterson, 2016). They further emphasized how context-rich, authentic communicative tasks fostered cultural awareness and pragmatic competence (Plass et al., 2015), while the supportive and cooperative environment mitigated anxiety and heightened learners' self-assurance in producing the target language (Reinders, Wattana, 2015). The modular, flexible architecture of the intervention facilitated ongoing personalization, allowing participants to focus on their individual goals and receive bespoke feedback attuned to their evolving capacities (Reinhardt, 2019).

The convergence of diverse data sources and analytical strategies reinforces the robustness, credibility, and interpretive depth of the present conclusions (Thorne et al., 2012). While these findings firmly establish the positive effects of gamification on language proficiency, motivation, and engagement, several caveats merit attention. The relatively limited sample size (N = 60) constrains broad generalization, and the intervention's temporal scope (one semester) may not fully capture long-term retention or maintenance effects. Future inquiries should expand the participant pool and adopt longitudinal designs to ascertain the durability and transferability of these outcomes.

The group of participants in this study, all adults without any prior experience studying Russian, inevitably brings up questions about whether certain characteristics – such as age, educational background, or prior familiarity with other foreign languages – might influence how effectively a game-based approach can improve learning. It remains an open question if older

learners or those with a history of studying related languages would respond similarly. Future investigations could probe these differences more directly, testing the adaptability of the approach across various learner profiles and environments. A further consideration lies in the fact that this research relied, to some degree, on self-reported measures for assessing motivation and engagement. While these accounts offered useful initial insights, they may have carried a risk of personal bias or influenced responses. Upcoming studies might incorporate more objective tools – such as detailed behavioral analytics or physiological tracking methods – to gain a richer, more accurate understanding of the factors guiding student involvement and long-term persistence.

Additionally, the study did not attempt to isolate the effect of individual elements within the game-based model. Because the approach combined several interconnected features – including structured challenges, interactive feedback loops, and opportunities for collaboration – it remains unclear which specific components drove the most significant gains. Future work might dissect these factors one by one, enabling educators to pinpoint which aspects are genuinely most effective and thus refine the overall design for even greater impact.

Despite these considerations, the findings here strongly suggest that a thoughtfully implemented game-driven strategy can substantially enhance both linguistic progress and sustained interest in learning Russian as a foreign language. The participants who engaged with the game-based materials showed clear improvements in core communicative skills, while also expressing higher levels of enthusiasm and willingness to continue their studies. This positive outcome underscores the potential of this approach not merely as a novelty, but as a durable, adaptable method suited to a wide range of educational contexts.

5. Conclusion

This research demonstrates that a carefully structured game-based approach can make a tangible difference in how learners acquire and refine their Russian language skills. Participants exposed to these interactive methods showed clear gains not only in listening, reading, and writing, but also in the more elusive realms of speaking and understanding spoken language. Beyond improved test results, learners described a heightened sense of accomplishment, a more confident engagement with the material, and stronger connections with their peers. They also indicated that tasks felt more meaningful, reflecting real-life situations rather than abstract exercises. Such consistent progress across various levels of proficiency suggests that this model can adapt to a wide range of learners' needs, transforming the classroom into a more dynamic, supportive, and encouraging environment. In sum, the findings point toward a promising avenue for enriching language education with techniques that capture learners' interest and sustain their commitment over time.

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How Students Develop Creative Skills and Critical Thinking with ChatGPT: Experimental Results

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Abstract

Mass access to AI-technologies like ChatGPT or other AI-assisted tools has significantly expanded the student's ability to search for and process vast amounts of information during the education process. Student use AI-generated texts to develop projects in the human sciences. It seems that application of synthetic content into student work is inevitable. This paper aims to study development of students' critical thinking and creative skills with application of ChatGPT. Haphazard delegation of the initiative to AI-based chatbots directly affects the development of these skills. To evaluate these effects an experimental approach has been applied. Sixteen students have participated in the experiment. There were two groups. Each group prepared weekly materials on a predetermined topic. The experimental group could use only AI-based chatbots. The control group could use any other resources, except chatbots. Students had written an initial essay and final abstracts for the conference. After the experiment, students provided feedback about working with AI. The results showed that critical thinking parameters and creative skills have been comparatively underdeveloped in the experimental group.

Keywords: AI, media literacy, critical thinking, creative skill, higher education, ChatGPT, international relations, political science, political communication.

1. Introduction

The number of sophisticated technologies that mankind uses to improve its standard of living grows rapidly. Explosive technological growth provokes public discussion about the place of technologies in our future. How could new instruments change our daily lives and social structure? What is the place of a human being in new social paradigm? New machines, robotic technology and AI-based virtual bots are firmly in place now. What is the fundamental difference between human and machine activity? Scientists also raise concerns that AI could soon take a leading role in the

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social structure. They call for an active debate about how a human differs from AI and how to integrate it into everyday life (Van Quaquebeke, Gerpott, 2023).

All of these issues are related to the educational process (Bykov, Medvedeva, 2024). It is especially important to know what skills should be in demand for development of the next generations and who will integrate innovations into their daily lives. AI-based programmes are able to perform algorithmic tasks much faster than humans. AI-technologies are convenient for a number of manufacturing tasks. This is why AI-based technologies are already finding applications in a variety of human endeavours. This situation inevitably leads to the use of human resources' reconsideration in different industries. Organisation of warehouses' distribution systems and development of unmanned transport could be a good illustration. If robotic technologies can handle algorithmic activities better than humans typically do, then what should be the direction of human endeavour? For example, Ray notes that ChatGPT's IQ, based on various tests, ranges from 147 to 150 points, which is a very high figure. A language model can pass a number of tests and even pass some exams (Ray, 2023: 134).

Corresponding examples can also be found in social and humanitarian spheres. In 2023, there were attempts to replace news anchors with deepfakes (Deepfake..., 2023). The potential of using AI is already being used quite boldly. The lack of clear legislative framework and control mechanisms also contribute to the use of AI-technologies in virtual communication. For example, characters generated by artificial intelligence could easily enter social virtual space. A human could distinguish a fake from a real person now. But it is quite possible that in the future a real person on the video will be practically indistinguishable from a virtual one (Bykov, Medvedeva, 2024). A flow of events and facts around modern man is currently so huge that it is impossible to control it. That is why development of critical thinking, an ability to verify information and to assess critically surrounding events are becoming a necessary part of social life (Abrami et al., 2015; Darwin et al., 2023; Essien et al., 2024; Hejres, 2022; Nassar, 2019; Spector, Ma, 2019). Educational projects which chatbots partially replacing teachers are under development. Some studies also indicate effectiveness of utilising technologies in educational activities (Bykov et al., 2019; Faqih, 2023; Gui, Lee, 2023; Walter, 2024; Yi, 2024).

The penetration of AI technologies into social processes is already deep enough to start testing the limits to what extent it is possible to use AI without human control. Spheres with active interpersonal interaction are particularly vulnerable in this regard. One of such areas is education. Educational activities imply not only training of technical skills to wield various researches or using production tools but also learning how to critically and creatively perceive reality and making sense of it. Development of critical perception is an integral part of an educational process. Perhaps, an ability to think critically will be the key aspect that will distinguish human activity from that of artificial intelligence. On the other hand, it is equally important to develop students' skills for creative production and original thinking.

Modern studies of critical thinking are based on Bloom's taxonomy. Bloom offered several categories of which critical thinking is composed. Among these categories are "knowledge, comprehension, application, analysis, synthesis, and evaluation" (Bloom et al., 1956). These categories include subcategories, clarifying basic ones. Also, subcategories are ranged from more concrete to more abstract. Thus, "knowledge" includes knowledge of facts, terminology, trends, classifications, methodology, theories, structures, etc. Nevertheless, this subcategory implies only the existence of knowledge as a fact. The "comprehension" section includes abilities interpretation and extrapolation, among others. "Analysis" implies an ability to analyse relations, elements, and principles. Category "synthesis" is the most interesting in terms of current research and includes an ability to produce new knowledge and make a conclusion (Bloom et al., 1956). In an overview on Bloom's taxonomy, Krathwohl relabels "synthesis" into "creativity" (Krathwohl, 2002). Also, the comprehension of critical thinking could have a structure of five stages: "absolute beginner (novice), advanced beginner (beginner), competent performer (competent), proficient performer (proficient), and intuitive expert (expert)" (Spector, Ma, 2019). A meta-analysis taken in 2015 shows that critical thinking should be viewed as a set of skills rather than a separate monolithic skill (Abrami et al., 2015). Recent studies also show that scientists have begun to consider not only understanding and strict adherence to methodology but also questioning skills and healthy scepticism as part of their analysis of critical thinking (Darwin et al., 2023).

The proposed classification allows quite clearly to define skills that a student should have after graduation. Nevertheless, we modified the classification and adapted it to our specific task.

According to Bloom's taxonomy, the main part is devoted to direct knowledge work: accumulation, memorization, searching for regularities, producing results. Almost all of these skills could be already detected in materials produced by AI-powered programms. In this study, focus also was on creativity. Some aspects of critical thinking are already implicated into AI-powered programs because they are well-structured and rational enough for a computer program. However, creativity implies an irrational approach that is still a mystery to scientists. Its integration into AI-powered programs has not yet happened. Therefore, we were also interested in comparing the aspects of critical thinking and creativity development in students who used AI programs and standard learning resources. To determine the level of creativity, we appealed to Guilford's classification (Guilford, 1973).

This paper aims to study development of students' critical thinking and creative skills with application of ChatGPT. We intend to explore whether a student can produce new knowledge only by accumulating what already exists. In this study we did not analyse students' progress on the basis of all five stages of critical thinking. The aim was to test whether there would be any changes at all. That is why the purpose of the experiment was to observe the changes of undergraduate students' critical thinking and creative skills when they use an AI-based chatbot as their only information source. We decided to conduct an experiment to understand how artificial intelligence technologies can be utilised in educational activities without guidance from the university's instructor.

2. Materials and methods

The method applied in this study belongs to the group of qualitative research methods. Qualitative methods typically involve smaller sample sizes and focus on depth rather than breadth. Researchers collect data through various techniques, including interviews, focus groups, observations, experiments, and content analysis. These methods allow for a more nuanced understanding of participants' perspectives, capturing the complexity of their experiences.

The experiment was conducted for ten weeks from February to May of 2024. The undergraduate students of the Moscow State University majoring in international relations participated in the experiment. In the experiment took part students of the second and third years. All students of the second and third year participated in the experiment. Since the experiment took quite a long time and required regularity in checking homework completion and participants' voluntary consent to publish the results, only 16 students gave their consent to publish the results. Results obtained on a larger volume correlate with results presented in the paper. Students of the course are divided into equal groups. Groups are formed in the first year and do not change during the whole period of the bachelor's program. Group formation is initially influenced by language level. The number of students in the group did not change during the selected semester. For the experiment, within their groups, the students were divided into two parts. Students had equal language level within each group. The language level of the students whose results were published was equal. Language level had no significant effect on the experiment results.

The control group did their hometasks using all available "traditional" sources, i.e. printed books, online resources, classmates' or friends' knowledge, social media channels, search engines, electronic dictionaries, paper dictionaries, etc. The experimental group could use only AI-powered chatbots to prepare their tasks. Students could use any publicly available chatbots. It was also allowed to use multiple AI-based resources at the same time. Students independently chose a way to accomplish a task during semester. Under conditions of the experiment students were required to submit their homework to a lecturer every week without skipping. An entrance and a final essay were required to participate in the experiment. If a student missed at least one task, he/she was excluded from the experiment. Once a method of completing an assignment ("AI" or "traditional") was selected during the semester, that method could not be changed. The course was taught in English. The program focuses on communicative aspect of international relations. The program includes modules on "propaganda", "information warfare", "climate change", "culture", "soft power", "interest groups and lobbying".

The research was conducted in three stages: 1) writing the entrance essay, 2) submitting tasks on given topics, 3) writing the final text in conference abstract format. The task of the entrance essay was to assess the students' baseline. For a moment of writing entrance essay was important that students had not been practicing skills being tested for a significant period. The time period of one winter month implies a break in learning activities. From our point of view, that is sufficient to resume the study process with available so-called residual knowledge. Among the requirements for

essay's structure were the next: 1) to formulate a problem; 2) to provide an introduction to the problem; 3) to express one's thoughts about the problem (to supplement the background knowledge with one's own thoughts). The first part allowed us evaluate the clarity in problem statement. The second part revealed student's general background knowledge. At last, the third part helped to estimate student's originality of thinking and inference skills expressed through ability to supplement background knowledge with one's own thoughts. There was no limit to the number of words. Nevertheless, it was necessary to keep the structure, which consisted of introduction, main part, conclusion. Essay topics were formulated on the basis of thematic sections to be mastered in the second and third year program. Students had two academic hours for writing the essay. It was not allowed to use auxiliary materials, as well as to communicate with classmates.

The second stage was the longest one. During the second stage, students were asked to complete assignments within the framework of the course program. The assignments had to be written and submitted weekly. Students could submit handwritten version, printed version or send to a lecturer an electronic version. There were two formats for assignments: an essay and a report. The report implied the preparation of a general overview of the topic. There were no limits on the number of lines, paragraphs, graphs, pictures, tables, and other textual and visual material.

The final assignment also had two academic hours to complete. It was not allowed to use auxiliary materials as well. However, it was possible to consult with classmates on any issue. The length of the text was limited to 500 words. The task was to write final texts on the given topics in the format of theses for a conference. One main topic with subtopics was proposed for each group. In each group, the lecturer chose a topic that suited the group. Students could choose subtopics from the proposed ones, or they could formulate their owns. The main requirement was that the subtopic should respond to the main topic. Students had had to cover four structure elements: actuality of the issue, a problem, a research question, and propose a method of solution.

Description of question actuality allows to assess general background knowledge about chosen research subject. Students were introduced to text structure requirements. Lecturers outlined for students that the first section should contain coverage of current situation in selected political sphere. In this part we offered students to write about practical side of a chosen political issue and the possibility of applying research results on the question in practice. We did not ask students to describe current research field or provide any scientific literature review. Final assignment supposed to reveal student's erudition degree, understanding of modern international political processes regularities, an ability to identify points of potential growth in the field of world politics. For problem section, lecturers indicated that it was necessary to identify any tension or contradiction that exists between political actors in the topic under discussion. It could also be a problem in the practical field of international relations, if a solution and work on which is important for the political international sphere. Here we wanted to estimate student's ability to formulate a problem clearly. While formulating the research question, students had to select one aspect of the problem. The aspect should have been formulated as a question. We also expected students to understand what problem the question would address, to hypothesise what the final outcome would be, and what type of result should be obtained.

The part of determining problem solution method was the next one. Here we asked students to consider a possible way of finding an answer to the research question stated in previous section. The course programs did not include a focused study of methodology. Nevertheless, some hometasks contained references to sociological research methods like surveys and quantitative data analysis. We introduced this section to assess students' originality of thinking, resourcefulness, and inventiveness. Our goal here was to leave room for imagination, assumptions, and searching for possible problem solutions.

Thus, the experiment was designed to note changes in four parameters: erudition, problem statement, original thinking, inference skills. The first parameter is "erudition". In terms of Bloom's taxonomy (Bloom et al., 1956), it corresponds to the "knowledge" category. The second parameter is the ability to define and articulate the research question and/or a problem. This parameter is consistent with "comprehension". The third parameter is originality of thinking. This parameter determines the ability to highlight non-obvious and not often mentioned and discussed environmental interrelationships and to approach the issue unconventionally. "Original thinking" represents part of the "analysis" category. The fourth parameter refers to student's ability to make an inference based on information presented in his/her text. Also it refers to an ability to add something new to already existing knowledge, i.e. to assume existence of new trends, patterns,

facts, phenomena. Finaly, it reveals capacity to propose further directions for research. This is an ability to analyse and evaluate information as an independent and objective researcher (corresponds with an ability to draw conclusions). The last parameter corresponds to “evaluation” and “sinthesys”.

We measured required parameters by entrance and final essays. The evaluation was based on a point system. A score of zero (0) indicates that the measured parameter was not detected at all. For “erudition” parameter we gave zero (0) points for demonstration of complete absence of knowledge on the topic. In section “problem statement” zero (0) points appeared in cases of 1) unclear problem statement, 2) too broad/general problem statement. In “original thinking” zero (0) points went to a student for poor or absent ability to summarize information and evaluate it. In “inference skills” column zero (0) points appeared when a student could not demonstrate skills in relevant data compilation and reaching final verdict on the topic.

If it was possible to detect the parameter but it was described only in general or was a recitation of common knowledge, half a point (0,5) was awarded. One (1) point indicates that the parameter is easily defined in the text. It is represented by description or/and considerations, or formulated as a concrete phrase or a sentence. If we identified the parameter as one at the basic level and then it was improved, another half-point (0,5) or one (1) point were added to the initial score. If the parameter has not been changed, the same score is given as at the initial stage. Thus, if a student initially showed a high score and his/her performance did not change, the “start” and “final” columns would have had the same score.

Although the course was conducted in English and also included English grammar, vocabulary development, and speaking skills, changes in language proficiency were not taken into account. This was done for two reasons. The first was that this is a different and more algorithmic type of work. The way the results were measured and the way the study was organised were not suitable for studying language proficiency improvement. The work did not include practicing the exercises and lexical part. In case we wanted to evaluate this aspect in addition to critical thinking and creativity the final task would also require modifications and inclusion of a test part. The second reason, however, was mandatory implementation of the basic program for second and third year students. The main condition of the experiment was absence of a feedback and supervisors' non-interference with homework assignments. It was not so easy to organise, as soon as weekly classes implied mandatory discussion of course topics to some extent. We took that into account in designing the experiment and in planning classes. During offline classes lecturers had been paying attention on learning English, while semantic part of the course was done by the students at home.

3. Discussion

The influence of artificial intelligence on the development of critical thinking and the possibility of AI becoming better than humans in critical thinking have long been of interest to scientists (Fedorov, Levitskaya, 2017). Scientists argue that artificial intelligence cannot surpass and therefore replace human intelligence for several reasons. Firstly, there are spheres where the presence of a human cannot be replaced. As an example, the author cites the field of sales. The programme is unable to persuade a person to buy something because the strict algorithm of questions does not meet the liveliness and instant changes in the human mind and emotional state. Difficulties also arise when it is necessary for the AI to update the current knowledge base (Nassar, 2019). The observation that AI needs to update the database in order to adequately respond to newly arriving challenges is noteworthy. From this point of view, we look at AI as a tool that is no different from an ordinary archive or a standard database. Such a viewpoint is quite relevant. Now, with the rapid increase in the number of AI-based tools, society is divided on how to perceive new technologies. Should technologies that utilize AI-based software be considered as part of social relationships? If so, then we automatically assume that AI is a superior force to humans, if only because of its speed of response. If we perceive AI as a tool, the question of its subjectivity cannot arise. However, it is quite possible that a discussion on this topic will lead to a discussion of a fundamentally new paradigm of social relations.

Some studies show that the implementation of AI in the learning process can be beneficial. For example, implementing AI as a tool for self-directed learning and using AI can improve students' speaking skills as well as relieve anxiety before a presentation (Hapsari, Wu, 2022). An experiment conducted in 2023 for students enrolled in a chemistry course showed that students

who used ChatGPT more often than others showed less imbedded abilities to understand theoretical concepts and to draw logical conclusions. The researchers conclude that over-reliance on ChatGPT may lead to passive consumption of information instead of developing critical thinking (Gou, Lee, 2023). Nevertheless, the use of AI-based tools can help students with different educational, cultural, and personal backgrounds adapt to the learning process. Nevertheless, the limits of AI technology must be considered (Walter, 2024). The problem of individual differences in students is also pointed out by Spector (Spector, Ma, 2019). The researcher emphasizes that AI can help to customize the educational environment and create a more comfortable educational environment.

Discussions about individualization of education are noteworthy. At the moment, there is not enough data to understand how exactly the educational process of the future will be organized. At the moment, the use of AI in the educational process is rather chaotic, unstructured, and unregulated. This can be partly explained by the overall changes that are taking place in the technological and societal environment too fast for society to adapt to these changes. Also, research in this area at the moment may take a relatively short period of time to see a clear enough trend. The point is that the implementation of a new tool may be based on old ideas of what the educational process should look like. A similar example could be seen during the 2020 pandemic. This is the year when most organizations in the world, including educational organizations, shifted to remote working and learning. And, despite the availability of the most modern means of communication and virtual interaction, as well as the existence of meta-universes that provide virtual infrastructure for the most complex interaction, there was no educational and communicative breakthrough.

Interestingly, some authors point out that AI technologies can help with routine automated tasks, while, for example, educational managers and teachers can focus on more creative tasks and working with students (Fullan, 2023). In general, it can be noted that most scientists agree that AI technologies can significantly improve the automatic part of human activity. But until now, a number of professions have been tied to conveyorized, algorithmic activities. There is a growing debate about what the advantage of humans over AI is. This is why a number of scientists have come to the conclusion that it is so necessary to actualize and explore ideas about what critical and creative thinking, leadership skills, and an individual's view of the world are. Researchers also caution against handing over the management initiative and instructional leading to AI (Hejres, 2022). Some studies emphasize the need for intelligent implementation of AI in the classroom as a launching pad for students to find ideas that can be developed and questioned (Yi, 2024).

As for the experiment method as a form of conducting research in society, it is also actively used by researchers. As a rule, such studies are complex and include several different methodologies. It is effective to use both qualitative and quantitative methods in educational experimentation. Research methods include surveys as a quantitative-qualitative method, students' independent work in selected courses, and open-ended questions and interview methods. It is indicated that it is effective to use open-ended questions in surveys. This provokes subjects to share thoughts and insights (Essien et al., 2024). Among the methods noted is the usefulness of interviewing students, as it helps to contextualize the results of the survey through personal experience (Faqih, 2024).

The study has limitations. First, it is worth noting the difficulties in forming the sample. We didn't have the opportunity to sample students in a probabilistic way. Participation in the experiment was voluntary for both students and lecturers. Therefore, we can only publish some of students' results who gave consent to process and publish the outcomes. Also, we have tested our hypothesis only among students of one faculty and one field of study, i.e. "international relations". These aspects limit a possibility to generalize the results of the study. Limitation of the study also lies in the fact that the results section does not use statistical analysis methods. Although they are seen as redundant in our current study, development of the topic will allow inclusion of complex statistical methods in a research design to improve the accuracy of obtained results.

It is also worth noting the approach to working directly with AI in ongoing research. As a rule, it is one resource and one specific model, for example, ChatGPT4. Or it may be a particular mode, e.g., a conversation mode with the AI. In this study, the students did not have any predetermined AI model that all students had to use. The study was not intended to focus on a particular resource but on the mode of information as such. For this reason, students were asked to choose the resource they would use and were allowed to use more than one resource. The study used a point system to identify progress or regression in students. No separate interview was conducted. But the

students were asked to write a post-course paper in which they could give a free-form summary of their thoughts on the usability of artificial intelligence.

4. Results

Sixteen people participated in the study. Eight people used AI; eight people used any other resources for homework. All data were anonymized for the study. The table shows the results of the comparison of initial and final parameters. Significant changes in the demonstrated results are highlighted in dark green. Insignificant changes (indicators decreased or increased within half a point) are highlighted in pale green and orange. Significant deterioration of indicators is highlighted in red. Of the 16, only two students kept scores unchanged. Both students used traditional resources to complete their homework. As to the remaining 14 students, the parameters have been changed.

Table 1. Comparison of students' results on the characteristics of critical thinking (N = 16)

Students	Resource type	Erudition		Problem statement		Original thinking		Inference skills	
		Start	Final	Start	Final	Start	Final	Start	Final
Student 1	AI	0,5	0	1	1	0,5	0,5	0,5	0,5
Student 2	AI	0,5	1,5	1	0	1	1	0,5	1
Student 3	AI	0,5	1	0,5	1	0	0,5	0,5	0,5
Student 4	AI	0,5	0,5	0	0	1	0	1	0
Student 5	AI	0,5	0,5	1	1	0	0	0	0,5
Student 6	AI	1	1	1	0,5	1	0	0	0
Student 7	AI	1	1	1	1	0	0,5	0	0
Student 8	AI	0,5	0	0,5	1	0	0	0,5	1
Student 9	other sources	0,5	0,5	0	1	0	1	0	1
Student 10	other sources	1	1	1	0,5	0,5	1,5	0	1
Student 11	other sources	0,5	1,5	1	1	1	1	0,5	0
Student 12	other sources	1	1	1	1	0,5	0,5	0,5	1
Student 13	other sources	1	1	1	1	1	1	1	1
Student 14	other sources	1	1	1	1	1	1	1	1
Student 15	other sources	1	0	1	1	0,5	0,5	0	1
Student 16	other sources	0,5	0	0,5	1	0,5	0,5	0	0

Source: compiled by authors

Thus, the first parameter, 'erudition', showed virtually no change in both groups. Significant improvements by one person in each group were compensated by minor improvements and deteriorations, as well as one significant deterioration in the group that worked with traditional sources. The problem statement parameter showed some improvement in the group that used conventional resources and a slight deterioration in the group that used AI. Significant improvement occurred in the group using traditional resources on the "original thinking" parameter, as opposed to the group using AI.

It is worth noting that the most significant improvement occurred in the 'inference skills' parameter in the group that used conventional sources. Here the results are practically not levelled by a slight deterioration. While in the second group this parameter has not changed practically, there are three insignificant improvements within the possible error and one significant deterioration.

It should be noted that the assignments were completed within the framework of the course. That is, the goals set in the course – improvement of the parameter's "erudition", "problem statement", "original thinking", and "inference skills" – were achieved to some extent. However, homework was the main part of students' work. The working programme allocates the largest number of hours for independent work. The results of the study showed that using only chatbots based on artificial intelligence as a source without feedback from the teacher does not improve these indicators. On the contrary, the use of any other alternative sources, even without feedback from the instructor, allows to achieve a significant improvement of these parameters in students.

In addition to this analysis we assessed also flexibility, fluency, elaboration, tolerance of ambiguity, breadth of interest, sensitivity, independence, and reflection. These parameters were identified by J. Guilford as characteristics of creative adults (Guilford, 1973). Guilford identified 15 characteristics of creativity. We nevertheless included in the analysis only 8 parameters that could be identified in the written text.

Table 2. Comparison of students' results on the characteristics of creativity (N = 16)

Students	Resource type	Flexibility		Fluency		Elaboration		Tolerance of ambiguity		Breadth of interest		Sensitivity		Independence		Reflection	
		Start	Final	Start	Final	Start	Final	Start	Final	Start	Final	Start	Final	Start	Final	Start	Final
Student 1	AI	0	0	0,5	1	0,5	0,5	0	0	0	0	0,5	0,5	0,5	0,5	0,5	0,5
Student 2	AI	1	0,5	0,5	1	0	1	0	0	0,5	0,5	0,5	1	1	1	0,5	1
Student 3	AI	0,5	0,5	0	0,5	0	0	0	0	0	0	0,5	0,5	0,5	0,5	0,5	0,5
Student 4	AI	1	0,5	1	1	0,5	1	1	1	1	1	1	1	1	1	1	1
Student 5	AI	0	0	0,5	0	0	0	0	0,5	0	0	0,5	0,5	0,5	0	0	0,5
Student 6	AI	0,5	1	0	1	0,5	1	0	0,5	0,5	1	0,5	1	0,5	1	0,5	1
Student 7	AI	0	0,5	0,5	1	0,5	1	0,5	1	0	0,5	0,5	1	0,5	0,5	0,5	1
Student 8	AI	0	0	0,5	0,5	0,5	0,5	0	0	0	0	0,5	0,5	0	0	0,5	0,5
Student 9	other sources	0	0,5	0,5	0,5	0,5	1	0	0	0,5	1	0,5	1	0	0,5	0,5	0,5
Student 10	other sources	0.5	0,5	0	0,5	0	0,5	0	0	0,5	1	0,5	0,5	0,5	0,5	0,5	0,5
Student 11	other sources	0,5	0,5	0	1	0	0,5	0	0	0,5	0,5	0,5	1	0,5	1	0,5	0,5
Student 12	other sources	0,5	0,5	1	1	1	1	0	0	0,5	1	1	1	1	1	1	0
Student 13	other sources	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Student 14	other sources	1	1	1	0,5	1	0,5	1	0	1	0,5	1	1	1	1	1	1
Student 15	other sources	0	0	0,5	0,5	0,5	0,5	0	0	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Student 16	other sources	0	0	0,5	0,5	0,5	0,5	0	0	0,5	0	0	0	0	0	0,5	0,5

Source: compiled by authors

The results of creativity parameters analysis show average progress for the majority of students. At the same time, three students showed significant progress in fluency and elaboration. Two of them used AI. Two students who used alternative sources showed regression in the parameters of tolerance of ambiguity and reflection. In general, more progress can be seen in the students who used AI.

In the course of the study, students were told that assignments could be done both in written and printed form. It was not necessary to print out the work; it could be sent electronically. However, only a few papers were handwritten. All others were submitted to the teacher in printed form or sent by mail. It should also be noted that the volume of papers was approximately the same for all students and varied from three to five pages. At the same time, all papers were well structured.

5. Conclusion

There were three important aspects to this study. Firstly, the experiment excluded feedback from the supervisor, which was the teacher, because it was necessary to find out whether it was possible for a student to develop critical thinking skills only through information gathering through available sources, guided only by the framework of topics, without feedback from the supervisor. Secondly, the experiment did not involve practicing standard actions with a given algorithm, such as practicing the use of grammatical constructions or new words when learning a language. The point of the tasks was to collect all the information that could be found on the topic – in the same way the task was set for the students – and to check whether this action without feedback was enough for the student to produce new knowledge only on the basis of the received information. Third, in the behavioural experiment, AI-based chatbots were used as next-generation search engines. Many experiments in the field focus on the formulation of problems, followed by the correction of questions to the chatbots, taking into account recommendations from the AI itself or from teachers. In this case, explanatory feedback was excluded. The work on correcting the prompts, checking the literacy of the received material, and correcting and directing their own knowledge depended only on the student.

The analysis of such parameters as erudition, problem statement, original thinking, inference skills refers to Bloom's taxonomy helping to assess the development of critical thinking skills. In this aspect, the experiment results' show that the use of AI reduces students' critical thinking abilities. In particular, problem statement ability, original thinking and inferense skills regress. While the students who used alternative sources significantly increased these same indicators. At the same time, the erudition index is higher in students who used AI.

The assessment of characteristics of creative adults shows an interesting picture. Students who used AI showed progress in several parameters: fluency, elaboration, tolerance of ambiguity, breadth of interest, sensitivity, reflection. According to Guilford's explanations, these parameters indicate students' erudition. Fluency and elaboration refer to the ability to find different possible solutions to a problem and to work out the details of these solutions. Breadth of interest and tolerance of ambiguity refer to interest in abstract ideas and the ability to combine different details of these ideas without contradiction. Sensitivity helps to detect problematic aspects. Whereas

reflection is the skill of seeing the full picture of an issue under study. It is likely that using AI tools to work through a topic helps to broaden the student's horizon and draw attention to aspects that for some reason may not be known or may not be the focus of students' attention. Arguably, AI offers a set of viewpoints that has a lot of variation. This raises the possibility of seeing aspects that were somehow out of focus. This aspect can be compared to what is called forethought capability.

A comparison of the results for the critical and creative thinking skills assessment showed that student student 6 showed stable growth, student 13 showed stable results, with student 14 showing significant regression of the result. This regression can be explained by the nature of the final assignment. Unlike the starting essay, the final assignment was more formalized and could provide less space for creativity. However, student 13 even demonstrated high skills in the sense of humor parameter. This item was not included in the analysis because the academic texts did not suggest its presence. Nevertheless, student 13 was creative in completing the assignment. He produced a starter essay in the form of a parody of a New York Times-style newspaper article, following the newspaper layout (arrangement of text and hand-drawn graphic elements) and journalistic style of the newspaper.

After finilizing the experiment, we conducted a free-form survey about semester's work. It is worth noting that when the experimental format was proposed, not all students were enthusiastic about the possibility of submitting tasks with the help of AI. Many were wary of the assignment. After a couple or three weeks of work, several people asked if they could change groups and work with regular sources. However, it was not possible due the experiment rules.

Students were asked to write short essays to express their thoughts about the semester's activity. The students made some interesting points:

– The information that AI-powered chatbots provide is a very general information. It also often requires additional human verification and fact-checking. Also, the information was often incomplete, and some students indicated that it would be good to supplement it with information from other sources.

– Some topics could not be developed through AI using the original wording. In many chats, there is a technical restriction on keywords like "information warfare", "propaganda", "war", "weapon", and "modern military conflicts". Nevertheless, the course touched on such topics, and, as students noted, this is a major obstacle for international relations professionals.

– The available open-source free chatbots are not good enough to generate pictures and do not produce infographics. Therefore, almost all reports from the group working with AI are made without pictures and illustrations. A few illustrations in the papers were purely decorative in nature.

– Despite the unreliable data provided, chatbots always provide structured information. It usually fits within 100 words. So, some students entered the prompt 'keep writing the previous answer' and got an extra few paragraphs of text. Also, some students used the generated text as a basis and completed some parts of the reports on their own. Also, students used several prompts and assembled a single text from disparate parts.

– Most of the students used many chatbots instead of one.

– It was noted that one of the functions of the AI, which it copes with very well, was very convenient for work: shortening a large text by selecting the main thoughts from it and reducing them to one or two paragraphs. This helped to save time and digest the main thoughts of the text already highlighted by chat.

There was also a comment in which the student said that he tried to use a chatbot in everyday life for communication, advice, and obtaining an additional opinion. However, such use "looked very silly", so the student noted that he actively used the chatbot only for homework.

In conclusion, further research is required in this field. The problems of creative skills and critical thinking need to be studied with application of statistical analysis in order to get general results. Further studies should use statistical analysis methods to improve the reliability of the results obtained. Also, there is a need for longitudinal studies to verify the effects of AI on society.

However, we hope that our experiment contributes to the discussion. It is clear that nature of AI requires deeper understanding in the psychological characteristics of the participants, their emotional condition during the semester, predisposition to writing certain formats of texts, relationships in the team, motivation to take part in the research. AI is increasingly changing social reality. It seems relevant to study the impact of this technology on the educational process, because it is the educational sphere that determines what the society of the future will be like.

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Design and Implementation of a Chronological Procedure for Solving Engineering Application Problems

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Abstract

Problem-based learning (PBL) is a technique used in the engineering field to enhance meaningful learning acquisition and competencies. This research focuses on the construction and application of a didactic tool consisting of a series of steps (chronological procedure) implemented to solve application exercises in the Engineering field. A quantitative and descriptive investigation was carried out about applying a procedural chronology based on PBL in chemical and biochemical engineering. The chronological proposal consists of data identification, unknown typification, process diagram development, mathematical expression selection and solution, unit analysis, and result attainment. The tool was implemented in a student population enrolled in initial and intermediate courses in chemical and biochemical engineering. A statistical (quantitative) study was conducted to determine the development of thinking and problem-solving skills to determine the technique's efficiency. Statistical results demonstrate that the proposed chronological procedure is a supportive instrument for PBL methodology. The results indicate that the knowledge and application of the chronological procedure contributed to the development and improvement of practical skills in students.

Keywords: problem-based learning, chemical engineering, binary logistic regression, statistical analysis, chronological procedure.

1. Introduction

Engineering is a field of knowledge that relies on the study and application of scientific, technological, and mathematical learning to design, construct, innovate, or create new processes and products for the benefit of society. During professional academic preparation, learners acquire and refine generic, specific, and technical competencies, which are composed of knowledge, skills,

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attitudes, emotions, values, and social and behavioral abilities, gradually acquired in different contexts and applied in specific situations to address complex problems present in academic activities, promoting personal and professional development (Freire et al., 2013). The teaching-learning process implements various educational strategies for students to achieve the necessary skills and competencies in the engineering area that will allow them to face the challenges that today's society demands; these strategies include collaborative, problem-based, project-based, competency-based learning, etc. (Fernández, Duarte, 2013; Lozano et al., 2017; Kolmos, 2021; Kolmos, Ryberg, 2023).

Problem-based learning (PBL) is a method based on constructivist cognitive psychology that promotes interaction between teachers and students (Jones, 2006; Bodagh et al., 2017). This learning process is student-centered, and the teacher provides guidance and support, promoting autonomous learning, flexibility, creativity, and productivity (Jones, 2006; Lazakidou, Retalis, 2010; Klegeris, Hurren, 2011; Bodagh et al., 2017; Rodríguez, Fernández-Batanero, 2017; Dahl, 2018; Ruiz-Meza et al., 2021). The basis of the PBL approach lies in applying theoretical knowledge to solve practical exercises (real problems), enabling learning through the acquisition of experiences (Luy, 2019; Marcinauskas et al., 2024). This triggers the development of critical thinking, because the student is actively involved in solving a problem based on the integration of his previous multidisciplinary knowledge, proposing answers to some questions posed by the real situation to be solved. The PBL methodology responses to the education challenges, demonstrating efficiency for competencies development, employability, and sustainability (Kolmos, 2021; Kolmos, Ryberg, 2023). The PBL method was proposed by Howard Barrows et al. in the late 1960s for the higher education and applied in the health sciences. Nowdays, the PBL method follows the same basic steps: identify the problem, explore previous knowledge, generate hypotheses and possible mechanisms, identify learning deficiencies, self-learning, reassess and apply new knowledge to the problem, and evaluate and reflect on learning (Bodagh et al., 2017; Walsh, 2005).

The PBL model is an alternative teaching strategy that supports the progressive development of students' thinking skills (Jakni, 2016; Mukhlis et al., 2023; Low et al., 2024). This approach has been successfully implemented at the higher education level in various fields such as medicine, civil engineering, chemical engineering, and pharmacology, among others (Mukhlis et al., 2023; Marcinauskas et al., 2004; Low et al., 2024; Mayasari et al., 2024; Yusof et al., 2012; Gómez-Coma et al., 2023), because the students have the necessary maturity and previous background. Mukhlis et al. (2023) demonstrated that the problem-based learning method application coupled with the STEAM approach contributes significantly to the development of critical thinking skills for problem-solving in the higher-level mathematics area, specifically for solving systems of linear equations with three variables.

Implementing the PBL technique at a higher level of education is a challenge, particularly in the engineering field, where students require complex technical skills. Marcinauskas et al. (2024) applied the PBL method to the subject of physics in an engineering program, concluding that the implementation of the technique improved teamwork, presentation, and critical thinking skills in the field of study, presenting an advantage over traditional learning that encourages the development of individual skills. A similar conclusion was reported by Low et al. (2024) in a study directed at university students. They determined that the PBL method strengthens students' understanding of the subject, leading them to higher levels of thinking on Bloom's taxonomy. Gómez-Coma et al. (2023) implemented the PBL methodology in a chemical engineering course for an industrial engineering master's program, and they reported that students improved their self-learning, organizational and planning, analytical, and teamwork skills, which were reflected in significantly higher evaluation. Dahl (2018) reports the application of PBL strategy in mathematics courses in the engineering field (basic level subjects in the engineering curricula), positioning it as a suitable tool to develop high-level mathematical skills that will be applied to the professional society or research.

The PBL model has been successfully implemented in a few subjects at different levels of chemical engineering, mainly in specialty subjects (Ballesteros et al., 2019; Vega, Navarete, 2019; Yusof et al., 2012). Ballesteros et al. (2019) implemented the PBL methodology for simulation and modeling of unit operations due to the complexity of the subject because of the integration and application of knowledge. They reported that students acquired tools to manage problems in chemical engineering and concluded that the PBL strategy supports the development of tools for transversal learning and understanding of the concept's application. Vega and Navarrete (2019)

used the PBL methodology for designing a chemical plant and acquired adequate results with high degree of satisfaction by the students with the learning obtained.

According to the OECD (Organization for Economic Co-operation and Development), higher education plays a key role in providing society with trained personnel with the tools to innovate. In this sense, Hoidn and Kärkkäinen (2014) conducted a literature review on the effectiveness of the PBL methodology, highlighting that it contributes to the development of competencies for innovation. It has been shown that the PBL methodology implemented at a higher-level increases students' creative thinking skills, as well as their flexibility, originality, and fluency, in addition to improving their adaptation to changing situations (Ersoy, Baser, 2014). The PBL tool can be successfully applied to engineering programs, focusing on the application and integration of knowledge for skill development (Perrenet et al., 2000; Hoidn, Kärkkäinen, 2014).

The PBL methodology is a potential tool for developing competencies in the engineer's training. In the field of Chemical and Biochemical Engineering is crucial to have a thorough understanding and mastery of subjects that involve solving application problems. These subjects promote the development of creative, reflective skills, and the management of essential knowledge needed to excel in both academic and professional settings (Cerato, Gallino, 2013; García, 2014).

According to recent statistical data from the Tecnológico de Estudios Superiores de Ecatepec (TESE), the chemical and biochemical engineering majors have experienced high failure rates of approximately 20 % and 25 %, respectively. These figures place them among the programs with the highest failure rates at the institution, contributing significantly to increased dropout rates. In particular, the average failure rate per semester has reached 40 % during the first four semesters. Chronologically, the highest failure rates are observed within these initial semesters for both programs. During this period, most of the subjects pertain to the physics-mathematics area; therefore, it is imperative to implement strategies that enable students in basic and intermediate-level subjects to acquire the competencies outlined in the educational program.

Considering the above, this research design and apply an instrument entitled “chronological procedure" as an educational tool to implement the PBL strategy in the classroom. The instrument proposes sequential steps to solve application problems in Chemical Engineering and Biochemical Engineering subjects. The strategy was applied to two courses, one at the initial level and another at the intermediate education level.

2. Methods

This study has three objectives: (1) Establish a chronological procedure for solving application problems in the Chemical and Biochemical Engineering; (2) Determine the influence of academic average on the chronological procedure application to solve application problems. (3) Analyzing the cognitive advantages in students after learning and applying the chronological procedure. To determine the influence described in objective 2, initial evaluations were applied and statistically analyzed by applying the binary logistic regression model. The following hypotheses were established: a null hypothesis (Ho) "The academic average held by students is not a factor that influences the identification or execution of the elements that make up the chronological procedure", and an alternative hypothesis (Hi) "The academic average held by students is a factor that influences the identification or execution of the elements that make up the chronological procedure".

2.1. Binary logistic regression (BLR)

Binary logistic regression is used to estimate the probability of an event (p) occurring, and it is characterized by presenting dichotomous response variables (Maroof, 2012). The BLR model is composed of statistical techniques that allow testing hypotheses or causal relationships when the dependent variable is nominal (Todd, Campbell, 2007; Reyes et al., 2007; Vega and Navarre, 2019; Maroof, 2012; Harrell, 2015). The logistic regression model is represented as follows (Reyes et al., 2007; Harrell, 2015):

$$\log\left(\frac{p}{1-p}\right) = b_0 + b_1x_1 + b_2x_2 + \cdots + b_nx_n = b_0 + b_1X$$

The probability estimation calculation of the event occurring is done by considering the assigned value of the independent variables, as follows (Reyes et al., 2007; Harrell, 2015):

$$p = \frac{e^{b_0+b_1*X}}{1+e^{b_0+b_1*X}}$$

where b_0 y b_1 are the regression coefficients. X is the independent variable; in this case of study, it is the academic average of the students. Graphically, the BLR fit generates an S-shaped or

sigmoid curve, which represents the characteristic properties of a cumulative probability distribution function (Reyes et al., 2007; Harrell, 2015).

2.2. Population and Sample of the research

A convenience sampling method was used, where the sample size was calculated the following formula:

$$n = \frac{Z^2 p(1-p)}{E^2}$$

Where n is the required sample size, Z represents the confidence level, p is expected proportion of the population, E is the margin of error. Since the population was small, an adjustment was applied using the following formula:

$$n_{adjusted} = \frac{n}{1 + \frac{n-1}{N}}$$

Where $n_{adjusted}$ is the corrected sample size and N is the population size.

For this work the parameter values were defined as follows: $Z = 1.96$ corresponding to a 95 % confidence level, an error margin of 5 %, with variability of $p = 0.5$.

For Chemical Engineering a corrected sample size of $n_{adjusted} = 43$ students was considered, specifically, students enrolled in the Electricity, Magnetism, and Optic subject (initial or basic level group), from a total population of ≈ 48 students. For Biochemical Engineering a corrected sample size of $n_{adjusted} = 40$ students was considered, specifically, students enrolled in the Programming and Numerical Methods subject (intermediate level group) from a total population of ≈ 45 students.

2.3. Instrument

The instrument developed is based on the constructivist educational model, adopting an approach where the student takes center stage in their own learning process, which transforms learning into an active and meaningful experience, fostering the construction of knowledge.

The chronological procedure was developed based on the knowledge acquired from the experience of ten teachers who applied PBL in the classroom (see Figure 1). The chronology consists of seven stages: 1. Problem Data: In this initial step, students analyze and contextualize the problem; this phase serves as an exploration stage, where the activation of prior knowledge is encouraged, and critical thinking is promoted; 2. Identify the Unknown Variable: Similar to step 1, this is also an exploratory stage where critical thinking begins to take shape; 3. Process Diagram: At this stage, knowledge is organized and structured independently through the use of a visual technique; 4. Formula Selection: This is an active, practice-oriented learning stage that encourages reflection and critical reasoning; 5 and 6. Active Learning Stages: These phases focus on deepening understanding rather than rote memorization; 7. Obtain Results: This final stage allows students to acquire meaningful learning based on the construction of their own knowledge.

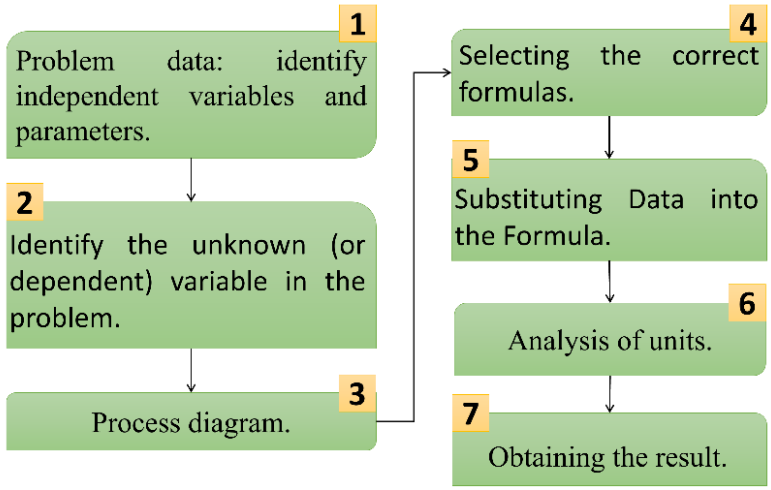

Fig. 1. Chronological procedure's seven steps based on PBL

Questionnaires and a standardized assessment instrument were employed as methods for data collection to evaluate students' knowledge and skills. The data were managed in accordance with the privacy policy of the Tecnológico de Estudios Superiores de Ecatepec. Furthermore,

the instruments used did not require personal data. Identification numbers were assigned to protect the identity of the study participants and ensure confidentiality.

Following this, the assessment instrument was designed to evaluate general knowledge in the Physics field, which is acquired in the Physics subjects (for Biochemical Engineering) and Classical Mechanics (for Chemical Engineering). The assessment instrument implements the PBL method with an application problem, which its solution requires the chronological procedure application. Subsequently, the instrument was applied to the control group for statistical validation. The software Minitab 19 was utilized to conduct the internal consistency analysis, resulting in a Cronbach's Alpha coefficient of 0.7516 for the initial level group and 0.7448 for the intermediate level group. These coefficients indicate that the components of the chronological procedure exhibit acceptable and good internal consistency (Taber, 2018). It is worth noting that recent research studies have also determined the Cronbach's Alpha coefficient for instruments measuring knowledge levels in various fields of study, showing a wide range of different qualitative descriptors (Hendricson et al., 2011; Taber, 2018; An, 2024). The statistically validated instrument is initially administered to both study groups.

The external consistency of the instrument was assessed using the test-retest method. The results demonstrate a moderate to high external consistency, with key variables such as unit analysis (r = 0.72) and final results (r = 0.64) showing stable correlations across both test administrations. These findings support the instrument's capacity to measure the constructs consistently over time, particularly in the domains of procedural analysis and problem-solving.

The final evaluation entails the completion of application exercises based on the academic content of the subject, incorporating chronological steps in their solutions. This activity is assigned after a four-month period during which students have comprehended, studied, and applied the chronological tool for PBL method. The application exercise for the basic level group is as follows: "Two spherical bodies with a mass of 15 g each one, hang from a 100 cm long rope, and they have equal charges ($q_1 = q_2$). Given that the angle is 30°, what is the value of the charge?". For the intermediate level group, it is: “30 g of salt was dissolved in a tank of 200 L. A stream with a concentration of one g of salt per liter enters the system with a velocity of 5 L/min. The tank is perfectly mixed and has a stream out at the same rate. Calculate the amount of salt in the tank after 25 minutes using the Euler’s method”. Instruments used to determine the cognitive contribution of the chronological procedure were employed.

2.4. Procedure

The evaluation instrument used in this study was designed to measure students' performance on the elements of the chronological procedure using a dichotomous scale. Each item evaluated was rated with one of two possible values: 0 → the item was either not performed or was executed incorrectly, presenting significant errors that impacted the solution (approximately 50 % errors), 1 → the item was executed correctly or contained minor errors that did not affect the solution.

That is, an evaluation of 0 corresponds to an unsolved item, while a score of 1 indicates the item was adequately solved. The overall scale represents the evaluation of mastery of the chronological procedure. The use of a dichotomous scale allowed for an objective and consistent assessment of each element of the procedure, focusing on the accuracy and clarity of the students' execution of the steps.

A subscale system was employed to assign scores based on the rate of progress in solving the evaluation instrument, as follows: 1 point → does not perform the procedure, 2 points → performs the procedure with more than 50 % errors, 3 points → performs the procedure with few errors that are not significant for obtaining the result, 4 points → performs the procedure without errors. These results enabled the calculation of measures of central tendency and variability.

The BLR calculations were performed using Minitab 19 software to identify the influence of the academic average (independent variable) on the execution of the chronological procedure elements (dependent variables).

3. Results and discussion

The results of the instruments of assessment are reported in a synthesized way, considering the elements that make up the chronological procedure. The percentages express success and failure based on the correct execution of the chronological steps. The initial evaluation results for the two study groups, using a dichotomous scale, are shown in Figures 2 and 3.

Figure 2 shows that students from the basic level group have a low success rate in identifying the problem's unknown (2.3 %), creating a process diagram (6.9 %), analyzing units (13.9 %), and obtaining a result (34.9 %); in resume, there is a high failure rate for solving the problem (65.1 %). The BLR adjustment coefficients were calculated and resumed in Table 1. The coefficients have fit percentage between 73 and 99.9 %, indicating that the variables depend on the academic performance reflected in the average.

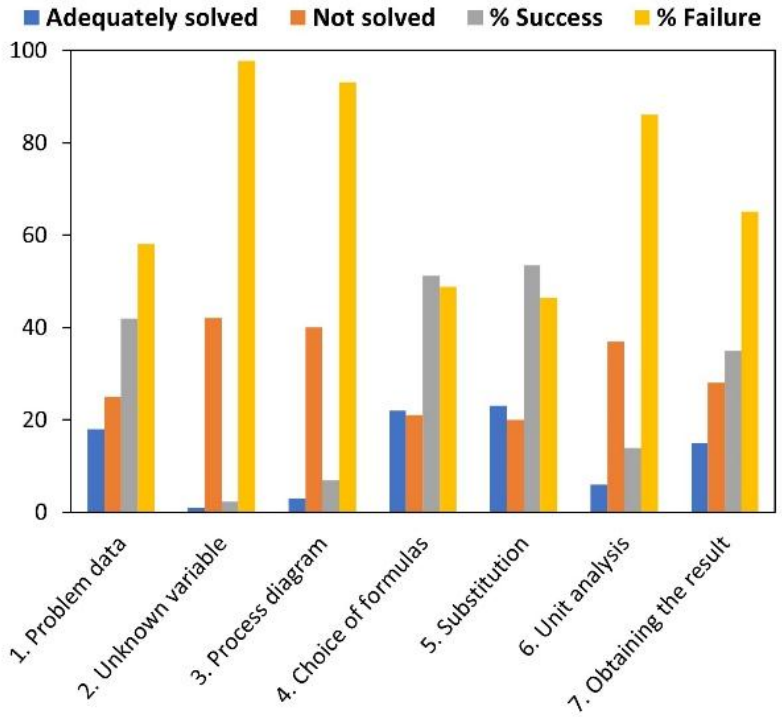

Fig. 2. Initial evaluation for basic level group

Table 1. Logistic regression adjustment coefficients for both study groups for the initial evaluation

Group	Variable	b_0	b_1	R^2 of deviation (%)
Basic	Data	-153	17.6	99.92
	Diagram	-84	9.5	99.96
	Choice of formula	-103	12.4	99.98
	Substitution	-360	45.9	99.96
	Analysis Units	-114	13.5	84.86
	Result	-189	25.8	73.79
Intermediate	Diagram	-113	12.5	99.97
	Choice of formula	-289	35.5	99.94
	Substitution	-178	23.1	99.97
	Analysis Units	-212	25.6	99.96
	Result	-154	19.2	99.98

The results obtained in the analysis of the chronological element "unknown variable identification" do not show variability. The 97 % of students were unable to identify the dependent variable in the application problem, resulting in the unsuccessful adjustment of BLR for this analysis parameter. It can be inferred that the students' academic average does not affect their ability to correctly identify the unknown variable in application exercises for this study group. The sigmoid curve from Figure 3 shows the dependence of the chronological procedure respect to the academic average for the basic-level group.

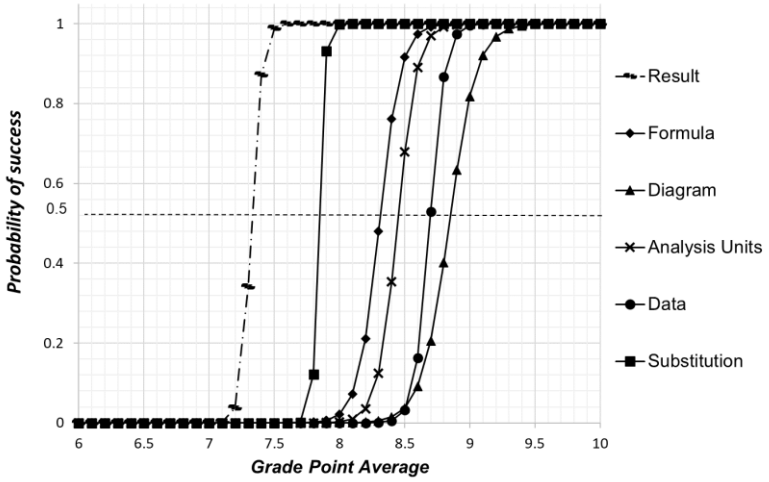

Fig. 3. Logistic regression adjustment of the initial evaluation of the basic-level group

In contrast to the basic level group, the intermediate group demonstrates significantly higher success rates in data identification (95 %), unknown variable identification (92 %), and formula selection (82.5 %), as shown in Figure 4. For the substitution of formulas (72.5 %), and analysis of units (57.5 %) a success percentage decrease is observed. The previous percentages can all contribute to obtaining accurate results (42.4 %); a 7.6 % percentage higher than the basic level group's percentage (34.9 %).

Table 1 shows that for diagram, formula selection, data substitution, unit analysis, and result acquisition variables, the average adjustment percentage is over 99 %. Also, the results of the instrument assessment show that the students were able to adequately identify the independent variables or data (95 %, see Figure 4) and the dependent variables (92.5 %, see Figure 4). This high success rate avoided a logistic adjustment for these chronological elements, due to the limited variability of the results. This indicates that the grade point average of the students does not interfere with identify correctly the variables of the problem for the intermediate-level group. This indicates that the grade point average of the students does not interfere with identify correctly the variables of the problem for the intermediate-level group. Figure 5 illustrates the sigmoidal graphical behavior, representing the attribution of the five elements of chronological procedure based on the academic average.

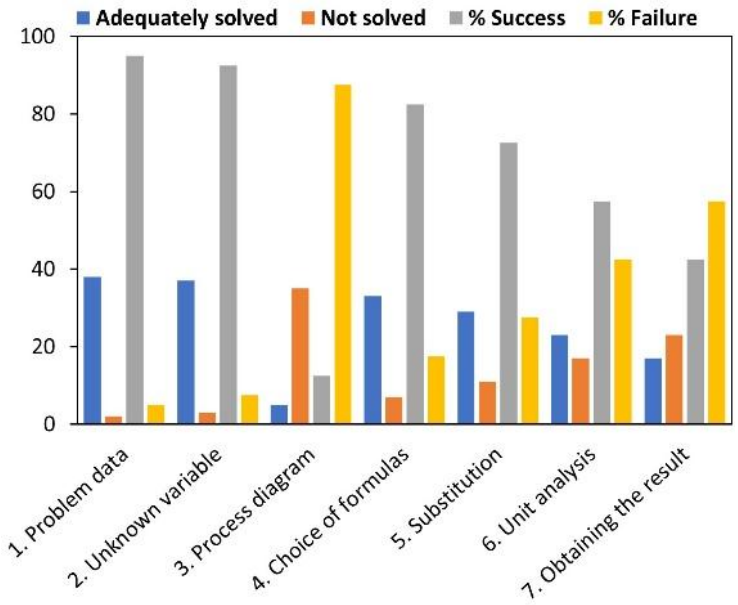

Fig. 4. Initial evaluation for intermediate level group

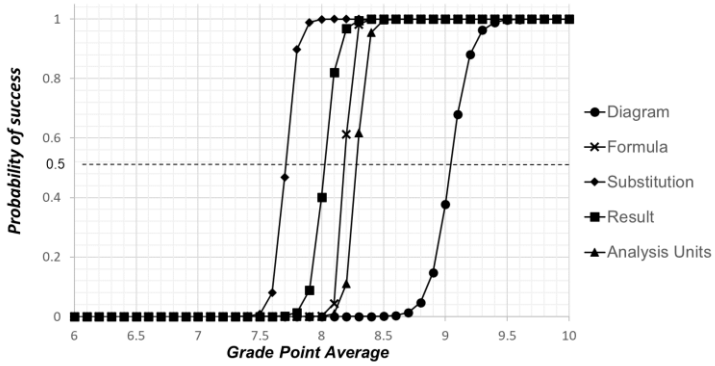

Fig. 5. Logistic regression adjustment of the initial evaluation of the intermediate-level group

3.1. Hypothesis analysis

The purpose is to determine the validity of the hypothesis. The p-value was calculated with a confidence interval of 95 %, which means implementing a significance level of 0.05. The results of the correlation between the academic average and the seven elements of the chronological procedure (using validated instruments with a Cronbach's Alpha coefficient of 0.75 for the basic-level group and 0.74 for the intermediate-level group) are presented in Table 2.

Table 2. Results of the correlation between the academic average and the elements of the chronological procedure, for both study groups

Null hypothesis (Ho)	P (GB)	Conclusion (Ho) de GB	Pearson coefficient	P (GI)	Conclusion (Ho) de GI	Pearson coefficient
GPA factor does not influence in the data identification for an application problem.	0.000	Rejected	0.197	0.753	Accepted	0.267
GPA factor does not influence in the data identification of the unknown variable for an application problem.	0.688	Accepted	0.078	0.264	Accepted	0.231
GPA is not a factor in the development of the diagram of an application problem.	0.004	Rejected	0.785	0.005	Rejected	0.485
GPA factor does not influence in the correct choice of formulas used in the procedure for solving an application problem.	0.003	Rejected	0.453	0.001	Rejected	0.312
GPA factor does not influence in the correct substitution of variables in the procedure for the solution of an application problem.	0.002	Rejected	0.371	0.000	Rejected	0.702
GPA factor does not influence in the correct execution of the unit analysis in an application problem.	0.000	Rejected	0.738	0.001	Rejected	0.704
GPA factor does not influence in the correct result for an application problem intermediate level.	0.000	Rejected	0.629	0.004	Rejected	0.668

Notes: Where GPA is grade point average, GB was assigned for the basic academic level group and GI for the intermediate level group.

The hypothesis analysis for the basic level group reveals that the students' academic average directly influences chronological procedure elements, i.e. correctly identifying the independent variable, creating the process diagram, choosing formulas, substituting and using formulas, executing unit analysis, and obtaining the correct result. This is evident as they have p-values lower than 0.05, leading to the rejection of the null hypothesis established in the research. Academic performance does not influence the identification of dependent variables (unknowns) in an applied problem, as it has a value of p = 0.688, which is higher than the established significance level of 0.05.

Table 2 shows the analysis of the null hypothesis for the intermediate-level group, establishing the influence of academic average on the follows elements: diagram development, formula selection, variable substitution, unit analysis, and result acquisition. These elements have p < 0.05 values, resulting in the rejection of Ho. In the same context, the data identification has a value p = 0.753 and the unknown parameter of the problem study has a value p = 0.264, both of which are higher than the significance level. This allows to establish that academic performance does not show a relationship with the correct identification of data and the unknown parameter of the problem, leading to the acceptance of Ho.

Based on the above, it is established that the findings presented in the analysis of Ho are similar to the calculations obtained in binary logistic regression, where there is no correspondence between the independent variable of academic performance and the elements of unknown selection in the basic group and the identification of data-unknown in the intermediate group.

Table 2 also includes the Pearson correlation coefficient for the two study groups. In the case of the basic-level group, Pearson's correlation coefficients exhibit significant variability, indicating differing levels of relationship between the grade point average factor and the variables evaluated. The highest correlations are observed in the unit analysis step (r = 0.738) and the correct results step (r = 0.629), suggesting that grade point average is strongly associated with performance in tasks requiring logical reasoning and detailed analysis. Conversely, lower correlations, such as in identifying the data (r = 0.197), indicate a weak relationship between grade point average and these specific skills, possibly suggesting that other factors are influencing these aspects. For the intermediate-level group, Pearson's correlation coefficients also display variability. The highest correlations are found in the variable substitution step (r = 0.702) and the unit analysis step (r = 0.704), indicating a strong and consistent relationship between grade point average and these specific areas of the procedure. These findings suggest that grade point average plays a significant role in achieving success in tasks requiring accuracy and attention to detail. Conversely, lower correlations, such as in identifying the unknown (r = 0.231), indicate a weaker relationship, suggesting that grade point average has less influence on the initial steps of the process, such as the basic understanding of the problem.

3.2. Results of the final evaluation

The final assessment results for the study groups, using a binary scale, is reported in Table 3. After learners studied and implemented the chronological procedure for solving application problems for the basic level course, they achieved a higher success rate in developing and obtaining the correct result (74.4 %), which is 39.5 % higher than the initial assessment for this group. However, there are two elements that can be improved (see Table 3): the unit analysis (with a percentage of 27.9 %), and the resulting attainment (with a percentage of 25.6 %).

The variability in the initial assessment results for the basic-level group allows the BLR development (the adjustment parameters are presented in Table 4). Here, an appropriate adjustment percentage for the basic-level group elements is observed. In the same context, obtaining regression adjustment parameters is indicative of the correlation between the chronological elements, analysis of units, result attainment, and the students' academic average, as shown in Figure 6 (sigmoid curves, GB analysis, and GB result).

The final evaluation results for the intermediate-level group presented in Table 4 demonstrate a high success rate in executing the chronological steps, leading to an improved percentage of correct outcomes (75 %). This is a 32.5 % increase compared to the initial evaluation's percentage of 42.5, as shown in Figure 4. Based on the assessment results in Table 4 for this study group, the BLR was conducted. The coefficients displayed in this case deviate by 99.9 %, and their visual representation can be seen in Figure 6 (GI Result).

Table 3. Final evaluation for both study groups

Group	Adequately solved	Correctly solved	Not solved	% Success	% Failure
Basic	1. Problem data	33	10	76.7	23.3
	2. Unknown of the problem	43	0	100	0.0
	3. Process diagram	35	8	81.4	18.6
	4. Choice of formulas	41	2	95.3	4.7
	5. Substitution in formulas	38	5	88.4	11.6
	6. Unit analysis	31	12	72.1	27.9
	7. Get a correct result	32	11	74.4	25.6
Intermediate	1. Problem data	40	0	100	0.0
	2. Unknown of the problem	40	0	100	0.0
	3. Process diagram	38	2	95.0	5.0
	4. Choice of formulas	40	0	100	0.0
	5. Substitution in formulas	40	0	100	0.0
	6. Unit analysis	40	0	100	0.0
	7. Get a correct result	30	10	75.0	25.0

Table 4. Logistic regression adjustment coefficients for both study groups. Final evaluation

Group	Variable	Coefficients b_0	Coefficients b_1	R^2 of deviation (%)
Basic	Analysis of Units	-307	37.5	99.81
	Result	-165	23.6	71.83
Intermediate	Result	-407	50.0	99.94

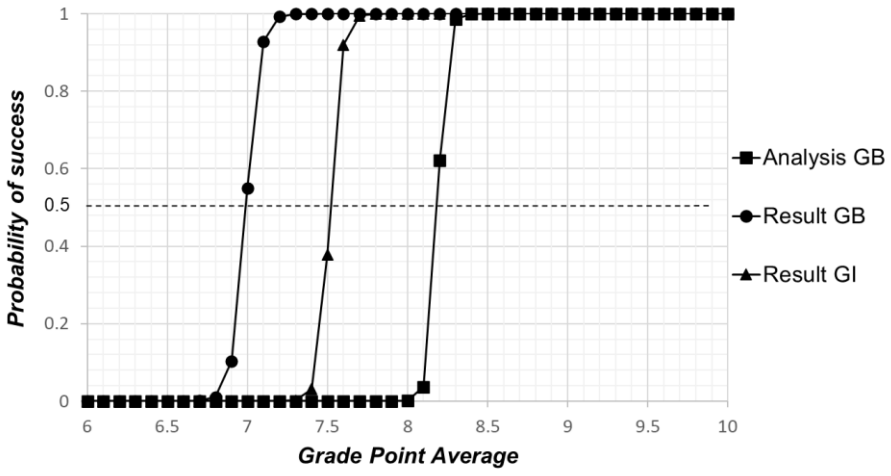

Fig. 6. Logistic regression adjustment of the final evaluation of the basic group (GB) and intermediate group (GI)

Similar results to those obtained in this work have been reported when the PBL methodology is implemented in some engineering programs. Macinauskas et al. (2024) reported, for the physics course of an engineering program, that the implementation of PBL method is more effective for

learning and increased student motivation. Their conclusion agrees with the results presented in the present study, where an improvement in knowledge acquisition was observed, mainly for the basic-level group. Ruiz-Meza et al. (2021) proposed the chronological tool as a didactic resource to support project-based learning (PBL). The authors suggest that this tool can help students visualize the sequence of activities involved in a PBL project and better understand the learning process. Meanwhile, Rodríguez and Fernández (2017) established a methodology for PBL that involves raising students' awareness of their responsibility for their own learning, with the teacher serving as a guide and learning directed towards solving problems in small groups. Both studies' results are similar to those found in this research. However, they do not provide a specific methodology for the field of study. Therefore, it can be inferred that the chronological tool is a didactic resource that can be implemented to support the PBL process.

Furthermore, the construction of the equations (Equation 2) for both study groups allows the predictions of the effect of chronological elements based on students' academic performance. These predictions can help teachers establish improvement alternatives and academic support to prevent low student achievement in subjects that require PBL. The initial implementation of the chronological tool for the basic-level group resulted in a high failure rate for all elements, ranging from 46.5 to 97.7 %. However, the final evaluation showed a significant reduction in the percentage of failure, from 0.0 to 27.9 %. For the intermediate-level group the initial assessment presents a failure percentage ranging from 5.0 to 87.5 %, while the final evaluation shows a failure percentage ranging between 0.0 and 25 %. The knowledge and application of the chronological procedure contributed to the students being able to develop and perfect practical skills. The chronological procedure as an educational instrument can be used as a guide for students to apply a sequence of steps to find the solution to a question of an engineering application exercise, with greater effectiveness and efficiency.

4. Conclusion

The present study investigated the effectiveness of the chronological procedure to supporting the theoretical-practical skills development in engineering students. The study also explores the relationship between students' academic performance and the implementation of the proposed procedure.

The study was conducted with two groups of students: one at the initial level and the other at the intermediate level. The chronological procedure was implemented in both groups, and the students' academic performance was evaluated through initial and final assessments. The initial evaluations showed a high failure rate, after implementing the chronological procedure, the final assessment presented a lower failure rate. These results indicate that the knowledge and application of the chronological procedure contributed to the development and improvement of practical skills in students. To generalize the application of procedural chronology to all subjects in the curriculum of each program, it is necessary to extend the study to a larger population and sample size. Since the reported results were based on a specific population, this could be considered a limitation.

In conclusion, the chronological procedure based on the PBL model is a tool that supports the strengthening of theoretical-practical skills in engineering students at both initial and intermediate levels. Furthermore, the influence of academic performance on the execution of the chronological elements implemented for PBL methodology was established to develop predictive equations to support the teaching-learning process. The implementation of the proposed tool led to better student performance.

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Heuristic Potential of the History of Mathematics (on the Example of the Composition of Mathematical Problems for Schoolchildren)

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Abstract

The work is devoted to the identification of new possible ways of historicizing mathematical education, which is considered as an important pedagogical phenomenon. The purpose of the study was to reveal the heuristic potential of the historicization of mathematical education by reconstructing the substantive component of the methodological system. The study confirmed the positive impact of historical information on improving the quality of mathematical education. The conclusions were obtained on the basis of an empirical study conducted, the respondents were students, secondary school teachers and teachers of higher schools, standardized scales served as diagnostic materials. Based on the SWOT analysis, a matrix was built in which the strengths, opportunities, weaknesses and threats of the historical and methodological approach being implemented were recorded. It is proposed to use mathematical problems with a historical plot as a means of historicization. A new task bank has been developed for unified subjects "Biography and scientific heritage of L. Euler", "Biography and scientific legacy of G.V. Leibniz". The choice of the scientific heritage of scientists is determined by a number of circumstances. Firstly, the versatility of their scientific interests – scientists have made discoveries in various fields of mathematics, physics, and philosophy. Secondly, scientists have left a rich scientific legacy, which has not yet been fully studied and understood, and new facts about the discoveries are constantly emerging. Thirdly, the scientific results obtained by scientists are included in the content of the school curriculum.

Keywords: historicization of mathematics teaching, composition of problems with historical plots, methodological heritage.

1. Introduction

The inclusion of historical information in mathematical education makes it possible to revitalize the teaching of mathematics, make it interesting, as well as expand the scientific and

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cultural horizons of students. Obviously, the use of historical information in teaching requires additional scientific training in the field of the history of science from a mathematics teacher.

The German mathematician Felix Christian Klein (1849–1925) was one of the first to introduce historical information during lectures (Klein, 1926). In Russia, the history of mathematics was first studied at the Imperial Moscow University, thanks to the efforts of Professor V.V. Bonynin (1849–1919).

In 1959, K.A. Rybnikov (1913–2004) founded the History and Methodology of Mathematics and Mechanics Department at Lomonosov Moscow State University, whose staff developed a program for teaching the history of mathematics (list and sequence of sections), which became widespread both in classical universities and pedagogical universities (Rybnikov, 1994). Yushkevich compiled a monumental work on the history of mathematics (Yushkevich, 1992). S.S. Demidov and other students of K.A. Rybnikova continues her research activities at the present time (Demidov et al., 2018), clarifying and discovering new facts in the field of the history of mathematics, which indicates the need for constant updating of the content of the history of mathematics course (Demidov, 2021).

A modern researcher T.S. Polyakova proposed to enrich the history of mathematics course for teachers with information on the history of mathematical education (Polyakova, 2002).

Currently, the search for ways to implement historicism in teaching mathematics continues. K. Clark, T. Kjeldsen, S. Schorcht, C. Tzanakis, X. Wang propose to improve mathematical education through the introduction of historical information into the course content (Clark et al., 2016), I.A. Mendes believes that the school mathematics course should be permeated with historical information (Mendes, 2020). E. Barbin determined the volume of historical information in mathematical education (Barbin, 2022).

Researchers O.A. Pavlova, Z.F. Zaripova, L.R. Zagitova, V.G. Zakirova suggest using cases from the lives of mathematicians as a means of implementing historicism (Pavlova et al., 2021). E. Gerasimova et al. They describe the experience of introducing information on the history of mathematics for the design of programs for spiritual and moral education (Gerasimova et al., 2021). I.M. Izmirli draws attention to the fact that the issue of lack of time cannot be considered as an argument when historical information is included in the content of mathematical education (Izmirli, 2020).

Thus, the existing work on the historicization of mathematical education focuses mainly on the design of the content, rather than the means of teaching. The possibilities of using mathematical problems as a means of implementing the principle of historicism have not been studied at all.

Thus, the purpose of the study was to reveal the heuristic potential of the historicization of mathematical education by reconstructing the meaningful component of the methodological system – the design of a system of tasks.

2. Materials and methods

The research was conducted at the level of theoretical and empirical understanding.

At the first stage of the theoretical research, the problem material in mathematics textbooks was analyzed (modern school textbooks on algebra by the author A.G. Mordkovich, the author's team led by S.M. Nikolsky, the author's team led by Yu.M. Kolyagin, etc.). In order to study the content of the problem material in mathematics textbooks, the content analysis approach proposed by F. Zeynivandnezhad (Zeynivandnezhad et al., 2024) was used. It was revealed that the plots of mathematical problems do not sufficiently take into account (cultural sensitivity and inclusivity), which, in the fair opinion of the scientist, is one of the criteria for the quality of mathematical education.

A survey was also conducted, which made it possible to identify the value attitude towards the implementation of the principle of historicism in teaching mathematics and possible obstacles to its implementation. The target audience consisted of high school teachers, secondary school teachers and students enrolled in various educational programs. The representative sample was formed by stratified selection and included 200 respondents. The main characteristics of the sample are presented in Table 1. The study participants answered a questionnaire consisting of a section of bio-data (gender, age, status and educational programs) and a validated scale evaluating methodological aspects of historical material related to the value attitude towards the introduction of historicism in mathematical education. For example: "Do you think it is necessary to include

information on the history of mathematics in the learning process?", "Will tasks on the history of mathematics enliven the learning process?", "What causes the difficulties of including elements of historicism in teaching mathematics?", "Is the lack of thematic methodological developments on the history of mathematics an obstacle to inclusion elements of the history of mathematics in the lesson?", "Is lack of time an obstacle to including elements of the history of mathematics in the lesson?", "Will a collection of problems on the history of mathematics be in demand in a modern school?" etc. The questionnaire included 12 questions in total. All responses were evaluated on a nominative scale. The survey process was organized through correspondence between respondents and researchers. Empirical data processing was carried out using technical tools (MS Excel) and methods of mathematical statistics (Anova). Additionally, a survey was conducted with the respondents, in which the strengths, opportunities, weaknesses and threats (SWOT analysis) of the methodological project were recorded.

Table 1. Characteristics of respondents

Variable		**Frequency**	**Frequency**
Gender	Male	72	36
	female	128	64
Age	18-24	83	41,5
	25-35	65	32,5
	>35	52	26
Status	Professor	49	24,5
	High school teacher	68	34
	Student	83	41,5
Educational programs	Education and pedagogical sciences	32	16
	Engineering, technology and technical sciences	28	14
	Mathematical and natural sciences	23	11,5

At the second stage, sources on the history of mathematics were collected, systematized and analyzed, as well as their comparison in order to identify the most reliable events and facts. At this stage, the method of historical reconstruction of events related to the life and scientific work of scientists L. Euler (1707–1783) and G. Leibniz (1646–1716) was used. The works of L. Euler and G.Leibniz and the literature on their contribution to science were analyzed. In addition to the well-known works of Thiele Rüdiger on the biography of Euler (Rüdiger, 2005) and Eric Aiton on the biography of Leibniz (Aiton, 1985), the works of modern scientists were analyzed.

New details about Leibniz's scientific activities at the Academy of Sciences are given in the article by M. Palomo (Palomo, 2021). Researcher L. Strickland has discovered new information about Leibniz's discovery of formulas for numerical series and the scientist's difficult attempts to publish this result (Strickland, 2023). Katz Mikhail G., Kuhlemann Karl, Sherry David, Ugagli Monica, based on Leibniz's letter addressed to Masson, provided a clarification in Leibniz's understanding of infinitesimals (Katz et al., 2021). Then this idea was developed from the point of view of philosophy in other works by M. Katz (Katz et al., 2021, Katz et al., 2023). Moreover, between the teams of authors Richard Arthur and David Rabouin (Arthur, Rabouin, 2024) and J. Bair, A. Borovik, V. Kanovei, M. Katz, S. Kutateladze, S. Sanders et al. (Bair et al., 2022; Bair et al., 2023), the controversy about the extent to which Leibniz's understanding of the infinitesimal differed from previous authors. O. Esquisabel, F. Raffo Quintan clarified the philosophical component in Leibniz's mathematical discoveries (Esquisabel et al., 2021). M. Rajab Nezhadian, A. Hosseini showed how the theodicy of God proposed by Leibniz can be applied to explain the philosophical categories of good and evil in modern research (Nezhadian and Eskandian, 2021).

Another famous scientist, Leonard Euler, left a huge and diverse scientific legacy. Researchers from different countries are working on understanding his works, some of which have not yet been studied and published. In a recent work by G.I. Sinkevich, the history of L. Euler's discovery of the most beautiful formula in mathematics was clarified. Another famous scientist, Leonard Euler, left a huge and versatile scientific legacy. Researchers from different countries are

working on understanding his works, some of which have not yet been studied and published. In a recent work by G.I. Sinkevich, the history of the discovery of L. Euler, the most beautiful formula in mathematics, left a huge and diverse scientific legacy by another famous scientist, Leonard Euler. Researchers from different countries are working on understanding his works, some of which have not yet been studied and published. In a recent work by G.I. Sinkevich, the history of L. Euler's discovery of the most beautiful formula in mathematics was clarified. Another famous scientist, Leonard Euler, left a huge and versatile scientific legacy. Researchers from different countries are working on understanding his works, some of which have not yet been studied and published. In a recent work by G.I. Sinkevich clarified the history of L. Euler's discovery of the most beautiful formula in mathematics ($e^{i\psi} = -1$) (Sinkevich, 2023), in the study of T.A. Lavrinenko and A.A. Belyaev, L. Euler's role in the development of methods for solving diophantine equations was rethought (Lavrinenko, 2021).

G. Ferraro revealed Euler's contribution to the restructuring of mathematical analysis. He wrote: «Euler changed the architecture of this science and regarded analysis as lying at the heart of mathematics, while geometry and mechanics were considered as a sort of applied analysis» (Ferraro, 2020).

S.R. Bistafa (Bistafa, 2022) and independently of him a large team of scientists M. Fahad, S. Ali, M. Khan, M. Husnain, Z. Shafi, A. Samad and N. Jan (Fahad et al., 2021) present new arguments about the priority of L. Euler in the discovery of facts in the field of differential equations. The work of D. Bruno shows that the role of Euler's discoveries in the field of non-standard analysis has not lost its significance today (Bruno, 2023).

At the third stage, the method of modeling problems with historical content was used. Y.M. Kolyagin suggested using mathematical problems as a means of teaching and developing students. He identified three main elements in the task structure (task condition, task object and task goal), which we used for task composition (Kolyagin, 1977). V.V. Guzeev formulated the requirements for the task system structure: completeness, availability of key tasks, connectivity, increasing difficulty, target orientation and sufficiency, psychological comfort (Guzeev, 2001).

V.N. Sadovsky emphasizes the need to comply with certain principles of designing a system of tasks: integrity, structurality, purposefulness, integrativity, hierarchy (Sadovsky, 1974).

3. Results

The effectiveness of including historical information in teaching mathematics has been proven not only on a theoretical but also on a practical level. The survey showed that 97 % of respondents recognize the usefulness of including historical information in a mathematics course (the distribution by status is as follows: 50 % are students; 25 % are teachers; 25 % are higher school teachers). The majority of respondents (96.3 %) agreed that problems on the history of mathematics would introduce an element of novelty and interest into the learning process (age distribution: 18-24–52 %; 25-35–37 %; >35–11 %); 92.6 % of respondents agreed on the need to create a modern collection of tasks with a historical plot and its relevance (distribution by status: 14 % are students; 65 % are teachers; 21 % are high school teachers).

The measure of internal consistency of the test (consistency, reliability), based on the average interpoint correlation, was determined using the Cronbach's alpha analysis method in a complete sample (12 respondents) for all 12 test tasks. This number of questions in the questionnaire is optimal so that there is no artificial overestimation of the value of the Kronbach coefficient (the "weak point of the indicator"). The assumptions of this method were as follows: firstly, the testing performed is based on independent observations. Secondly, the determination of the type of distribution for each group of points on the scale by comparing the main characteristics of the sample – mode (M_o), median (M_e) and mean values (μ), revealed its normal distribution (Table 2).

Table 2. Checking for the normality of the distribution

B202 | =СРЗНАЧ(B2:B201)

	A	B	C	D	E	F	G	H	I	J	K	L	M
202	μ	1	1	2	3	1	2	2	2	1	3	2	2
203	Mo	1	1	2	3	1	2	2	3	1	3	2	2
204	Me	1	1	2	3	1	2	2	3	1	3	2	2

The obtained value of the alpha-Kronbach coefficient using the MS Excel add-in "Analysis Package" turned out to be 0.75, which indicates a good level of agreement between the positions of the scale (Table 3).

Table 3. Results of the analysis of variance

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Strings	23,71833	199	0,119188	0,410357	1	1,179863273
Columns	577,875	11	52,53409	180,8723	1,5687E-297	1,793013411
Error	635,7917	2189	0,472648			
Total	1237,385	2399				
Cronbachs Alpha	0,74783	=1-(U222/U224)				

In addition, an analysis of strengths and weaknesses, opportunities and threats (SWOT analysis) was applied. The opinion of teachers, students, and teachers of higher education was taken into account. A summary of the results is shown below.

Strengths: actualization of the values of education through immersion in the scientific atmosphere of the past; the interest of the teaching staff; consideration of the mathematical concept, method from the point of view of its historical development contributes to building the logic of the subject, more solidly assimilating it; tasks with a historical plot introduce an element of novelty and interest in the learning process; formation of students' understanding of the general methods of historical-scientific knowledge; improving the quality of knowledge (consistency, depth, strength); formation of a scientific worldview; ensuring the humanitarization of mathematical education; implementation of the educational orientation of education (development of spiritual and moral qualities of a person).

Weaknesses: lack of didactic support for the history of mathematics; excessive increase in the burden on teachers to search and comprehend relevant sources; lack of experience in training teaching staff to work with authentic mathematical texts; lack of time in mathematics lessons; poor consistency with modern curricula.

Possibilities: systematization and structuring of historical material for more effective solution of educational and developmental tasks with the possibility of implementing this approach at other levels and subjects; integration of new practice of organizing classes in the history of mathematical science into the traditional process; use of existing modern technological tools to update textbooks with historical content.

Risks: diverting students' attention from a mathematical fact to a historical one; reducing teacher participation due to an increase in their workload.

A specially designed system of mathematical problems should be considered as a means of implementing historicism.

Based on the principles clarified by us, proposed by Yu.M. Kalyagin, V.V. Guzeev and V.N. Sadovsky, an algorithm for composing problems on the history of mathematics has been developed. At the first stage, the content of the program, textbooks and problem books in mathematics is analyzed (1). At the second stage, mathematical knowledge is highlighted, which students must master in the process of solving problems (2). At the third stage, a historical topic is selected and material is selected for the formulation of the problem plot (3). At the fourth stage, tasks are formulated (4). At the fifth stage, the principle of the hierarchy of tasks is chosen (according to the sequence of historical events or according to the increasing difficulty) (5).

The most difficult stage in the composition of mathematical problems is the fourth stage (formulation of the problem plot). Its implementation can be carried out in two approaches. The first approach to the formulation of the problem's plot assumes that the result of solving the problem will be a number with which a historical event is associated. In the course of solving such a problem, the student not only consolidates mathematical knowledge, but also discovers a new historical fact for himself. For example, a possible formulation of the problem looks like this: "By simplifying the

expression $3(12^2+15^2 + 2*10^2)$ find the date of birth of the famous Swiss mathematician. Tell me the name of this mathematician" (The answer is 1707 – the year of L. Euler's birth).

The second approach to the formulation of the task's plot assumes that historical facts are used in the task's plot itself. For example, linear equations are used as models for composing a problem with a historical plot on the topic "Scientific creativity of L. Euler". Task: "The pen of Leonard Euler owns 850 works, including monographs, articles in the journal Commentarii Academiae scientiarum Imperialis Metropolitanae and 430 other works of various kinds. How many fundamental monographs have been published by L. Euler, if there were 20 times fewer of them than the articles in the journal Commentarii Academiae scientiarum Imperialis Metropolitanae.

The solution of this problem leads to the formulation of the equation $21x+430=850$.

The second method of construction is more complex, since it involves in-depth study and careful selection of historical information. On the one hand, the plot of the problem should contain a real historical fact, on the other hand, the text of the problem should not be overloaded with unnecessary details, not distract from the mathematical meaning (object (according to Y.M. Kolyagin). However, this method of constructing problems is preferable, since historical facts are not artificially tied here, but they naturally introduce the history of mathematics. A set of tasks is of particular cultural value if their plots reveal the details of one big historical theme.

Thus, the following requirements for the design of tasks of different types differ.

1. Requirements for the composition of tasks that contain a question that implements a cognitive goal in the field of the history of mathematics:

1) The presence of a single mathematical/historical topic;

2) Historical problems act as a supplement that supports interest in the history of mathematics;

3) The answer to the problem should be expressed as a number.

2. Requirements for the composition of problems with historical content in the condition, i.e. historical facts from the development of mathematics are used in the plot of the problem:

1) Tasks are proposed at the stage of fixing the material;

2) The presence of a single mathematical/historical topic;

3) The task condition should not be artificially overloaded with historical facts.

To compile such tasks, a thorough study of one of the historical topics will be required. Let's take two historical themes as an example: "Biography and scientific heritage of L. Euler" and "Biography and scientific heritage of G.V. Leibniz". The choice of the scientific heritage of these scientists is determined by a number of circumstances. Firstly, the versatility of their scientific interests – they made discoveries in various fields of mathematics, physics, and philosophy. Secondly, they left a rich scientific legacy. The legacy of scientists has not yet been fully studied and comprehended.

Mathematical topic "Linear equations", historical topic: "The great German mathematician G.V. Leibniz"

1. Having solved the equation, you will find the date of birth of the famous German mathematician. Who is this scientist?

$2x+170=3462$ (The answer. 1646. This is the year of G.V. Leibniz's birth).

2. By solving the equation, you will find the date of admission of G.V. Leibniz to the University of Leipzig.

$3x+ 240= 5223$ (The answer. 1661).

3. Having solved the equation, you will find the date of foundation of one of the very first mathematical journals "Acta Eruditorum".

$2x – 310=3054$ (The answer. 1682. The journal "Acta Eruditorum" was founded by G.V. Leibniz).

4. Having solved the equation, you will find the date of G.V. Leibniz's acquaintance with Emperor Peter I.

$4x + 180 = 6968$ (The answer. 1697).

We will also give some examples of problems on the mathematical topic "Degree with a natural indicator" and the historical topic "Biography and scientific heritage of L. Euler".

1. Simplifying the expression, find the date of the opening of a scientific institution opened in St. Petersburg and associated with the activities of L. Euler.

$3879*2^4:3^2$ (The answer. 1724).

2. Simplifying the expression, find the age of L. Euler, at which he moved to Russia.

$1900: 2^2 : 5^2$ (The answer. 19 years).

4. Discussion

The historicization of mathematical education involves a revision of the content of the assessment of textbooks in mathematics. We agree with O. Sahin and M. Basgul that an important parameter for evaluating the content of textbooks should be high moral values, which should be included in the content (Sahin, Basgul, 2018). However, we consider this list to be insufficient, since it lacks the requirement of historicism.

Zeynivandnezhad identified six main parameters for the systematic evaluation of mathematics textbooks: (1) language and communication; (2) content analysis; (3) pedagogical approach; (4) cultural sensitivity and inclusivity; (5) assessment and exercises; (6) visual aids and presentations. The principle of historicization may latently be present as part of the principle of "cultural sensitivity and inclusivity" (4) proposed by F. Zeynivandnezhad et al. (Zeynivandnezhad et al., 2024).

We agree with the possibility of implementing the principle of historicism through the content of mathematical education, considered by O.A. Pavlova, Z.F. Zaripova, L.R. Zagitova, V.G. Zakirova (Pavlova et al., 2021), but we believe that this is not enough. However, the authors propose a new way to implement this principle – through the composition of mathematical problems with historical content.

The requirements for the task system considered by V.V. Guzeev and V.N. Sadovsky take into account only the mathematical component in the content of the tasks, but do not take into account the historical and cultural function of the condition, therefore they require clarification.

The approach proposed by the authors has a number of advantages over previously developed cottage materials of mathematics textbooks. The use of historical information makes it possible to solve a system of pedagogical tasks in a complex, expand scientific horizons, develop cognitive abilities, and increase interest.

4. Discussion

The introduction of historical information into the teaching of mathematics is a necessary element, since it allows you to make teaching mathematics meaningful and interesting. This fact has been confirmed by theoretical, practical and empirical studies.

The results of the study show that the design and implementation of tasks with a historical plot will ensure the actualization of educational values through immersion in the scientific atmosphere of the past years, will contribute to building the logic of the subject, more solid assimilation; introduce an element of novelty and interest into the learning process; form students' understanding of the general methods of historical and scientific knowledge, expand scientific horizons, and they also improve the quality of mathematical knowledge (consistency, depth, strength). Unlike the theoretical method of introducing historical (short stories), the proposed method of composing tasks based on a historical approach does not require additional time in the classroom. The problems that exist in mathematics textbooks today can be painlessly replaced with tasks with historical content.

The main conclusion of the study is that the success of the modernization of the content of mathematical education will be guaranteed when the proposed innovations are based to the maximum extent on the heuristic potential of historicization.

The conducted research has certain limitations. First, the content of the tasks should be coordinated with the corresponding program of the mathematics course. Moreover, the teacher should focus the students' attention not on the historical fact, but on the mathematical one, so the plot of the tasks should not be excessively voluminous. Mathematical knowledge should remain dominant in the context of problems with historical plots, and historical information should play a secondary role. Secondly, the criteria for selecting the experimental sample were such indicators as age, gender, status and types of educational programs. However, additional variables that could potentially affect the results of the experiment, such as socio-economic status or cultural differences, were not taken into account. Studies by some scientists (Muijs et al., 2009; Pribesh et al., 2011) established the relationship of individual socio-economic characteristics of a person with different levels of cognitive skills development, the pace of learning, the availability of library and information resources for the implementation of this historical and methodological approach. Moreover, cultural differences can influence the formation of spiritual and moral qualities, values, beliefs and behavior of people (Sahin, Basgul, 2018).

Further promising areas include the possibility of applying the idea and algorithm of problem composition to other topics and sections of school mathematics. An example is the biography of I. Newton.

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The Problems of Formation of Civil Identity Among Students in the Process of Mastering Educational Programs of Secondary and Higher Schools

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Abstract

Formation of the civil identity of the population is an important task of each state. The results of many studies have shown that such identity is formed in citizens during their growing up period, which coincides with their education in secondary school, and consolidation occurs during the period of study in higher educational institutions. The basis of civil identity is the totality of knowledge about their state as a unique socio-cultural institution. The purpose of this study is to find out the degree of formation of knowledge of pupils and students on such basic components of the all-Russian civil identity as the Russian language, the history of the Russian state, state symbols and traditions.

The article was prepared within the framework of the project No. FSSW-2023-0002 "Formation of the all-Russian civic identity of youth within the framework of the implementation of the state youth policy of the Russian Federation and improvement of mechanisms for ensuring national security in the context of migration processes among youth", financed by the state assignment of the Ministry of Education and Science of Russia.

The results of the study showed that first-year students demonstrated significantly higher scores on questions about knowledge of the Russian language and Russian history compared to 11th-grade students. At the same time, the knowledge demonstrated by first-year students cannot be considered sufficient. The results obtained indicate the need to revise the programs of school and higher education and to build a motivational mechanism for senior secondary school students in order to improve and consolidate the level of knowledge that influences the level of all-Russian civic identity of young people.

Thus, the currently published results of other studies indicate a significant degree of theoretical elaboration of the problem of civic identity. At the same time, according to its individual basic components, there are still unresolved tasks in practice, including those related to the

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introduction of mechanisms for the formation of knowledge and skills acquired by young people during their studies at secondary and higher educational institutions through the system.

Keywords: civic identity, secondary school, higher education, youth, educational programs, Russian culture, Russian language, history of Russia, state symbols.

1. Introduction

Civic identity has repeatedly been the subject of scientific research and discussions in various scientific fields. First of all, it is necessary to pay attention to the results of studies on the concept, essence and identification of types of personal identity, on the place of civic identity in the aggregate of other types of identity and the relationship with them (Petrova, Odintsova, 2024; Galaktionova, 2010), on the elements of the structure of civic identity. In studies devoted to civic identity in a multinational state, the issue of its relationship with national identity is addressed, it is noted that strengthening civic identity helps to reduce the risk of interethnic conflicts (Razina, 2010). At the same time, measures aimed at forming civic identity can be successful only under the condition of normal interaction between state institutions and civil society institutions in the context of public trust in state institutions (Martynov, Purtova, 2013). At the same time, the process of forming civic identity should be built taking into account the elements of its structure, as well as a set of ideas about the main identifying features. The structure of civic identity consists of cognitive, value and emotional elements (Vodolazhskaya, 2010). Although various authors support this judgment, the issue of the set of identifying features is not resolved so clearly. A review of the diverse positions of researchers allows us to assert that the basis of the composition of such features for the all-Russian civic identity is the Russian language (Ikilikyan, 2017), Russian culture (Kanukova et al., 2017), Russian history (Buranok, 2022; Fadeev, 2021; Bagatova, 2021), official state symbols (Rosenberg, Karpova, 2024). At the same time, the formation of identifying features is especially active during the period of personality formation, therefore, attention should be paid to this process primarily in relation to young people in the process of receiving the necessary education. Thus, educational organizations at all levels of education in their activities have a direct impact on the formation, identity of civilization, and the identity of youth (Ivanova et al., 2024). Many scientists emphasize the need for humanitarian development of the individual and the introduction of the humanitarian component as the goal of the educational function of higher education (Vorobyeva, 2019; Danilkova, 2021; Vodenko et al., 2023).

Researchers emphasize the importance of historical education, the formation of historical memory of young people at the level of secondary and higher educational institutions, since the age of mastering basic educational programs by students is the most significant for them in the formation of ideological guidelines and civic identity (Bogatova et al., 2024). The negative consequences of insufficient attention to the teaching of Russian history in the domestic education system, including fragmentation, lack of historical knowledge, are noted.

The process of studying and demonstrating official state symbols has a significant educational effect on strengthening the degree of formation of civil identity, as well as the perception of regional symbols contributes to the formation of national identity in multinational states (Rosenberg, Karpova, 2024; Petrukhina, 2024).

The methodology for developing civic identity through the school course "Fundamentals of Life Safety" and its educational potential are given attention in the works of M.A. Kartavykh, I.A. Voronina, A.A. Arakelyan From an organizational standpoint, priority is given to the integration of classroom and extracurricular forms of education in the form of educational events (Kartavykh et al., 2021; Voronina, 2022).

The purpose of this study is to determine the degree of development of pupils' and students' knowledge of such basic components of all-Russian civic identity as the Russian language, the history of the Russian state, state symbols and traditions.

2. Materials and methods

The study was conducted based on a questionnaire survey of high school graduates and first-year students of higher education institutions. The total random sample consisted of 261 students, including 63 11th-grade high school students and 198 first-year full-time students in the following areas of study: Law, Legal Support of National Security, Business Informatics, Management, Advertising and Public Relations, Mathematical Support and Administration of Information Systems. The sample was randomly selected from among the participants of Open Days who also

wished to take part in the questionnaire survey as part of this study, as well as participants in all-Russian student scientific conferences. All of these events were held from March to June 2024 at the Plekhanov Russian University of Economics.

The questionnaire included questions on knowledge of the Russian language, history of the Russian state, state symbols and traditions. At the stage of evaluation of the results, analysis and comparative method were used. To test the hypothesis that the number of correct answers of schoolchildren and students is not affected by the level of their educational program, the chi-square criterion was used.

3. Results

Based on the questionnaire processing results were obtained, calculated as the number of people who chose one or more correct answer options. These values are presented as a percentage of the number of people who took part in the survey.

Figure 1 shows the results of the answer to the question about the correct construction of a phrase in Russian, and presents the ratio of the percentage of correct answers given by schoolchildren and students.

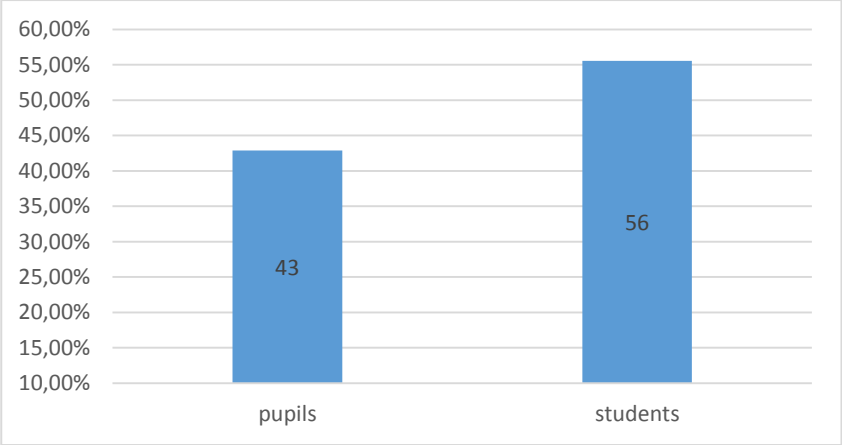

Fig. 1. Results of the answer to the question about the correct construction of a phrase in Russian

As can be seen from the figure, students gave more correct answers, but their value does not reach 60 %, while schoolchildren gave less than half correct answers.

Figure 2 shows the results indicating how well schoolchildren and students can correctly form the plural of a noun, they had to choose two correct answers from the proposed options concerning the two words "contract" and "keychain", where 1 is the correct plural of the noun "contract", 2 is the correct option the plural of the noun keychain".

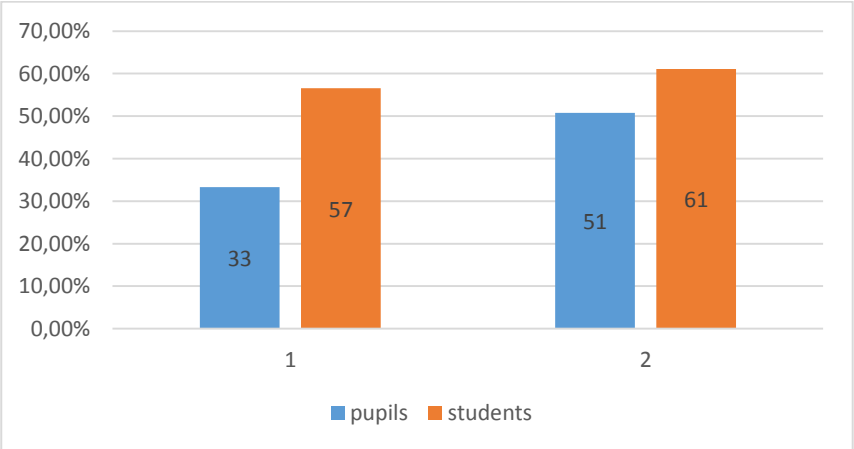

Fig. 2. Results of choosing the correct answers to the question about the plural of the nouns "contract" and "keychain"

Figure 3 shows the results of the answer to the question about the correct placement of stress in words, which assumed three correct answers, where 1 is the first correct answer, 2 is the second correct answer, 3 is the third correct answer. The results represent the percentage of schoolchildren and students who chose the correct answer.

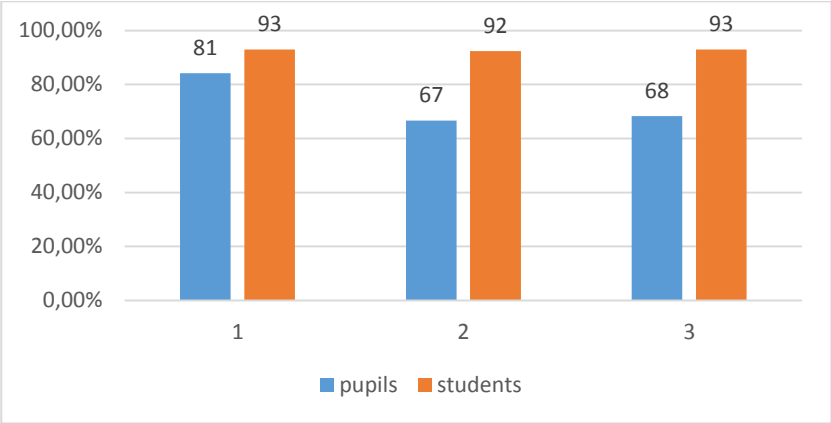

Fig. 3. Results of the answer to the question about the correct placement of stress in words

The respondents were asked to choose the correct ending of two proverbs. Figure 4 shows the results of the answer to the question about knowledge of proverbs, where 1 is the correct ending of proverb No. 1, 2 is the correct ending of proverb No. 2. As a result, the number of people who were able to choose the correct ending of each proverb was determined in percentage terms.

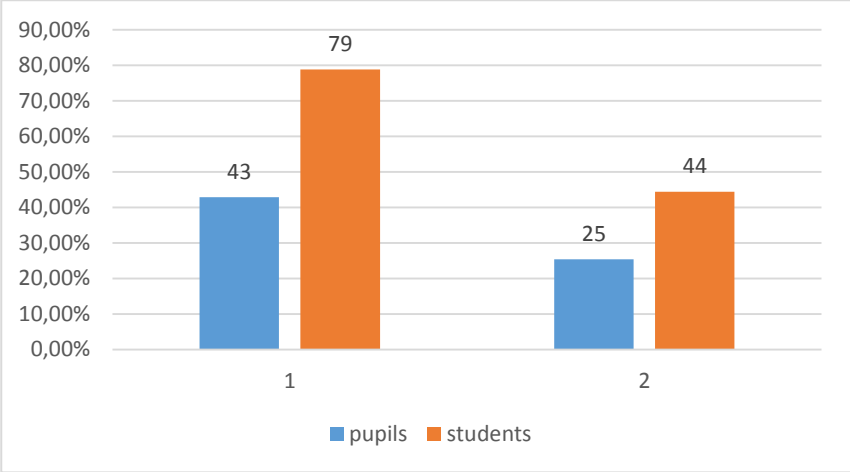

Fig. 4. Results of the answer to the question about the correct ending of proverbs

Thus, the average percentage of correct answers to questions aimed at testing knowledge of the Russian language among schoolchildren and students was 52 % and 71 %, respectively.

When answering question No. 5, it was necessary to arrange in the correct chronological order such events of Russian history as the abolition of serfdom, the Battle of Kulikovo, the annexation of the Kazan Khanate, the annexation of Crimea to the Russian Empire, the founding of the city of St. Petersburg, and the baptism of Rus. Figure 5 shows the results of the answers to the question about the chronology of events in Russian history. The results represent the percentage of schoolchildren and students who were able to correctly arrange the specified events in chronological order.

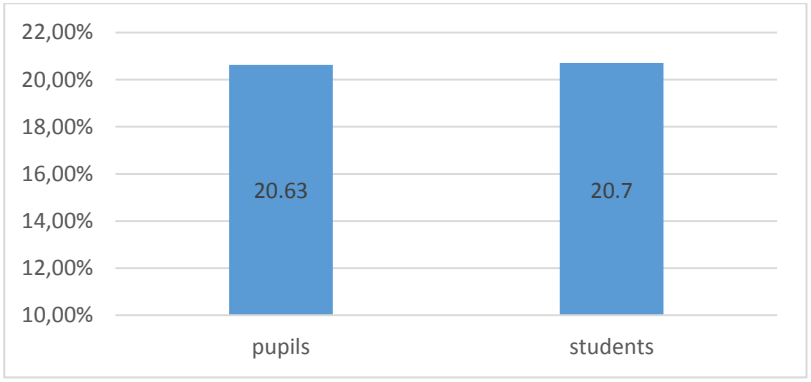

Fig. 5. The number of students and schoolchildren who have compiled the correct chronological chains of known facts of Russian history

The results of the answer to the question about the chronological sequence of events in Russian history are disappointing and differ among schoolchildren and students by several hundredths of a percent. For correct, error-free answers, it is one fifth of the total number of answers. At the same time, the results do not mean that most students have no idea about the time of a particular historical event, but made one or more mistakes.

Figure 6 shows the results of the answer to the question about who became the first Russian emperor. The results represent the percentage of schoolchildren and students who were able to answer this question correctly.

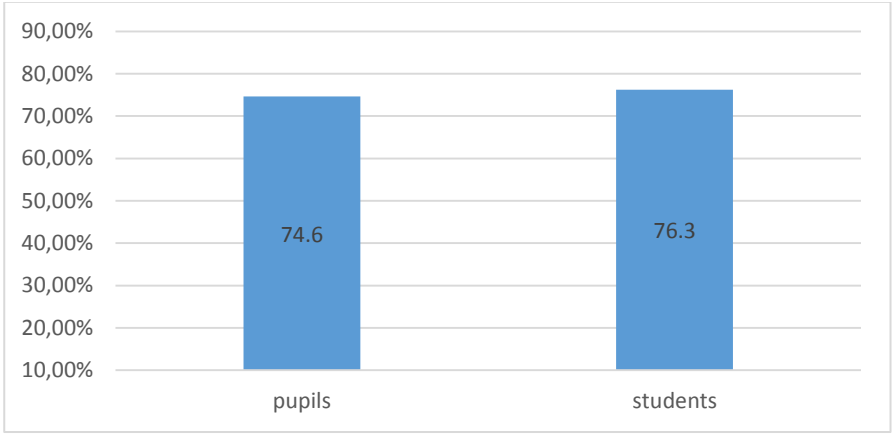

Fig. 6. Results of the answer to the question about the first Russian emperor

As can be seen from the results of the answer to the question about the first Russian emperor, students gave the correct answer more often, but only by 1.7 % compared to schoolchildren. In general, two thirds of respondents answered the question correctly.

Figure 7 shows the results of the answer to the question about the last year of the USSR. Students and schoolchildren had to choose one correct answer out of four.

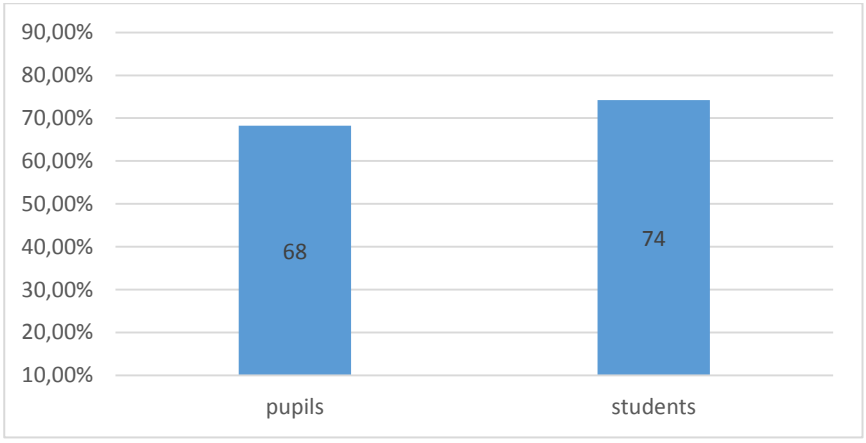

Fig. 7. Results of the answer to the question about the last year of the existence of the USSR

Schoolchildren and students were also asked what period of time corresponds to the years of the Second World War. Students had to choose from periods of other military events, including the need to demonstrate knowledge that the period indicated in the question was different from the period of the Great Patriotic War. Figure 8 shows the number of schoolchildren and students who chose the period 1939–1945.

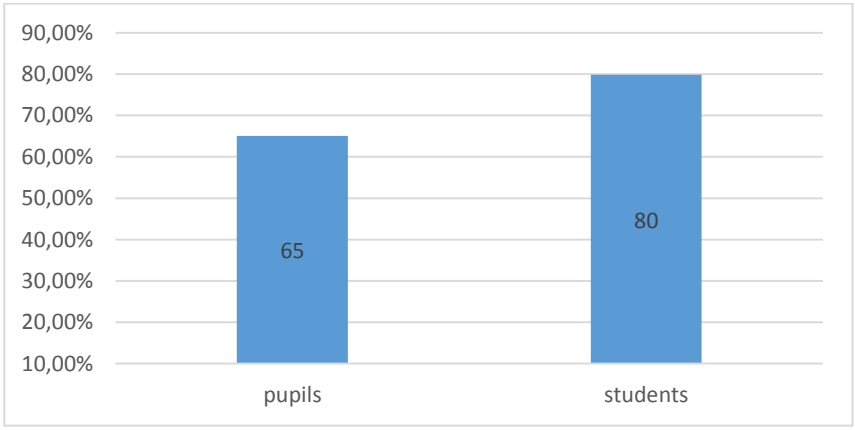

Fig. 8. The number of schoolchildren and students who gave the correct answer to the question about the time period corresponding to the years of the Second World War

Figure 9 shows the results of the answer to the question about the correlation of the names of Russian tsars with the nicknames that were attached to them. The question concerned such tsars as Dmitry Donskoy, Alexander Nevsky, Vladimir Monomakh, Vasily the Dark, Andrei Bogolyubsky, Ivan Kalita. As a result, the number of error-free answers was determined, and Figure 9 shows their percentage ratio to the total number of answers among schoolchildren and students.

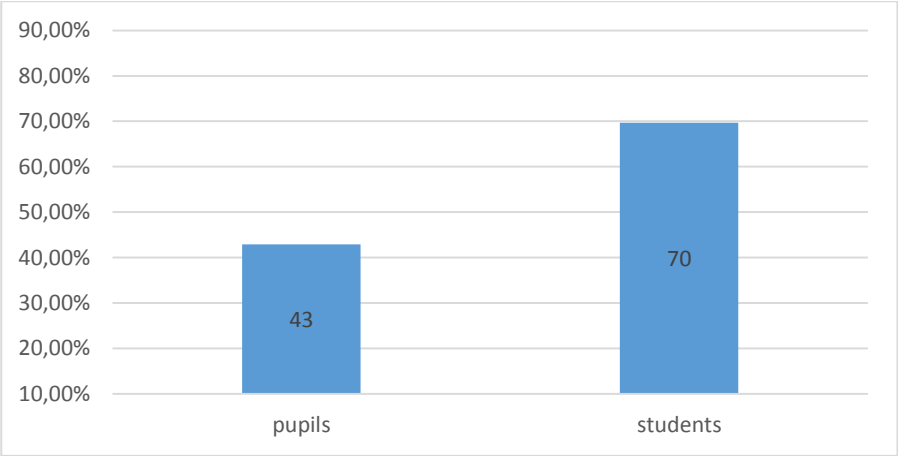

Fig. 9. Results of the answer to the question about the correlation of the names of Russian tsars with the nicknames assigned to them

Figure 10 shows the results of the answer to the question about wars and battles won by Russian (Russian, Soviet) troops. The following answer options were offered: the Battle of the Kalka River, the Battle of Kulikovo, the Patriotic War of 1812, the Crimean War, the First World War, the Great Patriotic War. As a result, the authors determined the number of people from among the survey participants who were able to choose the correct option (where 1 – Battle of Kulikovo, 2 – Patriotic War of 1812, 3 – Great Patriotic War) and calculated their percentage with the total number of survey participants for each correct option answer separately.

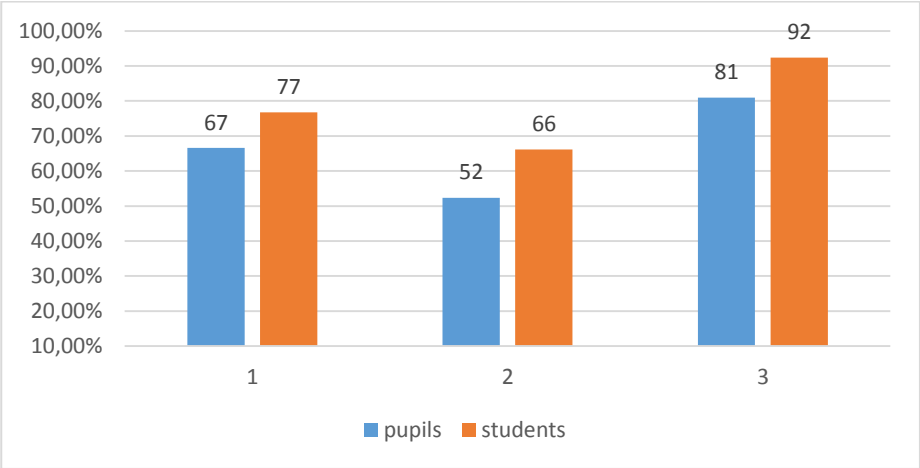

Fig. 10. Results of the answer to the question about battles won by Russian (Russian, Soviet) troops

Thus, the average percentage of correct answers to questions aimed at testing knowledge of Russian history among schoolchildren and students was 59 % and 70 %, respectively.

Figure 11 shows the results of the answer to the question about knowledge of the text of the National Anthem of the Russian Federation. When answering the question, it was necessary to indicate a line that is not in the text of the National Anthem. As a result, the number of people who correctly identified this line was determined, and their percentage ratio to the total number of survey participants among schoolchildren and students was calculated.

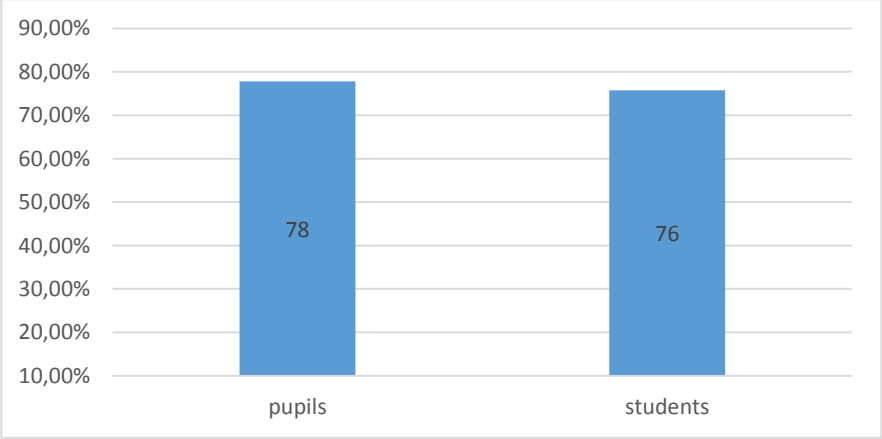

Fig. 11. Results of the answer to the question about the text of the National Anthem of the Russian Federation

These results show that schoolchildren made the right choice more often than students. In general, about two thirds of survey participants did not make a mistake when answering this question.

Figure 12 shows the results of the answer to the question about the background color of the State Emblem of the Russian Federation. When answering this question, it was necessary to choose one correct answer out of four. As a result, the number of people who correctly indicated the color of the State Emblem was determined, and their percentage ratio to the total number of survey participants among schoolchildren and students was calculated.

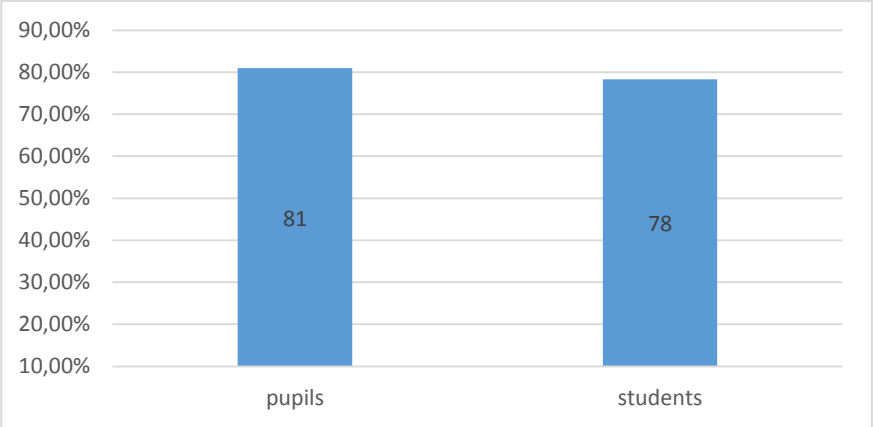

Fig. 12. Results of the answer to the question about the color of the State Emblem of the Russian Federation

Thus, the average percentage of correct answers to questions aimed at testing knowledge of official state symbols among schoolchildren and students was 79 % and 77 %, respectively.

The results of the study showed that first-year students showed significantly higher scores on questions about knowledge of the Russian language and Russian history compared to 11th-grade students. The gap in some cases is up to 40 percentage points. At the same time, schoolchildren showed a slightly higher score on questions about official state symbols, although the gap is not too large and is only 2-3 percentage points. Such results are quite natural.

The study also tested the hypothesis that the number of correct answers given by respondents does not change among students and schoolchildren, that is, about the equality of the probability of a correct answer to questions among schoolchildren and students, based on the use of the chi-square criterion at a significance level of $p = 0.05$ and a degree of freedom of $C = 1$. With $\chi^2_{crit} = 3.84$, the χ^2_{emp} values were calculated for each question of the questionnaire in relation to schoolchildren and students who chose the correct answer and made a mistake.

As a result, the following values of χ^2_{emp} were obtained: for questions on knowledge of the Russian language: 2.85; 10.32; 2.1; 4.43; 26.67; 25.68; 29.45; 7.23. Thus, when answering 75 % of questions on knowledge of the Russian language, the null hypothesis was not confirmed, which means that the probability of a correct answer to questions on the Russian language in most cases depends on whether the participant in the survey was a schoolchild or a first-year student.

As a result, the following values of χ^2_{emp} were obtained: for questions on knowledge of Russian history: 0.0002; 0.072; 0.87; 5.72; 14.81; 2.56; 3.87; 6.78. Thus, when answering questions on Russian history, the null hypothesis was not confirmed in only 50 % of the questions asked, which means that the probability of a correct answer to questions on Russian history cannot be unambiguously made dependent on whether the survey participant was a schoolchild or a first-year student.

As a result, the following values of χ^2_{emp} were obtained: for questions on knowledge of official state symbols: 52.36 and 9.46. Thus, when answering questions about official state symbols, the null hypothesis was not confirmed in 100 % of the questions asked, which means that the probability of a correct answer to questions about official state symbols depends on whether the survey participant was a schoolchild or a first-year student.

4. Discussion

The limitation of the conducted study and the conclusions obtained is that the sample on the basis of which the study was conducted was not formed in a random (probabilistic) way, but was spontaneous, which limits the possibility of generalizing the results of the study.

At the same time, the obtained results confirm the results of other studies demonstrating that most young people receive information about the state symbols of the Russian Federation primarily from schools – 87.4 % (Rosenberg, Karpova, 2024). On the one hand, it is logical to assume that the tradition of singing the National Anthem and raising the National Flag introduced in secondary schools, aimed at forming and strengthening patriotic and civic feelings even in childhood, should have been consolidated during school education and will not be lost among young people when they study in higher education institutions. On the other hand, the absence of general mandatory requirements for universities to organize the educational space and process in such a way that official state symbols would be an integral part of the space of classrooms, assembly halls and other premises, any official events, leads to a weakening of students' attention to the content of these symbols. The results of this study on the ambiguity of the relationship between the level of the educational program of students and the level of knowledge of Russian history confirm the results of previously obtained studies that Russian history lessons are not the only source of information on the history of Russia in demand among young people, especially when it comes to medium and low levels of involvement (Bogatova et al., 2024). Fiction, films, family members' memoirs and new media have the most significant impact on the formation of young people's ideas about historical events. At the same time, such sources of information cannot claim to be exclusively reliable, and therefore the ideas formed on their basis do not allow students to subsequently achieve high levels of knowledge of Russian history. At the same time, the choice of information sources with an artistic multimedia form indicates that the information presented in them is better remembered due to the fact that its consumption also involves an emotional component.

The results of the study on the insufficient level of knowledge of the Russian language by students, although with a significant difference between the level of schoolchildren and first-year students, confirm the results of other studies on the limited knowledge of students after graduation in first-year disciplines. They have developed the spelling skills, which is a natural requirement for admission to university, other skills, mainly competent speech communication, have not been properly consolidated, since they are usually not among the requirements for academic disciplines of the first year in the absence of the discipline "Russian language" in the curricula. In this connection, the shortcomings that were not eliminated at the previous level of education of young people and the gaps that exist in the educational programs of higher education become obvious (Barakhoeva, 2022).

5. Conclusion

The obtained results indicate that, firstly, the process of forming civic identity in terms of acquiring fundamental knowledge does not end upon completion of secondary school by students, and therefore requires attention in the process of mastering higher education programs. Secondly,

the existing order of organizing the educational process both at the level of secondary education and at the level of higher education does not allow for the formation and (or) consolidation of a sufficiently high level of knowledge in the most essential areas for the formation of all-Russian civic identity, such as the Russian language, Russian history and state symbols. Considering that the respondents were asked very simple questions, it is not possible to consider the obtained results sufficient. Thirdly, the authors came to the conclusion that the revealed gap in the indicators of correct answers to questions between the group of schoolchildren and students is influenced, first of all, by the existing mechanism of admission to higher education institutions, which motivates young people to a more responsible attitude to learning. Higher education institutions conduct a competitive selection of applicants, as a result of which better prepared graduates are enrolled in higher education programs. Indeed, despite the fact that the discipline "History of Russia" is taught in the first year of all bachelor's degree programs, the success of answering the relevant questions of the questionnaire cannot be made dependent on whether the participant in the questionnaire was a schoolchild or a first-year student, which is confirmed by the results of statistical analysis based on the chi-square criterion. And for groups of questions not directly related to first-year academic disciplines, such as the Russian language and state symbols, a predominant dependence was revealed between the choice of the correct answer and the level of the educational program. This means that the resource for raising the level of knowledge in these areas by universities has not yet been exhausted, which, in the opinion of the authors, will be facilitated by the efforts of higher education institutions to introduce the relevant academic disciplines into educational programs.

As the results of the study showed, pupils and students need to improve their knowledge of such basic components of the all-Russian civil identity as the Russian language, Russian history, state symbols. The authors of this study believe that the solution of such a task should be based on the revision of discipline programs and requirements for results that school graduates and students must meet. Schoolchildren are overloaded with the requirements of educational programs. School education programs need some revision. Some disciplines involve studying such sections in the final grades, the knowledge of which will not help every graduate in his or her life and professional sphere. At the same time, there is often not enough time to obtain and consolidate the knowledge that forms the all-Russian civil identity. On the eve of passing the Unified State Exam, already in middle school, students strive to limit themselves to only the knowledge that will be assessed within the Unified State Exam and will be useful for admission to higher education programs. In conditions of increased motivation, such as the desire to enter higher education institutions, students are able to achieve higher results. At the same time, not all young people who have graduated from school have an objective opportunity to obtain higher education. This means that motivational mechanisms for improving knowledge within the components of the all-Russian civic identity should operate during the period of study in senior classes. At the same time, first-year students who passed the relevant competition for admission to higher educational institutions, also, with rare exceptions, did not achieve the indicator of correct answers to the simplest questions by more than 80 %. In this case, it seems that it is necessary to pay much more attention to the structure of educational programs, to include in it disciplines or elements of disciplines aimed at raising the level of students' knowledge of Russian history, Russian language, state symbols and traditions. It is necessary to form the students' idea that knowledge of the Russian language and Russian history are necessary not only for the successful completion of the session, but are necessary throughout the educational process, applicable in all academic disciplines. Therefore, the strengthening of training in these areas of knowledge should also be ensured by appropriate requirements for other disciplines, for example, on increasing the requirements for the use of professional and colloquial vocabulary, on the ability to analyze the stages of development of events and phenomena in the professional sphere through the prism of events in Russian history.

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Teachers' Perceptions of the Contextual Factors that Support Teacher Leadership in School: A Co-Creation Perspective

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Abstract

This study has aimed to reveal the complexities of the contextual factors that support teacher leadership. Contextual factors reflect the environment where teachers work; they include but are not limited to teaching practices, trust in the support teachers receive from school administrators, school climate, parents' views, and school culture. In the study, co-creation has emerged as an overarching factor in managing the complexity of the contextual factors that support teacher leadership. This study was based on a qualitative research design involving thematic analysis. Data were collected through semi-structured interviews with 42 schoolteachers from Lithuania, and purposive sampling was applied. The results suggest that administrative support, school administrators' attitudes toward teacher leadership, teachers' co-creation-based formal and informal learning of leadership skills, teachers' partnership and collaboration with school communities, the use of learning spaces, and the modeling of educational processes through co-creation practices are contextual factors that influence the emergence and development of teacher leadership in school.

Keywords: co-creation, contextual factors, school context, semi-structured interview, teacher perceptions, teacher leadership, thematic analysis.

1. Introduction

Teacher leadership is a pivotal factor that significantly influences educational success and student achievement (Leithwood, Jantzi, 2000; Marzano et al., 2005). Since the 1980s, research on teacher leadership has attracted substantial interest. Efforts have been made to conceptualize teacher leadership (Wenner, Campbell, 2017), to analyze the internal and external factors that contribute to the emergence and growth of leadership (Jäppinen, 2017; Liu, 2021), to explore how leadership stimulates school change and improvement of the quality of schools (Geijsel et al.,

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2003), and to achieve many other aims. A large body of research has focused on teacher leadership, student achievement (Leithwood et al., 2008; Leithwood et al., 2010), and the development of school culture (Deal, Peterson, 1999). Some studies have specifically examined school-level and personal factors, such as lack of time, language barriers, and leadership style, or personal factors such as teachers' assumptions about and willingness to take on additional leadership responsibilities (Al-Taneiji, Ibrahim, 2017).

A growing body of research (Ainscow, West, 2006; Hallinger, Heck, 2011; Leonard, Leonard, 1999) has highlighted that teacher leadership is intrinsically linked to educational community and collaboration; as a result, leadership research adopts a broader perspective wherein leadership is regarded not only as an individual phenomenon but as a product of a school's culture and wherein each teacher's role is viewed in relation to other teachers and to students. It is natural, therefore, that research has begun to explore contextual factors that stimulate the emergence and development of teacher leadership. Contextual factors reflect the environment where teachers work and include, but are not limited to, teaching practices, trust in the support teachers receive from school administrators, school climate, parents' views, and school culture. Thus, many studies have focused on the development of school culture as an important element in the manifestation of leadership, emphasizing the contributions of all members of the school community to the development of an open and supportive culture (Roby, 2011). Teachers' opinions concerning cultural and organizational issues are important in determining whether they will accept leadership roles (Mulford, Silins, 2003). However, cultural and organizational factors are diverse and include many complex components. One such component is trust, which is important in organizational culture and has a stronger association with teacher collaboration and a positive work environment than the other criteria (Demir, 2015).

Within this field of research on contextual factors, a growing body of research is increasingly examining not only collaboration between community members (teachers, administrators, students, parents) but also the phenomenon of co-creation, in which leadership is exercised through an open and ongoing co-creation process (Geurts et al., 2023). This co-creative practice was defined as a "collaborative, reciprocal process" that engages all participants of the school community (Cook-Sather et al., 2014). Collaborative and co-creative factors are emphasized in Cassata and Allensworth's (2021) study, which highlights five patterns of teacher leadership actions – inspiring others, sharing with colleagues, working in collaboration, advocating for change, and providing individual support—and underscores the interactions between these teacher actions and school-level contextual factors. Some contextual factors are more important than others in relation to different types of actions, and particular attention should be devoted to sharing and collaborative work.

Although collaborative aspects have been considered contributors to teacher leadership (Schiff et al., 2015), limited attention has been dedicated to the complexity of contextual factors in relation to co-creation, such as how co-creation enhances the emergence and development of teacher leadership. For this reason, this study aimed to explore and describe the teachers' experiences regarding the school-level factors through the lens of the relationship between co-creation and support for teacher leadership. It raises the following research questions: What are teachers' perceptions regarding the contextual factors that support their leadership at school? How do teachers' experiences support their leadership through co-creative practices at school? The study thematizes teachers' experience-based perceptions of the contextual factors that support teacher leadership in school through a co-creative approach.

2. Literature review on the emergence of co-creative factors in teacher leadership studies

Teacher leaders do not act in isolation. An analysis of the scientific literature has revealed a dominant focus on shared leadership approaches (Harris, DeFlaminis, 2016), which implies that teacher leadership is strongly linked to a school's community and can be successfully realized through the active contributions of all community members. Teacher leadership is viewed as an essential component of effective school leadership, as one person cannot work alone to make the changes needed to fulfill students' ever-changing learning and school community needs (Timperley, 2005). Teacher leadership encompasses work at schools on different levels with students, colleagues, and school administrators and work that is focused on instructional, professional, and school development (York-Barr, Duke, 2004).

Further expounding upon the role of stakeholders and community members who support and maintain leadership at schools, Schieffer (2006) introduced the concept of co-creative leadership. He contended that leadership is primarily about ensuring that the members of an organization work together to achieve a common goal and solution. In organizations, it is typically not possible to successfully mobilize a community toward a common goal; this is because different groups within the same organization tend to compete or act separately. Schieffer (2006) argued that in today's complex environment, it is extremely difficult to maintain team leadership. Co-creation in a contemporary school is embedded in teacher leadership (Kaminskienė et al., 2022; Schieffer, 2006). It is closely associated with the school's culture and with community members' collaboration; however, it transcends simple collaboration, as it implies sharing responsibilities, redistributing power, creating new learning environments, initiating transformational change, and other endeavors. These aspects indicate that co-creation in teacher leadership manifests in transformational leadership practices (Spillane et al., 2004). Therefore, it makes sense to seek means to express leadership that integrate the different perspectives of the members of an organization; this can help to determine a common position or solution and to strengthen the agency of community members.

One of the pre-requisites for co-creation to develop in schools is related to the fact that contemporary organizations are becoming increasingly flat, less hierarchical, and that co-creative and self-directed management represents a new direction that can help today's schools operate in a complex and changing environment (de Souza, Begeer, 2020). In this manner, teacher leadership has become associated with teachers' intrinsic motivation, peer support, rapport with pupils, and trust.

Co-creation as a new practice and as an emerging concept in education allows us to analyze teacher leadership through new perspectives linked to the development of the agency of school community members, particularly teachers and learners (Geurts et al., 2023; Kaminskienė et al., 2020). Teacher leadership, as expressed through co-creative practices, confers a more holistic understanding of leadership for learning (MacBeath et al., 2018). It is characterized by a consistent focus on learning, a trusting climate, and qualitative dialogue about improvement, which is expressed as a multifaceted and complex narrative that takes place within and outside an organization (Robinson, Smith, 2014). Thus, teacher leadership in a co-creative paradigm stimulates the reassessment of existing power relations and dominant practices at schools (Jarrett et al., 2010).

The co-creative approach to teacher leadership holds that school principals play a role in sustaining a favorable school climate and environment to foster teachers' collaboration and co-creative practices. At the same time, a co-creative approach to teacher leadership helps to investigate teaching improvement (Coenen et al., 2023), assuming that school administrators no longer have to maintain teacher leadership single-handedly because teachers can seek support and encouragement from one another first. Thus, revelations in the research have suggested that despite the recognized support of school administrators, which contributes to teacher leadership, schools often depend on "in-group" teachers to take on leadership activities (Al-Taneiji, Ibrahim, 2017).

Recent studies on teacher leadership reveal how teacher leadership is implemented in the classroom through collaborative practices. It should be acknowledged that co-creation research more often focuses on higher education and emphasizes the role of students as co-creators in the educational process (Bovill et al., 2016; Bovill, 2019). However, research on teacher leadership at school suggests that collaborative learning in the classroom is related to teachers' values, pedagogical approaches, support for self-regulated learning skills, and the promotion of collaborative teamwork through active learning methods. Co-created initiatives enable experiential, problem-based, and active learning (Kaminskienė, Khetsuriani, 2019). Research findings also suggest that co-creation can contribute to a strengthened learning community in the classroom and at school in general. The use of co-creation practices results in improved quality of teaching and learning, which is meaningful to both teachers and students. Additionally, co-creation stimulates a variety of peer learning models and enhances experiential learning, leading to better engagement, meta-cognitive awareness, and a stronger sense of identity among learners (Cook-Sather et al., 2014).

The literature on the co-creative approach to teacher leadership is not vast; thus, this study aims to reveal the complexity of the contextual factors that support teacher leadership when co-creation appears to be an overarching factor. This co-creative perspective, which regards teachers as active agents in the school community, can help to understand new and emerging factors that support and nurture teacher leadership at schools.

3. Research methodology

Research design

Qualitative research is important in educational research, as it addresses the "how" and "why" of research questions and enables a deeper understanding of experiences, phenomena, and relevant contexts. The study used a qualitative research design for two primary reasons: first, qualitative research allows the researcher to ask questions about matters that cannot be easily quantified to understand human experiences; second, exploring the everyday realities of social phenomena and studying important questions can help to extend our knowledge and understanding (Cleland, 2017).

Sample

A purposeful heterogeneous sample was developed using maximum variation, which allowed the research participants to share patterns that they had observed (Palinkas et al., 2016). The appropriateness of the sampling type determined the selection of teachers as members of a professional community.

The following criteria were applied for the selection of research participants: educational experience of at least three years, minimum age of 22 (coinciding with the completion of at least a bachelor's degree), having worked as a teacher at a school, and having taught different subjects in school. The teachers who participated in the interviews represented schools from large cities, small towns, and rural areas as well as public and private schools (six from primary, nine from lower-secondary, and 27 from high schools). In this manner, a sample was formed that would reflect the diversity of concepts and experiences in terms of contextual factors related to support for teacher leadership in school.

In this qualitative study, personal and direct methods were used to gain the consent of the research participants, to recruit them (e.g., via phone or in-person recruitment), and to establish rapport and trust with them. Their participation was confirmed through a follow-up email, phone call, or text message, wherein researchers reminded the participants of the date, time, location, and duration of the research session as well as the purpose and expectations of the research (Newington, Metcalfe, 2014). Participants who met the selection criteria were recruited until data saturation had been achieved (Jalali, 2013). The sample size was determined by the principle of data saturation. Data saturation is the point in a research process where enough data has been collected to draw necessary conclusions, and any further data collection does not produce value-added insights. It is a process-oriented concept, meaning that there is no specific point at which no new information can be obtained from additional data (Rahimi, Khatooni, 2024). A total of 42 teachers were interviewed.

Table 1. The characteristics of the research participants

Aged	22-64 years old;
Gender	14 men, 28 women;
Work experience	3-42 years;
Education	– tertiary level: 32 university graduates with a bachelor's degree and 10 from college with a professional bachelor's degree, – 30 graduates of educational studies and 12 graduates of studies in other subjects (history, biology, theology, philosophy, natural sciences, and technologies);
Teaching subject	4 in physics or mathematics, 4 in biology, 4 in history, 2 in basics of citizenship and economics, 5 in foreign languages, 5 in Lithuanian language and literature,

	6 in primary education, 4 in information technology, 2 in philosophy, 2 in economics, 2 in arts, 2 in music.

Data collection

The data were collected from 2020 to 2022 in an online format using semi-structured individual interviews with open-ended questions. A semi-structured approach entails guiding the research participants to reflect on their experiences with a particular phenomenon and inspiring deeper reflections, which are conveyed as experience-based narratives (DeJonckheere, Vaughn, 2019). The interviews provided the opportunity for teachers to relay their direct experiences with the phenomenon of leadership by narrating it specifically (Maguire, Delahunt, 2017).

The overall purpose of using semi-structured interviews for the data collection process was to gather information from informants regarding their personal experiences, attitudes, perceptions, and beliefs related to the topic of interest. The researchers used semi-structured interviews to collect new, exploratory data related to the research topic (Lincoln, Guba, 1985). The semi-structured interviews enabled the researchers to collect qualitative, open-ended data and to explore participants' thoughts, feelings, and beliefs about particular topics (Schoenborn et al., 2017).

In this study, researchers used the following approaches to help them plan for and conduct the semi-structured interviews (Jamshed, 2014):

1. Preparing for the interview: Researchers wrote down what information they wished to obtain. They did this by reviewing past observations and identifying gaps in the information. The researchers discussed the areas they needed their participants to elaborate upon.

2. Writing a guide: Once researchers had an idea of what questions they needed to be answered, they wrote a guide that included key topics and questions. Since the interviews were not formal, the researchers knew that they did not have to rigidly adhere to the guide. The researchers decided to approach specific research participants according to a unified list of topics and questions.

3. Introducing the self and building a rapport: Once the interviewee had joined the interview, the researcher introduced themselves, became comfortable with the participant, and explained the purpose of the interview. This included presenting topics they planned to cover during the interview.

4. Starting with the simple questions and transitioning to specific questions: The specific questions arose when research participants were discussing their experiences.

5. Being mindful of interview questions: Asking the right types of questions was vital to facilitate the success of the interviews. Researchers ensured that their questions were open-ended, and they avoided leading questions.

6. Recording and transcribing the interviews: This involved listening to the audio files and typing out the spoken words. Researchers used a text editor to transcribe the interviews manually. This required strong listening skills, a rapid typing speed, and attention to details.

Researchers developed and used an interview guide with the list of topics that needed to be addressed during the conversation (DeJonckheere, Vaughn, 2019). The topics were as follows: school administrators' support and attitudes regarding teacher leadership, teachers' leadership skills, teacher leadership within interactions with students and fellow teachers, teacher leadership in relation to teaching and learning co-creation in the classroom. All formulated questions began with the same wording: "Please share your experiences about …" The open-ended nature of the questions provided opportunities for both the interviewer and interviewee to discuss topics in greater detail (Schoenborn et al., 2017).

Each interview was composed of two parts:

– The participants were asked about their experiences related to their pedagogical background and work in school. This helped to build rapport with teachers and contextualize their experience-based answers.

– Experience-based perceptions of the phenomenon of leadership were focused on uncovering a thorough account of contextual factors that support teacher leadership in school.

The participants were asked to narrate their experience-based perceptions of support for teacher leadership at school with a focus on contextual factors and co-creation. The concept of 'contextual factors' was shortly presented to research participants as characterizing schools as

dynamic systems that influence a broad range of dimensions of student learning, including academic, affective, social, and behavioral domains. A school's context shapes the core processes of teaching and learning in classrooms. Such an explanation did not limit the narratives of the research participants' experiences but provided clarity. This explanation added to the study participants' understanding of contextual factors and thus avoided reducing the validity of the study.

The following were the main interview questions:

1. Please narrate any experiences that reflect your perceptions of contextual factors that support your leadership at school.

1.1. Please share the experience-based cases, examples about supportive actions of administrators to sustain teacher leadership in school.

1.2. Please share experience-based cases, examples about school administrators' attitudes toward support for teacher leadership.

2. Please share your experiences related to support for your leadership through co-creative practices at school.

2.1. Please share experience-based cases, examples about your formal and informal learning of leadership skills.

2.2. Please share experience-based cases, examples about your leadership through co-creation-based collaborations with students, fellow teachers, and the school community.

2.3. Please share experience-based cases, examples about your use of learning spaces in teacher leadership through co-creation.

2.4. Please share experience-based cases, examples about your leadership related to modeling the educational process through co-creation practices.

The goal of the interview was to get as detailed narratives, stories, and details about their expressions of leadership at school as possible from each research participant, rather than facts without context.

The shortest interview lasted 64 minutes, and the longest was 101 minutes. The average duration of one interview was 87 minutes.

Data analysis

A thematic analysis was conducted for the data analysis. The goal of a thematic analysis is to identify themes or patterns in the data that are important or interesting and to use these themes to address the research or draw conclusions about an issue (Braun, Clarke, 2006). This methodology is not related to a particular epistemological or theoretical perspective (Clarke, Braun, 2013). Data was analyzed using Braun and Clarke's (2006) six-step framework:

1. Becoming familiar with the data: Read and re-read the transcripts while becoming familiar with the entire body of data and taking notes about early impressions.

2. Generating initial codes: Organize the data in a systematic manner using open coding. This means that the researchers did not have preliminarily formed codes; rather, they developed and modified them through the coding process. The researchers worked through each transcript coding that seemed to specifically address the research questions. After finishing the coding, the researchers compared their own codes created from the same data; they then discussed and modified them and formed a consensus regarding the final list of codes by generating new ones or modifying the existing ones.

3. Searching for themes: Examine the codes and synthesize them into a theme. This means that the codes were organized into broader themes.

4. Reviewing themes: Review, modify, and develop the preliminary themes identified in step 3. For this step, the researchers read the data related to each theme and considered whether the data supported it. They then discussed whether the themes fit into the context of the entire data set, as themes should be coherent and distinct from each other.

5. Defining themes: Identify the "essence" of each theme by revealing what the theme conveys, how the themes interact with and relate to the main theme, and how the themes relate to each other.

6. Writing: Prepare the research report, manuscripts, and conference presentations.

A semantic approach was applied for analyzing the explicit content of the data. With a semantic approach, the themes are identified within the explicit or surface meanings of the data and the analyst is not looking for anything beyond what a participant has said or what has been written (Braun, Clarke, 2006).

Ethics

Ethical approval for the research study was obtained from the Board of Ethics of Vytautas Magnus University (12.02.2020, Protocol No. 2). Trustworthiness was established through the fulfillment of the following parameters (Ainscough et al., 2018; Halkoaho et al., 2012): credibility, transferability, dependability, and confirmability.

The *credibility* of the data collected is representative of the phenomenon under study, namely the contextual factors that support teacher leadership in school. The credibility of the qualitative data was ensured through multiple perspectives throughout the data collection process to ensure that the data are appropriate. This was done through investigators' triangulation; the data was collected and analyzed by three researchers (authors of manuscript). The interviews were conducted by all three researchers, each of whom communicated with different research participants and then independently transcribed the audio recordings of the interviews. The researchers forwarded the texts of the transcriptions to each other, read them to become fully familiar with the content of each interview, and engaged in several reflective discussions about the content to synthesize and distinguish between elements of the interviews. Such discussions were a prerequisite for the data analysis. Each researcher independently analyzed the texts of the transcribed interviews. Each analyzed interview was sent to the other two researchers so that the whole team became familiar with the sub-themes and the themes connecting them.

Transferability concerns the applicability of findings to similar contexts or individuals as opposed to broader contexts. The findings concerned teacher leadership, school environments, and co-creation in relation to teacher-student collaborations in the classroom. The results provide prerequisites for teachers and school administrators to reflect on their schools' culture and teachers' leadership role within it as well as teaching/learning environments where learning co-creation between teachers and students is relevant.

Dependability was ensured through rigorous data collection techniques and procedures and analyses that were well documented.

Confirmability was documented via clear coding through triangulation, wherein three researchers (authors of manuscript) checked the data to account for their potential personal biases.

4. Results

The findings revealed the co-creation-based contextual factors that support teacher leadership in school. Each factor included sub-themes classified into broader themes. Based on the themes in the content structure of each factor, a central theme emerged as an integral concept related to the influence of each specific factor (see Table 2).

Table 2. Themes and subthemes

Themes	Subthemes
Supportive actions of administrators to sustain teacher leadership in school	Recognizing the teacher leadership exhibited through teachers' initiatives Motivating teachers to be active and creative Communicating equally with the teachers Fostering co-creation through communication culture
School administrators' attitudes toward support for teacher leadership	Caring about enhancing teaching quality by providing teachers with necessary tools Encouraging teachers through being open to their suggestions Trusting in teachers' leadership by providing opportunities to make autonomous decisions Empowering teachers for leadership through involving in activities and engaging in problem solving
Teachers' co-creation-based formal and informal learning of leadership skills	Fostering school community engagement through sharing ideas with each other Building rapport through collaboration with fellow teachers Building consensus with fellow teachers by sharing experiences, ideas and helping each other

Themes	Subthemes
Teacher leadership through co-creation-based collaborations with students, fellow teachers, and the school community	Constructing a general vision of activities within the teachers' community Cooperating with fellow teachers and students by providing evidence of mutual learning Creating authentic connections with students Building mutual trust with students
The use of learning spaces in teacher leadership through co-creation	Increasing students' motivation of learning through encouraging learning-related communication and cooperation Using school spaces for students' targeted learning and concentration
Teacher leadership related to modeling the educational process through co-creation practices	Cooperating with students in teaching and learning activities Collaborating with students in determining the quality of the teaching Accepting help from students by contributing to teachers' self-learning Cooperating for discovery-based learning through listening to students' needs and suggestions Realizing the own expertise in educational processes by fostering students' engagement

Supportive actions of administrators to sustain teacher leadership in school. School administrators supported teacher leadership morally, socially, materially, and intellectually by recognizing teachers' contributions to increasing students' creative potential; supporting teachers' initiatives related to organizing extracurricular activities; communicating equally with teachers; and inviting them to participate in decision-making. School administrators recognized the teacher leadership exhibited through teachers' initiatives, including organizing events with students and participating in competitions with students based on co-creation:

The teacher's leadership in the school is visible and supported. I can experiment in my professional activities by applying methods, creating educational environments in the classroom, organizing outdoor learning, i.e. going outside the classroom with students to understand the subject matter through real-life experiences. The school administration supports teacher's leadership in a professional and social sense – provides opportunities to study in high-quality professional development courses, buys the necessary teaching tools and books. We as teachers are recognized at school – it's nice to be seen and praised. The school administration is always open to discussions and joint decisions. I see my mission in leadership through the development of students' creative potential, so my contribution is to inspire, encourage, support them through training and empowerment for motivated learning (R24).

I am convinced that extracurricular activities contribute to the reduction of student dropouts and increase their creativity. Therefore, I organize various activities for students, excursions, discussions by inviting authoritative and high-achieving people from society. All of this contributes to increasing students' self-awareness and self-confidence and strengthens students' social and moral competences. My extracurricular activities are always supported by the school administration socially, intellectually, and materially. Teachers' activity in organizing extracurricular activities is encouraged at school and visible (R22).

School administration is not one-sided – teachers are always invited to get involved in decision-making. The school administration talks and treats teachers as equals. The school administration supports the teacher's leadership not only through conversations, but also through concrete actions (social and moral support, material methodical strengthening), when the teacher is innovative, when the teacher does more than work with students only in the classroom. Many of our teachers prepare students for various competitions, knowledge Olympiads, exhibitions, concerts and etc. – it depends on the specific educational subject. Students like it, because through various activities they believe in their own strengths and creativity, and contribute to the co-creation of learning, when students learn from each other, and teachers exchange their knowledge, ideas, and creativity with students (R8).

The teachers felt that the school administrators supported their leadership initiatives. Thus, they were intrinsically motivated to be active and to create:

When I feel that I am visible, the school administration supports my ideas, then I have an internal motivation to move forward – to initiate, to give more and more through working creatively, and to do it in the name of student well-being through learning. And I think to myself – how important it is when you are not ignored, when you can do what you want. It grows wings. Then I go to school with pleasure and my dedication to students is getting stronger. The work of a teacher is not professional monotony, these are daily challenges, and in order to overcome them, I have to constantly grow and improve. And that requires constant learning. Therefore, requests to support participation in events, courses, seminars, conferences are always satisfied by school administration. Because the administration sees the result. I implement the innovations by working with the students. The teacher's activity and creativity are greatly supported by the school administration (R19).

To me, being a leader means being a creative, active, innovative teacher. I have to empower myself for this, because I need to devote extra time to both personal, professional development and the involvement of students in various non-typical activities inside and outside the classroom during learning. All ideas are supported by the school administration, because they see that the ideas work – the students are satisfied, the learning results are good enough. And when I am supported, then there is an internal motivation to come up with something else, to strive for even better student learning results. It's like a learning circle or spiral. I think it is good when a teacher does not feel alone with his/her ideas and the school administration recognizes them. Then learning in the classroom becomes a kind of learning laboratory (R2).

School administrators communicated equally with the teachers by supporting their leadership. Thus, ensuring open communication between the teachers and the administration by encouraging teachers to provide suggestions was part of the communication culture, thus fostering co-creation in the school culture:

I don't experience hierarchy at school. I feel understood and supported. I don't have to be afraid to say what's wrong. A culture of openness and equality is being created in the school. And teachers are also very involved in creating and maintaining such a culture. I love the way we all communicate because it's a strong part of co-creating together. The teacher's leadership is very clear here. Co-creation through learning in various directions - for teachers from students, students from teachers and administration, administration from teachers and students, teachers from administration – is the strength of our school. However, the teacher is seen as a key actor here (R20).

School administrators' attitudes toward support for teacher leadership. The school administrators displayed their attitudes toward teacher leadership through particular actions, such as taking care of the means to support the quality of teachers' teaching, supporting teachers' initiatives, trusting teachers and involving them in problem solving and independent decision-making, and empowering teachers to engage in leadership.

The school administrators' attitudes revealed that they care about enhancing teaching quality by providing teachers with the necessary teaching tools:

If you tell them that you need music, instruments, that you need a blackboard, that you need blinds, that you need a carpet, then you will get everything. Through this, I see the positive attitudes of the school administration towards the teacher's initiatives, creativity, and innovation (R24).

School administrators' openness to teachers' suggestions and encouragement of their creativity demonstrated that they support teacher leadership:

Most of these are initiatives. Indeed, these initiatives are within the reach of the administration and are certainly being considered. But I have never experienced that the administration does not support, rejects the teacher's suggestions and ideas. We talk openly together. We make joint decisions thinking about the students, about the school. Administration seeks opportunities and positive outcomes for the school community, showing that the teacher's ideas and suggestions are supported (R8).

The school really supports initiatives and always allows teachers to work creatively (R7).

The school supports a culture of equality. The school administration consults with teachers, involves them in decisions and considerations. This allows teachers to be valued, respected, and recognized (R12).

The school administration's trust in teachers' leadership was realized by providing opportunities for them to make decisions autonomously:

The teacher can make decisions about the student's teaching and learning forms, methods, strategies, can initiate additional or extracurricular activities, can carry out innovations that have never applied before. The teacher's initiatives are heard and supported. Yes, it is necessary to discuss with the administration, but the final decision with responsibility is left to the teacher. Then the teacher does not feel that he or she cannot, or he or she is not capable. The openness of the administration and support for the teacher's leadership is the real professional life of the teacher in our school (R5).

The school administrators empowered teachers for leadership by involving them in activities, providing opportunities for leadership, and engaging them in problem solving:

The school administration involves teachers in various decisions. And this is not only related to teaching and learning. This is also related to the affairs of the school community. We discuss various things, for example, what needs to be strengthened, how to maintain values, what to prevent, so as not to harm the school's reputation and the well-being of the school community. It is this decision-making that is very felt and experienced at school. Not all teachers get involved. But still the majority are proactive and active teachers. They are role models for the school community. And the teachers or the administration are not alone in solving the problems. Everything together. Therefore, as a teacher, I feel good here (R10).

Teachers' co-creation-based formal and informal learning of leadership skills. Teachers acquire leadership skills in both informal and formal ways. The informal avenue includes learning through practice, engaging in empowering initiatives, sharing knowledge and experiences, proposing ideas, creating extracurricular activities, and communicating with all members of the school community. Teachers view themselves as community members who engage with others through empathic communication and by recognize others' needs to be supported, helped, and encouraged. This creates an empathic communication culture within the school. Teachers' work in the classroom with students also benefits from the development of leadership skills and from improvement activities that the teachers observe and recognize.

Teachers exercised leadership within the school community by fostering community engagement. Teachers motivated the community by sharing ideas with each other:

We have a gymnasium council that includes teachers, parents, and senior high school students. I had to work with the municipality. I felt that I could actually ignite, help, feed ideas, and help implement their own creative ideas (R22).

The professional teachers' community in the school is strong. We are not active. We aim to be an example of marriage, actions, attitude. We believe in the power of co-creation. When we are together, we learn from each other. We create and implement projects, we often discuss with each other – with teachers, administration, students, student parents. And the teacher's leadership is felt everywhere, as it is recognized and supported. We all see the essential result of co-creation – it is good for us to be together at school. We are proud of each other. Is that bad? (R32)

Teachers built rapport through collaboration with fellow teachers by working within a professional team:

This is the community in which you live and with which you constantly communicate. One of the most important qualities of a leader is the ability to build relationships with people. If you really know how to do it <...> the team, teamwork, support, and everyone's overall result are very important to me (R8).

I feel strong after working at school for many years, because we, the teachers, are connected to each other and act as a strong professional team. I know that this kind of feeling might not happen at school, but it's like that here. We as teachers communicate and collaborate with each other. We talk and talk about difficult things. I mean that there are also prejudices, dissatisfactions, maybe even healthy anger when we talk. But we always respect each other. We always have a lot of trust in each other's competence and personality. We know each other's strengths and weaknesses. We talk about it. We decide. We support each other. We learn from each other. I think that there is a team, and leadership, and co-creation at the same time (R30).

Teachers sought consensus by sharing ideas with fellow teachers and supporting them through encouragement and help:

There were 13 groups in the school, and there were even more teachers <... > it is necessary to come to an agreement, to agree, to accept other people's opinions, to offer your own (R24).

If I see the potential of a colleague or if I see that a colleague is timid, but I feel that he or she has some ideas, then I always want to encourage him/her, push him/her and collegially help

him/her to reveal himself or herself (R28).

I think that a one-size-fits-all solution is better than several individual solutions. It is important for me to understand the context, the system. Understand values and attitudes. Not only my personal, but also my fellow teachers. Because we are a professional community and we have to learn through co-creation, i.e. when talking, when making decisions, and we must do this based on the principle of consensus. It is a very difficult process, but there are always teacher leaders who take on responsibilities at a specific time and manage to focus all teachers and become united. Therefore, as teachers, strengthening each other, supporting each other and helping each other is a strength (R11).

Teacher leadership through co-creation-based collaborations with students, fellow teachers, and the school community. Teachers' collaborations manifest among the school community, fellow teachers, and students. Collaboration with the community helps teachers strengthen their professional identity. Collaboration with teachers develops teachers' solidarity in seeking a general vision within the professional community and solidifies the professional teachers' community in the school setting. Collaboration with students provides opportunities for both parties to learn from each other, to parlay their professional competences into the development of students' interpersonal skills by strengthening their social skills, and to build mutual trust with students. The co-creation context of teacher leadership becomes evident through the construction of a general vision of the activities within the teachers' community:

At the class level, if they are students or in those classes in which I am a subject teacher. Understanding or not understanding other teachers is very important in this area. If they understand each other, they will help and contribute, and the students will know how to e-mail, chat through Messenger, communicate, and ask for help. If the teacher does not understand this, then it is understood that the teacher is playing with the student and acting at the level of a friend. Cooperation between teacher and student is an important part of co-creation. It motivates students and teachers to do better, more qualitatively. To feel responsible, but at the same time not to feel alone. It's the communal feeling of being in communion. However, there must be equality, openness, trust (R12).

A teacher, in my opinion, should know their own professional mission and the school vision. And all the teachers at school know it, understand it, experience it every day. And we, teachers, know for sure that the community in our profession is strong only when we cooperate, talk, and decide together. When we learn from each other. When we initiate, discuss and support those initiatives among ourselves. When we share innovations with each other. It's better for all of us. That's what it's all about together. On behalf of the teacher, the student, the school. And if you don't do that, there will be no mutual understanding. To live with it, you need to empower yourself and not be passive. The teacher's leadership plays an essential role here (R40).

Teachers and students learned cooperatively, providing evidence of the mutual learning involved in co-creation and teacher leadership in the classroom:

We can learn a lot from each other. Children can learn from each other through mutual relationship building and group work (R32).

Collaboration and cooperation is important when working with students in the classroom. It creates an atmosphere of mutual trust and respect for each other's experience and knowledge. And through this I see how they become more self-confident, more creative, freer. Because a learning community is created in the classroom. So that the concept of "cooperation" between students does not become just a theory, I need to put in a lot of effort to help. This is not the result of one day. This is constant, persistent, and systematic work with students to enable them to learn together, to realize the power of co-creating learning together. To open to personal ignorance and reflect. I see there a lot of my leadership (R41).

Teachers created authentic individual connections with students in the classroom:

Based on my experience, when I talk to students directly and individually, there are completely different results. I see the student in a completely different way, and the students see the teacher in a different way. Actually, they see that the teacher cares about them (R30).

Individual connection and relationship with students is important. But for me, an authentic creative relationship with the entire student group is also important. Except not one. And then it's a big deal. Because I know what I'm aiming for – I'm aiming to create a learning community, to strengthen the culture of co-creation through learning. And the students feel it. They experience the power of learning together. And through learning, an authentic relationship between me and

the student is created. Because we are all learning from each other. And because of that, our growth is also related in the meantime. The more I know and learn, the more I can share and contribute to all knowledge. And this is good. I communicate this philosophy to students. Sometimes they are lucky enough to hear me, sometimes not so much. But still, in the implementation of co-creative culture through learning, and through it I see a unique relationship with students (R35).

Teacher leadership was manifested in the classroom by building mutual trust with students through open reflections on learning and by creating an equal and open co-creation-based relationship with students to achieve common learning goals:

A survey conducted in school showed that most homework was assigned on the Lithuanian language subject. This is me asking: Children, really? Of course, we are three Lithuanian language teachers. When you ask openly, they communicate openly, and they tell you. Then, you talk and tell them straight (R34).

My students trust me because I am their companion. I do not try to be superior to them. Specifically, I emphasize that I am here to help them and that they can help me, too. We will all achieve more together (R38).

We create an atmosphere of mutual trust in the classroom. It means talking openly, making decisions while learning together. It means co-creation. And that relationship between the student, me and the student is created precisely through the co-creation of learning. You will not create this alone or artificially. And this means that when preparing for lessons every day, I think about assignments from various "angles:" how to involve, empower, open, motivate, direct, etc. This is my leadership. I see obvious results – students are more focused, cooperative, able to discuss and make decisions together. And everything focuses on motivated learning, learning achievements and results, student satisfaction with their learning (R17).

The use of learning spaces in teacher leadership through co-creation. Teacher leadership involves finding and creating teaching and learning spaces, aligning them with topics and teaching/learning subjects. This creative action enables teachers to empower themselves to want, initiate, and implement, which requires time and the creative planning of teaching/learning activities. For students, learning outside of school in spaces of nature, science, and art exerts an impact; it encourages learning-related communication and cooperation and increases the motivation for learning.

The closest spaces are all the spaces of the district where we are located. These are parks and district libraries (R15).

They also like going to the labs, but we have problems with that. For example, only ninth graders can come to the labs. Sometimes there is this limit. Eighth graders are still too young. They have to have enough knowledge to come to the lab, but we can find them there too. (R26)

Previously, we moved learning spaces to universities, and the teachers participated. The children went to universities, and our teachers taught them. The subject is taught, but if it is in a laboratory, tests are used. We primarily use the opportunities provided by universities. They are broader and bigger (R2).

Some of the main spaces are museums, various laboratories, and various public spaces in the city where you can come, such as libraries, bookstores, and some theatres (R27).

There are institutions that cooperate with other institutions. These are festivals and events. We travel to institutions. The Quiz Olympiad is held. We go to each other's places (R15).

Outdoor learning is very effective. Through teaching, I implement my creative ideas in various spaces, and at the same time, students realize that learning is possible in various contexts, that there are learning partnerships and networks, that learning is action and empowerment, cooperation and collaboration, sharing and dissemination. Because learning is life itself (R42).

Learning spaces provide opportunities for listening, speaking, expressing opinions, and being a member of a group. In this manner, students acquire skills relevant to everyday life and coexistence in society. The targeted use of school spaces is also important for students to realize that the classroom is an essential environment for their targeted learning and concentration.

I worked with a class in which there was such a project. During the last week of the school year, the teacher went outdoor with the whole class to study in nature. It can be any unconventional place, and you live there like you're at camp. We had been to xx by the sea, and we lived there successfully for a whole week. There are also parental vigils and assistance (R37).

Those spaces were quite large. I try to look at what topics we are covering. If it is related to architecture, then why not go to the city and look around old towns? If we're talking about food,

then we can go to a cafe with the children. The task would be to order while speaking only in English. If it's about sports, we find a space where they can play, such as a basketball court (R40).

These things contribute a lot to the development of students. You can hear it from the students' reflections when they speak. It is an exceptionally interesting activity for them, and they enjoy it very much. Because they can be in a non-traditional environment, their motivation is completely different. This is co-creation through learning. (R29)

Teacher leadership related to modeling the educational process through co-creation practices. The modeling of educational processes in the classroom occurs through the cooperation and partnership of teachers and students in teaching and learning activities.

At the level of lessons, you can really feel it in certain situations in which the students say what they like and what is difficult, but this is through reflection and feedback. (R29)

Cooperation and partnership are actions and performances, understanding and perceiving, hearing, and listening, it means learning co-creation. The tasks given to students have to be reflected on every time in order to stimulate them, teach them to work together in cooperation and learn from each other. Therefore, we create a lot of projects, implement learning in groups and teams, and talk a lot while reflecting. I always provide the students with detailed feedback that includes both the disclosure of strengths and an explanation of limitations. I always emphasize the possibilities, benefits, and value of learning together. I think that this contributes to raising them as citizens, active learners, to the expansion of their tolerance and intelligence. This is the essence of my leadership. (R4)

Teachers and students collaborate in determining the quality of the teaching. This occurs when teachers recognize the need to listen to students' opinions and criticisms and learn from them.

I always think that today is an easy day. Something went well, and I would apply that next time, or something was extremely difficult. And student opinions on teaching, learning, cooperation, collaboration, etc. are particularly important. It is always important for me to hear and listen to the students (R36).

Students are not afraid to tell me my mistakes or help me improve (R42).

Students' criticism is often direct, maybe even rude, but open and honest. Over the years, I have learned to appreciate it very much. Because they say as they feel and understand, which is very true. It is my leadership duty and responsibility to hear what students say and reflect, and then improve and change the educational process, focusing on the students' all-round well-being, in which learning is the essence. Communication and cooperation based on mutual relationships create full-fledged conditions for co-creation of learning for me and the students, to which each of us contributes (E19).

It is important for teachers to overcome their professional "omniscience" and accept help from students, as cooperation based on partnership contributes to teachers' meaningful self-learning and helps forge an equal educational relationship between them and students.

Through students' feedback questions, I see where I seem to have too much or too little of something to change, improve. I believe in the idea that we exchange ideas, attitudes, values, experiences, expectations, hopes, etc. It takes place on a learning partner basis. However, it is my leadership responsibility to start and support this process. That's what I do. For better or worse, I do it because I believe in the idea of self-constructed learning (R12).

You have to constantly improve and realize that you don't know something that your students know. You need to catch up with them, and it's not that easy. Pride affects young teachers who think they know a lot (R22).

I really learned a lot from students because they are very eager and curious. Sometimes, they ask me themselves, and when they discover it, they share it. This is how I encourage the sharing of common knowledge. I'm not the only source of information. We all contribute to common knowledge by 'bringing' our visions, ideas, knowledge, skills to it (R33).

Learning and teaching co-creation occurs every day in the classroom "here and now" when teachers and students cooperate for discovery-based learning and when teachers listen to their students' needs and suggestions.

Projects, presentations, or sometimes education outside the classroom and school is offered to students. And it is effective. Students are interested, engaged, and motivated to learn. Suggestions, yes, but to suddenly have such an idea in the lesson itself and fundamentally change something? Well, maybe not. Maybe tasks are born, maybe a joint project. Or "yes," when I see that I can use ideas "here and in nature" ad hoc and based on my professional experience, I am sure that

it will work in a specific situation. In this context, collaboration and cooperation are particularly meaningful and valuable – students learn by sharing existing knowledge with each other and creating new ones. They create new knowing (R10).

If there are any suggestions, I will take them into account and discuss them, but I still control the lesson and the educational process because I make the decisions myself. I know that one of my duties is to listen to the students, to listen to their expressed thoughts, ideas, and reflections. I do this during every lesson. And educational interactions have developed - we see each other in a different, new, unexpected way. Serendipity. Because you can't plan everything. And I think that this is a process of co-creation, in which most of it is discoveries - learning from others and learning from each other 'here and now' (R35).

Nevertheless, teachers maintain their professional self-esteem by realizing that they are expert leaders in the educational process in the classroom and that they can foster engagement, focus, and parity through co-creation.

I learn a lot from students and fellow teachers at school. We communicate very openly, and they ask, ask, and ask. Sometimes, I really say that this is the first time I'm hearing about it. I take an interest and think that we should all try to explore and discover it together now. My goal is to stimulate, interject, encourage students to learn for themselves and for themselves. and teaching them to learn. And this is possible only by forming mutual involvement in mutual learning (learning co-creation), feeling each other's reinforcement and daring to act through leadership (R41).

It is clear that teaching/learning in the classroom is led by the teacher leadership because she or he knows what the end point should be. And we create meaningful learning co-creation together. But this does not mean that the teacher has a higher status. This means that the teacher is a high-level intellectual and professional who understands the students' learning processes and is able to control them, encourages creativity and knows how to do it. Stimulates students' ideas by encouraging them to be creative (R10).

5. Discussion

Our study contributes to the body of research concerning contextual factors that support teacher leadership through the co-creation approach. By analyzing the contextual factors that support and enhance teacher leadership development in school, we uncovered trends similar to those that have been identified and noted by previous studies. These trends are related to the need to seek more dynamic leadership approaches that allow the whole community to engage in dialogue and accommodate different perspectives in the search for a common solution and a common direction (Andreson, Wasonga, 2017; Nguyen et al., 2019). They also underscore the positive relationship between supportive school leaders and colleagues with the ability to use and experiment with digital technologies (Lucas et al., 2021).

Our study is consistent with the research on school community dispositions in enriching and supporting teacher leadership at school. For example, Anderson and Wasonga (2017) discussed the concept of co-creative leadership in their study on mentoring novice leaders and found it to be a significant concept that enriches organizations with collaborative and collective relationships based on dispositional values, thus opening more possibilities for the mentor and the mentee to develop leadership skills. Wasonga and Murphy (2006) identified seven dispositions that contribute to leadership development: collaboration, active listening, cultural anthropology, patience, humility, trust and trustworthiness, and resilience. The authors emphasized that practicing these values builds high-quality relationships within an organization and contributes to enhancing mutual understanding, thus fostering more open sharing and creating new knowledge. Therefore, teachers are more likely to self-reflect and improve their teaching practice on this basis (Binkhorst et al., 2022). They are not afraid to take risks and apply new teaching strategies; they are more responsive to the diversity of their students; and they plan and prepare lessons more carefully (Chiriac et al., 2023; Espinosa, González, 2023).

In our study, we found that the dispositions of school administrators, as expressed through caring attitudes, such as encouraging teachers to share professional innovations, encouraging teachers to improve their qualifications, delegating teachers to engage in capacity building and competence development, and empowering teachers to take responsibility in decision-making, also contributed to support for teacher leadership at school. It is important to understand that school leadership creates a safe and well-equipped working environment for teachers, helps to determine the effects of their professional activities on student achievement, and outlines the general

direction for improving the education process. Teachers' activities are characterized by reflective dialogue, instructional leadership, and interpersonal relationships (Belchetz, Leithwood, 2007; Çağatay et al., 2022).

Another group of contextual factors related to support for teacher leadership concerns learning formally and informally in different learning environments. This finding extends the discussion of teacher leadership experienced through and due to teacher professionalism (Hargreaves, 2003). It strongly reinforces the idea that teacher leadership is inseparable from a teacher's continuous development as a person and as a professional who is open to new challenges and uncertainties. For example, in learning environments based on the application of knowledge in practice, methods such as case studies, laboratory work, or project-based methods used to solve complex real-world problems may be emphasized. A pragmatic approach to learning environments highlights the importance of combining available resources and is associated with the creation of relevant learning environments (Cambell et al., 2013; Sahlin, 2023).

In our study, we have investigated contextual factors that support teacher leadership through the lens of co-creation at school. We have applied the concept of co-creative leadership proposed by Schieffer (2006), who noted that co-creative leadership does not aim to reconcile all the differences of a community but rather to build a common solution based on the power of different perspectives. This is achieved through collaborative communication and dialogue. The new element highlighted in our study is related to dialogue without students. Our research reveals that co-creation between teachers and students in the classroom takes place "here and now" for both parties to create an educational relationship based on mutual trust in learning. The teachers' openness to the students' opinions, suggestions, and criticisms is important in this context. It enables teachers' self-learning to take place, the essential premise of which is critical self-reflection in realizing one's own ignorance and seeking means to fill this gap through reading and seeking information primarily from students.

The study presented in the article was conducted in Lithuania, where the understanding of teacher leadership is still developing. The studies (Cibulskas, Zydziunaite, 2012) revealed that novice teachers very frequently associate teacher leaders with administrative functions and less with caring about the progress of the organization. Therefore, it is important to further investigate the development of teacher leadership in educational institutions because it positively affects teachers' work, encourages students to become involved in the learning process, galvanizes the organization to improve, and significantly affects students' learning achievements and the results of extracurricular activities (Gumuliauskienė, Vaičiūnienė, 2015).

Psychological environment (Bukšnytė et al., 2022) have also been noted as a significant contributor to teachers' effective job performance, job satisfaction, and motivation, which are also important prerequisites for leadership to emerge. The leadership of teachers must focus on fostering partnership relations; sharing experiences, ideas, support, and assistance with colleagues; and engaging in joint activities (Valuckienė et al., 2015). Teacher leaders serve as agents of change inside and outside classrooms by improving teaching and learning practices through collaborative work with fellow teachers. Teacher leadership in creating diverse learning contexts and environments has also been emphasized in national studies in Lithuania.

It is important to note that the study presented in this manuscript has some limitations. First, the analysis revealed a teacher-leader-centered approach, as it was based only on the schoolteachers' responses. Second, the research only covered the country of Lithuania, and only 42 schoolteachers were interviewed. Despite these limitations, this study contributes to the existing body of knowledge by offering new perspectives regarding analyzing contextual factors that support the development of teacher leadership through the proposed co-creation and leadership framework, which focuses on the person, process, and practice components.

This study can be extended to include studies about schoolteachers, school principals, and students from different countries or regions. It can also be extended beyond thematic analysis by combining qualitative and quantitative research methods.

6. Conclusion

The contextual factors that support teacher leadership in school through co-creation are administrative support, the school administration's attitudes toward teacher leadership, teachers' co-creation-based formal and informal learning of leadership skills, teachers' partnership and

collaboration with the school community, the use of learning spaces, and the modeling of the educational process through co-creation practices.

The techniques and context of the caring leadership of the school administration, such as support, care, openness, recognition, and encouragement, are the key components that support teacher leadership in school. The school administration's attitudes are expressed through its actions by adopting caring leadership through empowering, supporting, and trusting teachers who exercise teacher leadership in school.

Teachers' co-creation-based formal and informal learning in acquiring and developing leadership skills involves the school community, fellow teachers, and students, and it encourages teachers' leadership in school. It is possible to implement teacher leadership through teachers' cooperation with the school community, the professional community of teachers, and the students. Empowering teachers to embrace creativity, initiative, and responsibility to increase students' learning motivation is directly related to the targeted selection of teaching and learning spaces. In this context, empowering teacher leadership becomes relevant. The research results give the message to the global professional community of teachers that the teachers exercise leadership through daily activities. However, this type of teacher leadership is often 'invisible' and 'unrecognizable' in the school environment.

Teacher leadership has emerged from the data as an essential aspect that unites teachers and students as co-creators. Teachers are professionally competent when they know their essential role. While listening to and opening up to their students, they must remain expert leaders, guiding the students' learning toward a clear goal that must be mutually achieved in the classroom during lessons.

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Adapting to Digital Education: Insights into Teaching Russian as a Foreign Language Online in Turkey

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Abstract

The article is devoted to the current trends in digital education with a focus on the use of distance learning for teaching Russian as a foreign language (RFL) in Turkey. The global pandemic and subsequent national lockdowns have provided a valuable experience in this field. In Turkey, distance learning for RFL continues to be popular prevailing trends of deglobalization and regionalization. This popularity is also due to Turkish Higher Education Development Plan 2030 of complete digitalization. Developing effective distance learning methodologies and integrating social sciences with modern online technologies are essential for advancing RFL teaching methods. In the process of developing teaching methods instructors' experiences and attitude towards this innovative format, together with their readiness for change are very important.

The aim of the study is to describe the experience of teaching RFL in a distance format in Turkey. Its primary goal is to identify the perceptions, preferences, readiness, and willingness of instructors to transition to this new instructional format. The research employed both theoretical (analysis) and empirical (online questionnaire) methods. The study was based on the responses from 73 RFL instructors in Turkey. The online survey, created using Google Forms, consisted of 29 multiple-choice questions and one short-answer question designed to see satisfaction with the online format of teaching RFL. The survey also included socio-demographic questions and targeted queries about the challenges, features, and observations of the online educational process.

The study revealed that during the transition to online format, instructors encountered several challenges, particularly in developing writing skills, phonetic competence, speaking skills, managing homework, and explaining complex topics. Some instructors believe that traditional face-to-face teaching methods are ineffective in an online environment, yet they continue to use

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them out of habit and due to a lack of specialized methods. The study found that insufficient technical skills and the significant amount of time required for lesson preparation are major obstacles. Despite the convenience of online format for some, many instructors still prefer in-person or blended format, emphasizing the importance of a balanced approach. Additionally, the digitalization and globalization of education have significantly transformed the roles of instructors, necessitating new strategies and comprehensive training to face these challenges.

Keywords: distance learning, foreign language, online, Russian, Turkey, instructor, blended, hybrid, survey, remote learning.

1. Introduction

The global community is still addressing the social and economic crisis caused by the COVID-19 pandemic. In 2020, due to the lack of effective measures to combat the pandemic, the World Health Organization recommended self-isolation. These measures prompted responses from all aspects of life, including education. During the pandemic's active phase, the Turkish Council of Higher Education decided to shift the entire education system to an online format. Consequently, Turkish education system found itself in a new environment characterized by forced and accelerated digitalization. These conditions differed radically from previous stages of educational modernization in two main aspects: firstly, forced digitalization impacted all levels of the education sector, and secondly, the operational conditions of the education system itself underwent dramatic changes.

The development of the vaccine enabled the academic community to resume full-time education. However, the Turkish Council of Higher Education chose to continue with hybrid remote instruction for both the 2021–2022 and 2022–2023 academic years. Hybrid instruction was set at 40 % online for 2021–2022 and 30 % online for 2022–2023. In the current academic year, some general education requirements are still taught remotely. These percentages clearly illustrate the overall trend and direction in the development of higher education in Turkey. This approach aligns with the Turkish Higher Education Development Plan 2030, a key goal of which is complete digitalization (Saraç, 2021). The establishment of a distance learning faculty at Ankara University, one of Turkey's largest universities, in 2020, exemplifies this trend. This faculty offers, among other modern humanities programs, a bachelor's degree in Russian Language and Literature. Ankara University's experience marks a pioneering step in the public education system for teaching foreign languages in a synchronous remote learning format.

Today, despite the trends of deglobalization (Goldberg et. al., 2023) and regionalization (O'Neil, 2023), teaching RFL (Russian as a Foreign Language) in a distance format in Turkey remains a priority and promising field, due to the country's strategic neutrality. In this context, the development of distance learning for RFL and the establishment of effective distance learning methodologies become increasingly important. The development of methods for teaching RFL should include the integration of various areas of humanitarian knowledge and modern online technologies. This helps improve the acquisition of additional competencies and further develop student's speaking skills and abilities (Popova, Kolesova, 2023). In this context, special attention should be paid not only to the teaching process itself, but also to the preparation of tutors to work in a digital environment (Feyzer, Dyakova, 2023).

Aim

This study describes the experience of teaching RFL in a distance format. Its primary goal is to identify the perceptions, preferences, visions, readiness, and willingness of instructors to transition to this new instruction format. To achieve this, an anonymous online survey was conducted, involving 73 Turkish instructors of Russian language. The findings of this study are based on the analysis of the experience in this field during the pandemic. These findings hold both theoretical and practical significance for training RFL instructors now and in the future. Additionally, this study contributes to understanding the regional characteristics of teaching RFL.

2. Literature review

According to Clark (2020), distance learning has a history spanning more than three centuries. However, the global academic community has never utilized it as extensively and actively as in the past three years. The experience accrued during the pandemic is crucial for the development of both distance learning and education. The increased adoption of distance learning has spurred a variety of research in this field. In the last two years, significant findings have

emerged in several areas: innovative approaches and instructor attitudes towards distance learning (Vidergor, 2023), the mental and emotional state of students in the new learning format (Kwaning et al., 2023), quality of teaching in a distance format (Jaekel et al., 2023), development of frameworks for fully online education programs (Ryneveld, 2023), the influence of high-speed broadband availability on student engagement in distance learning (Mac Domhnaill et al.), the impact of remote proctored exams on academic honesty (Paredes et al., 2021), and the effects of synchronous online learning environments on students' cognitive engagement (Dinh, 2023), among others.

Notwithstanding the burgeoning interest and adoption of distance education, the domain remains in a developmental phase, its merits and drawbacks still actively discussed. Among its advantages, researchers underscore increasing accessibility of education and improving students' motivation and self-organization (Almomani et al., 2023). Research also supports the improved academic performance and effectiveness of synchronous learning (Spitzer et al., 2023; Outoukarte et al., 2023). A survey of instructors from Peter the Great St. Petersburg Polytechnic University highlights the flexibility and opportunities for professional growth provided by online learning (Almazova et al., 2020).

Despite the array of positive attributes, some studies have also shed light on the negative aspects of distance learning. (Reznikova et al., 2020) note that the requirements for students and instructors in this area differ from traditional teaching methods, which requires new approaches. (Casalone et al., 2023) indicate a negative impact on student performance. (Yorkovsky et al., 2022) highlight instructors' preference for traditional teaching methods. Garza Mitchell et al. (2024) identified faculty concerns about the lack of interaction in online learning. Almazova et al.'s (2020) and Sadeghi (2019) survey also found that limited communication with students was considered a disadvantage of online learning.

However, instructors' willingness and enthusiasm play an important role in the success of e-learning. Works by authors such as Vidergor (2023), Şanlıöz-Özgen et al. (2023), Çınar et al. (2021), Cidral et al. (2018), Keramati et al. (2011) and Sun et al. (2008) confirm this relationship. Some instructors may be reluctant to use online teaching due to their unconventional approach to teaching, as noted by Y.M. Tang et al. (2021), Kadleˇcík et al. (2021) argue that different approaches are required for e-learning and traditional learning and the adoption of information technology is important. Mohmed et al. (2020) encourage instructors to use new methods that can improve the quality of education.

Institutional and sociodemographic factors have a significant impact on student satisfaction with distance learning (Bacci et al., 2023). On the other hand, education is deeply intertwined with the region in which it exists, often developing unique characteristics based on its geographical and cultural context (OECD, 2007). This connection is particularly evident in the field of distance education. Mardini et al. (2022) highlight that the level and success of distance education vary significantly depending on the region and the local education system.

Turkey is an example of this regional influence in education. Given the overall trend of Turkish higher education towards digitalization and considering its regional attributes, research in the field of distance education in Turkey reveals several intriguing findings. These studies show how regional factors shape the adoption and effectiveness of distance learning in the Turkish context, reflecting a blend of global trends and local nuances. Şimşek and Toprakçı (2023) highlight internal problems of educational organizations in Turkey such as staffing and infrastructure, while Özaydın Özkara (2023) notes the positive attitude of students towards distance learning. Yeşiloğlu et al (2021) suggest that theoretical subjects are better suited for distance learning than practical subjects. Çutuk's (2023) study reveals the positive impact of distance learning environment on students' academic motivation. Furthermore, the distance learning medium offers extensive opportunities for engaging with the linguistic culture and foundational aspects of a language, aiding in adaptation to the language environment (Dikilitaş et al., 2009).

These findings collectively indicate that while there are certain challenges inherent to distance education in Turkey, there are also significant opportunities for positive outcomes, particularly regarding student motivation and the effective delivery of theoretical subjects.

3. Methods and materials

The study used theoretical (analysis) and empirical (anonymous online questionnaire) research methods. The research material was the responses of 73 RFL instructors in Turkey.

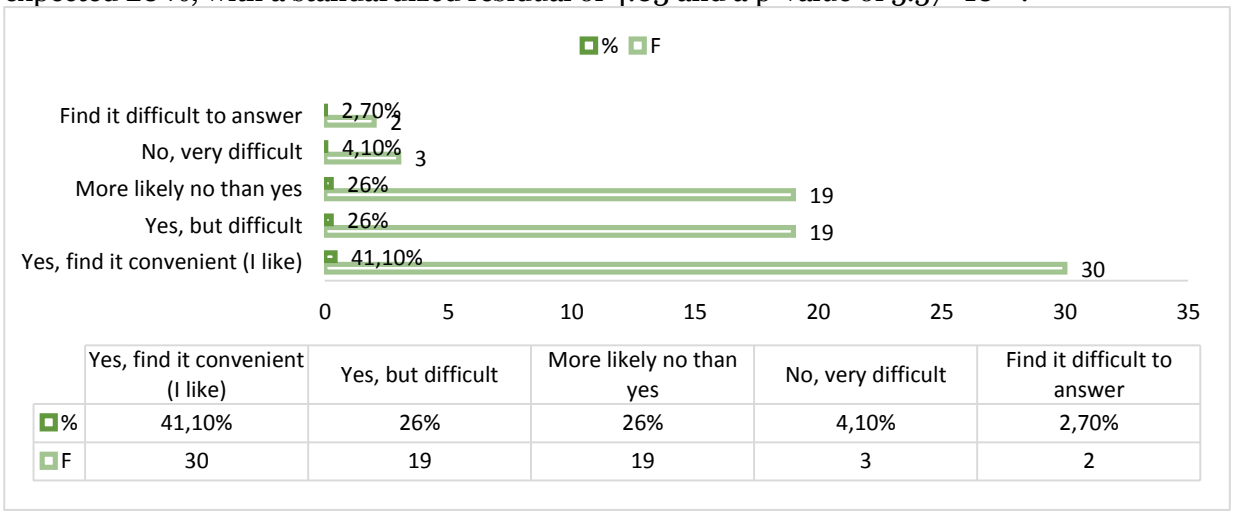
The questionnaire was compiled using the Google Form online service, consisted of 29 multiple choice and one short answer question, and was aimed at identifying the degree of satisfaction with the online format of teaching Russian as a foreign language. Along with questions of a socio-demographic nature, respondents asked targeted questions about the difficulties, features, and observations of the educational process in an online format. The data obtained through an online survey were analyzed by frequency of common instructor's responses and were stated in percentages. The significance of the compiled data was analyzed using a Chi-squared analysis of the responses followed by post-hoc analysis of each group. The significance of results were determined using a combination of the p- value of all responses for a question and the p-value of the individual answer type. The p-value stemming from the Chi-squared value was calculated using the SciPy package on Python. The post hoc analysis was achieved by calculating the residuals and calculating the p-Values of the individual residuals on SciPy. Demographic data were obtained using the Likert scale and are reported in the percentage of instructors' responses.

4. Results

89 % of the participants were female (65 of 73) and 11 % of the participants were male (8 of 73). In addition to this, 17 participants had a bachelor's degree (23.3 %), 33 participants had a master's degree (45.2 %), and 23 participants had a PhD (31.5 %) as their highest-achieved degree. The most common academic attainment amongst participants was assistant professor (f = 45, 61.6 %). This was followed in decreasing order by instructor (13), full professor (8), assoc. professor (4), senior assistant professor (2), and assistant (1).

When participants' language teaching experience was examined, the largest group had experience between 11 and 20 years. This group contained 30 academic staff out of 73 total. 19 of all academic staff were in the 5-10 years group (26 %). Additionally, the number of academic staff with more than 20 years of experience was 15 (20.5 %) and less than 5 years was 9 (12.3 %). In addition to the participants' teaching experience, their online teaching experience was also examined. The most populated group was experienced between 1 to 5 years, with 52 participants out of 73 total (71.2 %). This was followed by 15 participants with less than 1 year of experience (20.5 %), and 4 participants with 5 to 10 years of experience. The most popular platform used by RFL instructors is Zoom (f = 42, 57.5 %). This was followed by Moodle, Zoom MS Teams, Zoom and Skype with three instructors using each combination.

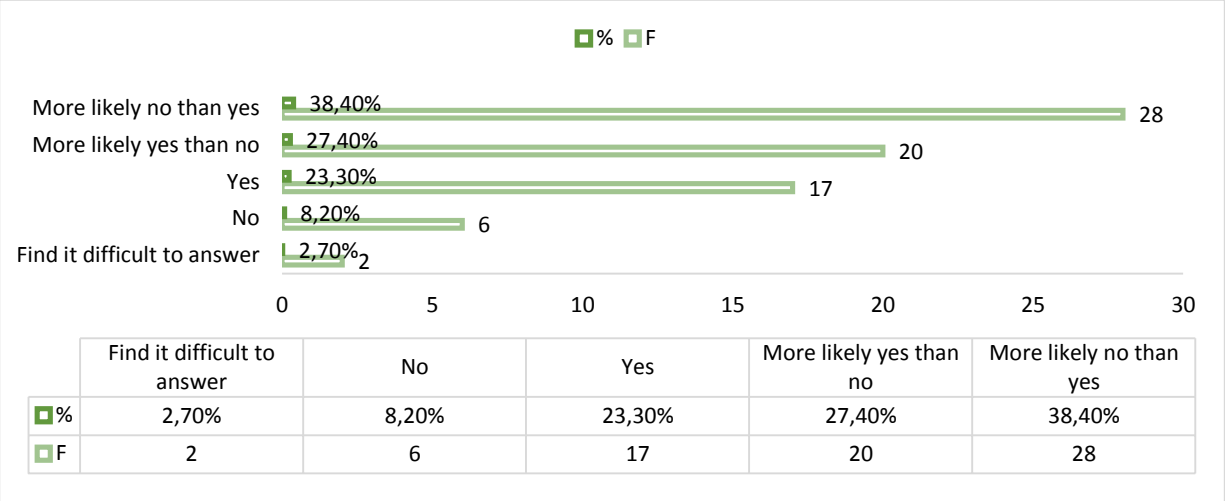
41.1 % of participants found teaching online convenient (f = 30). 19 Participants each responded to the question as "Yes, but difficult" and "More likely no than yes" (26% each). 3 participants responded with "No, it is very difficult" and 2 participants responded with "I find it difficult to answer." (Figure 1). All of the results deviated from the expected distribution of 20 % or approximately 15 participants. There were 4 degrees of freedom and the Chi-Squared test resulted in a statistically significant p-value of 7.01×10^{-8}, indicating a significant difference in responses regarding the convenience of online teaching. The group that found online teaching "convenient" "Yes, find it convenient" proved to be the most statistically significant with 41.10% instead of the expected 20 %, with a standardized residual of 4.03 and a p-value of 5.57×10^{-5}.



	Yes, find it convenient (I like)	Yes, but difficult	More likely no than yes	No, very difficult	Find it difficult to answer
%	41,10%	26%	26%	4,10%	2,70%
F	30	19	19	3	2

Fig. 1. Responses to the question "Do you find online teaching convenient?"

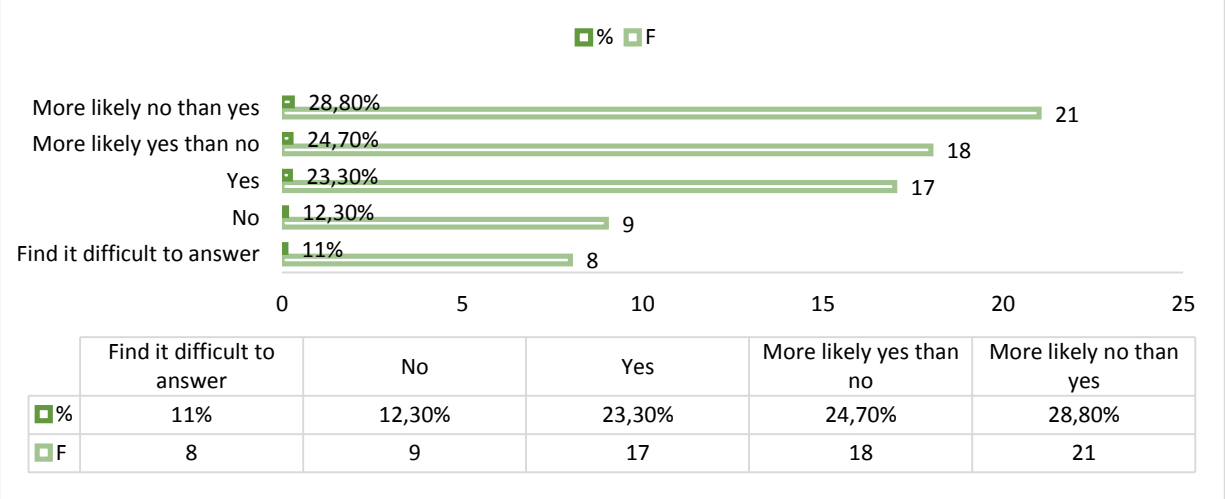
When satisfactions of participants were investigated with the question "Are you satisfied with teaching online?" 38.4 % responded, "More likely no than yes." This was followed by "More likely yes than no" (f = 20). 17 participants responded "Yes" and 6 participants responded "No". Two participants responded with "Find it difficult to answer." (Figure 2). All of the results deviated from the expected distribution of 20 % or approximately 15 participants. There were 4 degrees of freedom and the Chi-Squared test yielded a statistically significant p-value of 3.64×10^{-6}, reflecting notable variation in satisfaction levels among participants. The "More likely no than yes" group emerged as the most statistically significant with 38.40 % instead of expected 20 %, with a standardized residual of 3.51 and a p-value of 4.53×10^{-4}.



	Find it difficult to answer	No	Yes	More likely yes than no	More likely no than yes
%	2,70%	8,20%	23,30%	27,40%	38,40%
F	2	6	17	20	28

Fig. 2. Responses to the question "Are you satisfied with teaching online?"

When posed with the question "Do you think your educational institution is ready for high-quality online language teaching" 28.8 % responded, "More likely no than yes." This was followed by "More likely yes than no" (f = 18). 17 participants responded "Yes", and 9 participants responded "No". 8 participants responded with "Find it difficult to answer." (Figure 3). All of the results deviated from the expected distribution of 20 % or approximately 15 participants however not significantly enough. There were 4 degrees of freedom and the Chi-Squared test resulted in a marginally non-significant p-value of $5.81\text{x}10^{-2}$, suggesting limited differences in perceptions of institutional readiness. None of the groups showed statistical significance, indicating that the observed variations may be due to random chance rather than a true effect.

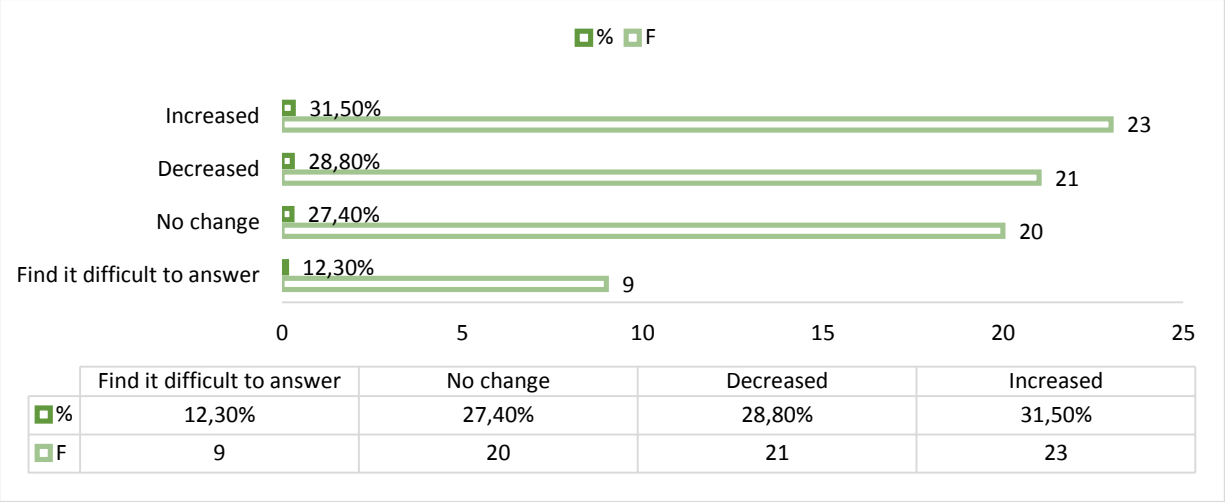


	Find it difficult to answer	No	Yes	More likely yes than no	More likely no than yes
%	11%	12,30%	23,30%	24,70%	28,80%
F	8	9	17	18	21

Fig. 3. Responses to the question "Do you think your educational institution is ready for high-quality online language teaching?"

When asked about the level of technical assistance received by participants 32.9 % responded with “yes, regularly” (f = 24). 24.7 % responded with “more likely yes than no,” and 23.3 % responded with “No technical assistance received.” 9 participants responded with “more likely no than yes,” and 5 responded with “find it difficult to answer”.

When posed with the question “In your opinion, how did the students’ workloads change in the online learning format.” 23 answered with “Increased.” This was followed by a similar distribution of 21 “Decreased” and 20 “No change” responses. 9 participants answered with “Find it difficult to answer” (Figure 4). All of the results deviated from the expected distribution of 25 % or approximately 18 participants. There were four degrees of freedom, and the Chi-Squared test produced a non-significant p-value of 0.0894, indicating that differences in perceived changes in student workload were not statistically significant overall. However, the "Find it difficult to answer" group which had 31.50 % instead of the expected 25 %, showed some significance with a residual of -2.17 and a p-value of 0.0304.



	Find it difficult to answer	No change	Decreased	Increased
%	12,30%	27,40%	28,80%	31,50%
F	9	20	21	23

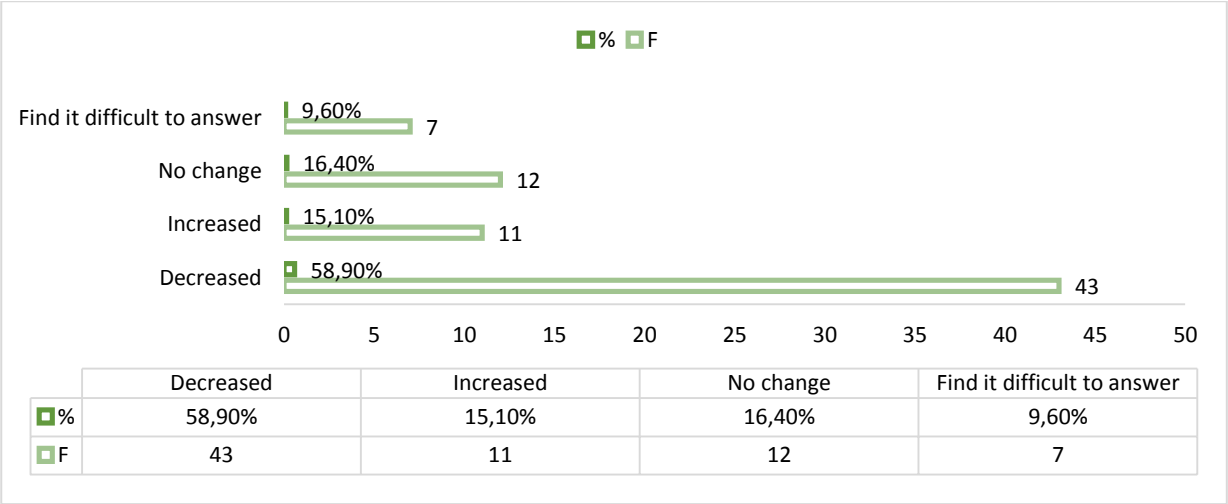
Fig. 4. Responses to the question “In your opinion, how did students' workloads change in the online learning format?”

When asked “How students’ motivation changed in online learning?” 43 participants responded with “Decreased” (58.9 %). 12 participants responded with “No change,” 11 responded with “Increased” while 7 participants responded with “Find it difficult to answer.” (Figure 5). All of the results deviated from the expected distribution of 25 % or approximately 18 participants. There were 3 degrees of freedom and the Chi-Squared test revealed a highly significant p-value of 7.17×10^{-10}, underscoring substantial differences in perceived changes in student motivation. The "Decreased" motivation group was the most statistically significant which had 58.90 % instead of the expected 25 %, with a standardized residual of 5.79 and a p-value of 6.89×10^{-9}.

When asked “How online class attendance changed?” 35 participants stated “Decreased.” 13 participants responded “Increased,” 22 participants responded, “No change” while 3 participants responded, "Find it difficult to answer”.

When posed with the question “How do you classify the psycho-emotional state of students in online lessons?” the responses were as follows: 43.8 % of participants classified the psycho-emotional state of students as interest; 30.1 % as uncertainty; 16.4 % as rejection; 12.3 % as astonishment.

31 of the participants stated that the level of knowledge of online and in person students were not the same while 10 participants stated that it was equal. 30 participants stated the levels of knowledge were similar but not completely the same. 2 participants found the question difficult to answer.

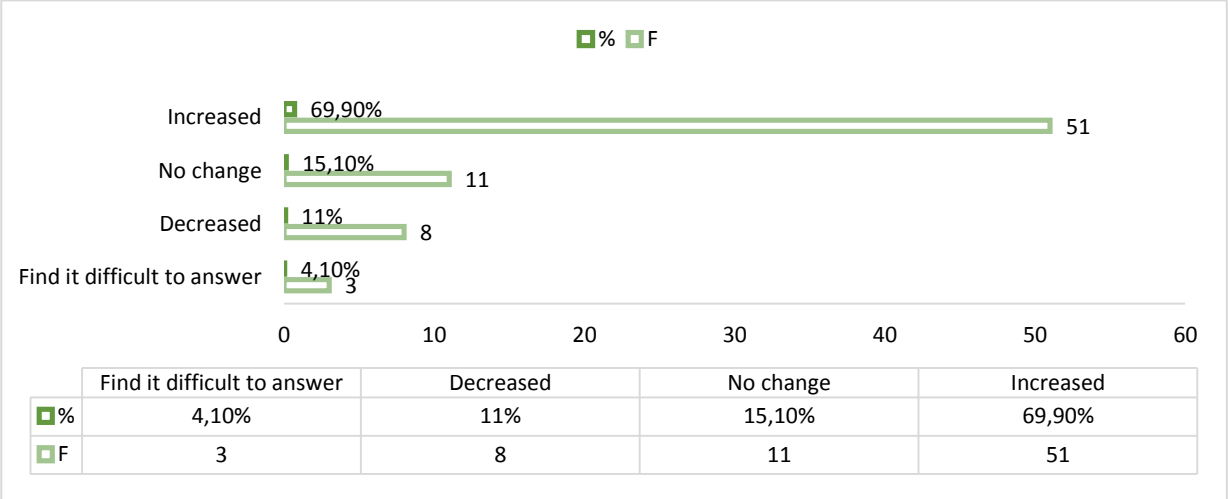


	Decreased	Increased	No change	Find it difficult to answer
%	58,90%	15,10%	16,40%	9,60%
F	43	11	12	7

Fig. 5. Responses to the question "How students' motivation changed in online learning?"

When asked, "Do you have a place in your educational institution equipped with a computer(s)/laptop(s) with internet access?" instructors responded as follows: 28 participants stated, "Yes, I can use it if needed." 24 participants stated they worked from home on their personal computers. 12 participants stated they had access to such facilities but not always. 9 participants stated they had to carry their devices with them.

Participants' change in workload increased for 51 participants while decreased for 8. 11 participants experienced no change in workload while 3 found it to be difficult to answer (Figure 6). All of the results deviated from the expected distribution of 25% or approximately 18 participants. There were 3 degrees of freedom, and the Chi-Squared test indicated an extremely significant p-value of 2.85×10^{-17}, reflecting pronounced differences in teachers' workload perceptions. The "Increased" workload group was the most statistically significant which had 69.90% instead of the expected 25 %, with a standardized residual of 7.67 and a p-value of 1.78×10^{-14}.



	Find it difficult to answer	Decreased	No change	Increased
%	4,10%	11%	15,10%	69,90%
F	3	8	11	51

Fig. 6. Responses to the question "How did teachers' workload change in the online learning format?"

Instructors were asked to mark where they struggled the most in teaching RFL online, because multiple answers were allowed, a total number of responses was calculated. The most struggled moment for the participants was developing writing skills (f = 39). That was followed by the development of phonic skills (f = 31), development of speaking skills (f = 29), and doing homework (f = 20). 9.4 % of participants struggled the most explaining difficult subjects in Russian, 8.4 % struggled the most with explaining grammar. Moments with the least number of participants

struggling the most in are development of listening skills (f = 13), working on exercises (f = 12), development of reading skills (f = 7), while 6 participants struggled the most in other moments.

Participants were asked what difficulties they face during online teaching. The most common difficulty was needing to spend much more time preparing for lessons (f = 40). This was followed by testing of knowledge (f = 39), lack of available online teaching methods (f = 28), technical failures (f = 25), and lack of skills to conduct online lessons (f = 19). Less common answers in decreasing order were difficulty with teaching material (7.4 %), lack of necessary technical means (6.9 %), lack of IT skills (4.2 %). Lastly 3 participants experienced no problems.

The most common level taught online by participants was A1 with 26.2% of participants teaching at that level. This was followed by (in decreasing order) A2 (f = 52), B1 (f = 41), B2 (f = 32). Least common levels taught by participants were C1 (f = 17), C2 (f = 13). 24.2 % of participants stated C1 was the best level to be taught online, while 6.6 % of participants stated A1 was the worst level to be taught online. In between, in decreasing order were, B2 with 20.7% of participants, C2 with 19.7 % of participants, B1 with 18.7 % of participants, A2 with 10.1 % of participants.

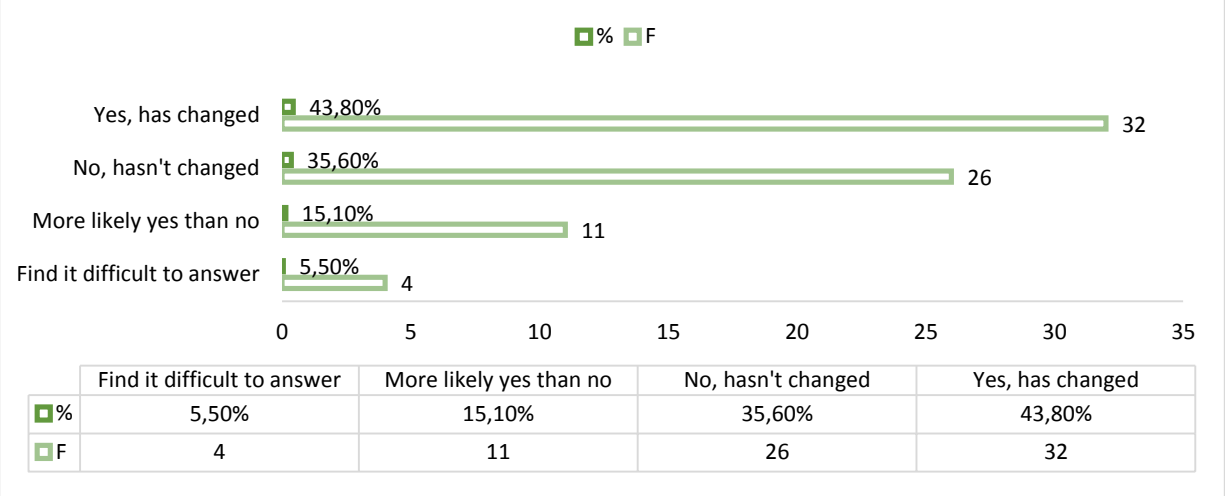
29 participants stated they could more likely use in-person methods online than no, while 20 participants stated that in-person methods were more likely incompatible online rather than compatible. 18 participants said they could use in-person methods online while 2 participants said they couldn't. 4 participants found the question difficult to answer.

When posed with the question "Teaching online, do you experience difficulties in developing students' language communication skills?" 35.6 % of responded "more likely yes than no." This was followed, in decreasing order, by "yes regularly" (34.2 %), "more likely no than yes" (17.8 %), "no" (9.6 %). 2 participants found the question difficult to answer.

When asked what form of teaching participants preferred to teach in, 32 participants preferred in person while 2 and 8 participants preferred distance and online teaching. Whereas 30 participants preferred mixed instruction.

When asked about the change in amount of homework in online instruction, 41.1 % of participants stated no change. 31.5 % and 20.5 % of participants stated increase and decrease respectively. 5 participants found the question difficult to answer.

In this context, when asked if the role of the instructor had changed online, 32 participants stated that it had whereas 26 stated that it hadn't. 11 participants stated "More likely yes than no" change in the role of the instructor. Finally, 4 participants found the question difficult to answer (Figure 7). All of the results deviated from the expected distribution of 25 % or approximately 18 participants. There were 3 degrees of freedom and the Chi-Squared test resulted in a statistically significant p-value of 4.29×10^{-6}, demonstrating significant variations in views on the changing role of teachers. The "Yes, has changed" group proved to be the most statistically significant which had 43.80 % instead of the expected 25 %, with a standardized residual of 3.22 and a p-value of 0.0013.



	Find it difficult to answer	More likely yes than no	No, hasn't changed	Yes, has changed
%	5,50%	15,10%	35,60%	43,80%
F	4	11	26	32

Fig. 7. Responses to the question "In your opinion, has role of the teacher changed in the online teaching?"

5. Discussion

Today, online teaching and learning has become a significant part of the academic world. The concept of online learning has almost fully formed. The scientific literature identifies key characteristics of online learning, including the separation between students and instructors, the use of electronic learning tools, the presence of a university's electronic information and educational environment, and the predominance of independent student activity (Baranova et al., 2020).

The digitalization of education has transformed the entire education system, bringing innovations such as adapting curricula to online conditions, incorporating technological processes into education, designing learning processes and creating a digital education environment (Lukyanova et al., 2021). This transformation necessitates improvements in digital tool usage for both instructors and students. Furthermore, the adaptation of the educational process is developing in two directions: creating a flexible control system that meets students' educational needs and developing curriculum content that aligns with this control system (Samofalova et al., 2023).

According to Feyzer and Dyakova (2023), digital linguodidactics of RFL is currently in its fourth stage of development. Each new stage in the evolution of RFL is marked by the introduction of new technologies and e-learning tools. This progression requires a continual revision of the terminology within the field of electronic linguodidactics for teaching RFL (Dyakova, Khvorova, 2020), as well as an update of the primary stages of the teaching process itself.

Our study among RFL instructors in Turkey about their online experience yielded several key statistically significant conclusions. 41 % of instructors find the online format convenient for teaching Russian, whereas 52 % either find it difficult or prefer not to teach in this format. Almazova et al. (2020) report similar findings, indicating that 61 % of participants consider online/video classes ineffective compared to traditional education. Additionally, only 23.3 % of instructors in presented study are fully satisfied with the online teaching process, while 27.4 % are more satisfied than dissatisfied. Notably, 38.8 % are more dissatisfied than satisfied with the process. These results combined by statistically significant deviation from standard distribution, highlight a significant divide in instructors' perceptions of online teaching RFL. While some find it convenient, a larger proportion encounters difficulties or prefers traditional methods. This variation in responses suggests the need for further research and development to address these challenges and enhance the effectiveness of online method.

Research conducted by Meirovitz et al. (2022) with EFL instructors highlighted the lack of technical assistance as a major issue in distance learning. Similarly, regarding the technical side of teaching RFL online in Turkey, instructors reported that the infrastructure of institutions is not fully prepared for a quality education in this mode. Additionally, 38,4 % of respondents mentioned having access to a computer and internet-equipped space at any time. However, they noted inadequate preparation, which is often compensated by the staff's involvement in the process. These answers indirectly indicate that instructors understand that the Internet and a computer alone are not enough to switch to an online format. Quality education requires methodology and readiness at every level of a systematic approach.

The study found that transitioning to an online format often leads to reduced class attendance, with 47.9 % of surveyed instructors noting a decrease. This decline, along with decreased motivation, can negatively impact the quality of education and outcomes. This is confirmed by current research, where instructors report a decrease in knowledge levels in the online format. Hopkins (2010) and Tao and Gao (2022) observed that instructors view low student participation as a major drawback of online teaching. There is a consensus that class attendance is typically lower in online education. However, it's important to consider that this drop in attendance might be due to inadequate technical resources and issues related to the students themselves. Additionally, the reduction was assessed by instructors based on personal observation rather than statistical data, an aspect that was not covered in the present study and requires further research. Decreased attendance could also be a consequence of reduced motivation. Thus, while the transition to an online format can reduce class attendance and motivation, impacting education quality and outcomes, it is crucial to explore further the underlying reasons, including technical resources and student-related issues. More comprehensive research is needed to address these challenges effectively.

Interesting results were obtained regarding the change in student workload due to online learning. Opinions were almost equally divided among those who felt the workload had increased, decreased, or remained unchanged. Even though the answers were equally divided, it should be

noted that the response indicating an increase was higher by approximately 3 %. This variation in opinion may be a consequence of the methodology and content of the curriculum, which is still in the process of being fully developed. The study conducted among preparatory class students in Turkey revealed mixed opinions about the extracurricular workload in distance education. According to the survey, 30 out of 78 students found the homework productive, while 22 felt they were given an excessive amount (Dolmacı, Dolmacı, 2020). Reznikova et al. (2020) observed that distance education requires students to understand materials independently, making the learning process more challenging and increasing their workload.

Although Reznikova et al. (2020) emphasized that high motivation is crucial for students in distance education, survey results indicate a decline (58.9 %) in motivation among many students. The decrease in motivation may stem from students' concerns about the effectiveness of online teaching. A study conducted in Saudi Arabia by Al Shlowiy et al. (2021) revealed that students worry about the effectiveness of online teaching and its impact on their GPA. They also expressed concerns that, even if they passed their courses, they might not be adequately prepared for more advanced studies. While motivation remains a critical factor for success in distance education, the transition to online learning has posed significant challenges. Concerns about the effectiveness of online instruction and preparedness for future courses are likely contributing to decreased motivation among students. These findings highlight the need for improved online teaching strategies and support systems to enhance student engagement and learning outcomes.

Observation of students' psycho-emotional states revealed two main trends: interest and uncertainty. The varied responses indicate that students experience a range of emotions during online lessons. While many students show interest, a significant number also feel uncertain or even rejected. This diversity in emotional response highlights the complexities of the online learning environment and the need for tailored strategies to support students' emotional well-being. Supporting these findings, research by Ambiyar et al. (2023) with Chinese students indicates that online education enhances students' desire to learn, increasing their interest in the course. Additionally, a survey by Smelkova et al. (2021) found that interest in classes during distance education is higher (79 %) compared to in-person education (58 %) among Chinese students. These results emphasize the importance of understanding and addressing the various emotional states of students to improve their online learning experiences. However, it should be noted that these studies might have an inherent bias as the data represents conclusions based on instructor's observations and might warrant future research.

According to the research results, the online format for teaching Russian as a foreign language (RFL) is preferred by instructors at more advanced levels. Instructors believe that the least suitable format is for level A1. This observation may be credible because advanced-level students have already developed their own personal learning methods for RFL, leading to better results.

The study found that 69.9 % of instructors reported an increase in their workload. Bui et al. (2023) suggest that effective teaching relies on the efforts of both instructors and students. For instructors, adapting to new technology often means additional work. This includes ensuring that their teaching methods work well with the technology, meeting both technological and student needs, and prioritizing the safety and health of students. These factors all contribute to the increased responsibilities instructors face.

Instructors encountered various challenges in different aspects of online education. RFL instructors particularly struggled with developing writing, phonetic, and speaking skills. Managing homework also posed difficulties, as did explaining difficult subjects and grammar. Fewer instructors reported issues with developing listening skills, working on exercises, and developing reading skills. The results align closely with findings from other researchers. Alimova et al. (2021) highlighted the significant challenge of teaching writing at the start of a distance learning program, especially for beginner students who cannot observe the instructor's writing movements or have their own writing monitored simultaneously. Hopkins (2010) pointed out the difficulties in developing students' phonetic and speaking skills online, noting that anxiety and competence in using technology play a direct role in these challenges.

Instructors reported various challenges in online teaching, with the most common being the significant amount of time required to prepare for lessons. Following this were difficulties in testing students' knowledge, a lack of effective online teaching methods, technical issues, and insufficient skills for conducting online lessons. Additional problems included managing teaching materials, lacking necessary technical resources, and inadequate IT skills.

These insights are supported by research from T. Meirovitz et al. (2022), which found that 14.46 % of EFL instructors considered lesson preparation for online teaching to be highly time-consuming, making it a major challenge. Similarly, a survey by Almazova et al. (2020) identified obstacles such as insufficient skills for online teaching, the extensive time needed for lesson preparation, and the inability to use active teaching methods effectively online. A study by Madanat et al. (2024) with Jordanian instructors further corroborates these findings, highlighting the significant issue of lacking technological skills in online teaching. Researchers stress the importance of more training in using digital tools for educational purposes. The shift to online teaching has presented many challenges for educators, particularly regarding lesson preparation time, technical skills, and the availability of effective teaching methods. Addressing these issues through comprehensive training programs is essential for instructors to successfully navigate the complexities of online education.

Research has shown that many RFL instructors tend to use face-to-face teaching methods even in an online format. However, a significant number of instructors also note the impossibility of using these traditional methods effectively online. According to Kevin W.H. Tai (2024), instructors often employ face-to-face education techniques in online education. The study observed two different online teaching methods and found that instructors used the same approaches as in face-to-face settings to engage students and explain subjects. For instance, instructors would draw the object being described on paper. This suggests that instructors' pedagogical approaches in online education are heavily influenced by their face-to-face teaching methods. While instructors often try to replicate face-to-face methods in online education, this can be challenging and sometimes ineffective. The reliance on traditional techniques highlights the need for developing and adopting new strategies tailored specifically for the online learning environment.

Most instructors preferred in-person teaching, with only two participants favoring distance learning and eight preferring online their roles.

Finally, a key aspect of the study that must also be addressed is our sampling method. A convenience sampling method was used due to the difficulties associated with the more extensive and robust probabilistic sampling method. This could have introduced a sampling bias in our results. This non probabilistic method could mean that our results conducted on a limited group is not representative of the broader population of interest. As a result this could prevent our results from being applicable to Russian language instructors in general and could have introduced a systematic bias. Future research should consider using probabilistic sampling techniques, such as random sampling, to ensure the robustness and applicability of the samples for the wider population.

In summary, the impact of digitalization and globalization on education is evident in the evolving role of instructors. While many instructors acknowledge changes in their roles due to online education, opinions vary, reflecting the complexities of this transition.

6. Conclusion

During the pandemic lockdown, instructors faced a multitude of challenges across pedagogical, technological, systematic, organizational, and personal domains. Pedagogically, adapting traditional teaching methods to an online format proved difficult. Technologically, the lack of adequate system and equipment was a significant barrier. Systematic organizational challenges included insufficient technological support and guidance from institutions, while on a personal level, instructors struggled to maintain boundaries between work, family, and leisure (Shamir-Inbal, Blau, 2021).

While distance learning offers numerous advantages, it also demands greater responsibility from instructors and increased motivation from students (Klisowska et al., 2020). The importance of institutional support, particularly in providing reliable internet access, is crucial for ensuring the continuity of education, especially for students and instructors in rural areas (Butarbutar et al., 2023). In Turkey, internet access provided by schools is particularly important for students living in dormitories. The success of e-learning heavily depends on the readiness of instructors (Keramati et al., 2011). Therefore, findings from this study should guide educational initiatives aimed at improving instructors' preparedness for e-learning, ensuring more effective implementation of e-learning strategies.

The study highlighted a significant divide in instructors' perceptions of online teaching RFL. While some find it convenient, a larger proportion encounters difficulties or prefers traditional

methods. This variation in responses suggests the need for further research and development to address these challenges and enhance the effectiveness of online teaching methods.

A critical issue identified is the lack of technical assistance and inadequate institutional infrastructure, which hampers the quality of education. Instructors report that merely having access to a computer and the internet is insufficient; effective online education demands comprehensive methodological preparation and systematic readiness. The study also found a notable decrease in class attendance and student motivation, factors that adversely impact educational outcomes. This decline is attributed to both technical deficiencies and inherent student-related issues. Additionally, opinions on changes in student workload due to online learning are mixed, with a slight majority indicating an increase. This variation likely stems from the evolving nature of online curriculum development. Overall, the findings underscore the necessity for more thorough research and the implementation of robust support systems to enhance the effectiveness of online education.

The transition to online learning has presented significant challenges, including decreased student motivation, increased instructor workload, and varied emotional responses among students. Instructors report an increase in workload, particularly when adapting to new technologies, which demands additional effort to ensure effective teaching and address both technological and student needs. Moreover, the preference for online formats varies with the level of proficiency, being more suitable for advanced students who have developed personal learning methods. These insights underscore the necessity for improved online teaching strategies and methodology, comprehensive support systems and specialization, as well as ongoing research to enhance the quality of online education and address its multifaceted challenges.

In conclusion, instructors faced numerous challenges in transitioning to online education, particularly in developing writing, phonetic, and speaking skills, managing homework, and explaining complex subjects. While some instructors found face-to-face methods ineffective online, they continued to use them due to familiarity. Research supports the finding that insufficient technical skills and the extensive time needed for lesson preparation are major obstacles. Despite the convenience of online learning for some, many instructors and students still prefer in-person or mixed instruction, emphasizing the need for a balanced approach. Additionally, the digitalization and globalization of education have significantly influenced instructors' roles, requiring new strategies and comprehensive training to face these challenges effectively. Overall, the evolving educational landscape demands tailored approaches to enhance both teaching and learning experiences in an online format.

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The Level of Awareness of Health-Saving Educational Technologies Affects University Students' Cognitive and Educational Skills

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Abstract

The aim of this study is to longitudinally examine the cognitive and educational skills of university students regarding health-saving educational technologies (HSETs) through observation. In this context, 325 students affiliated to the faculty of education were included in the study. At the same time, 35 faculty members followed these students through observation between 2020–2023. In this context, the participants' cognitive skills, activation criterion levels, motivational needs criteria, and morale-value criteria were scored between 0 and 10 by each teacher. Accordingly, the participant's cognitive and educational levels of HSETs were determined as optimal (10 points), sufficient (8 points), acceptable (6 points), and critical (4 points). According to the findings, the cognitive criterion level of the participants decreased from 53.3 % to 8.1 %, the active criterion level from 64 % to 50 %, the motivational-need criterion level from 64.6 % to 42.6 %, and the moral value level from 36.2 % to 6.1 %. As a result, according to teacher observations, students' cognitive and educational skills towards HSETs have improved a lot. However, the level of activity criterion and motivational-need criterion was still high. Therefore, in order to improve the HSETs skills of the students, the curriculum could include the acquisition of these skills.

Keywords: health saving educational technologies, cognitive skills, educational skills, educaiton.

1. Introduction

Educational technologies have an important role in today's educational systems and constantly evolving technological tools offer various opportunities to support students' learning processes (Jin, Bridges, 2014). Especially in the field of health education, health saving educational technologies (HSETs) are attracting more and more attention (Kondratska, 2023). Health saving

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helps individuals to increase their health awareness and use health services more efficiently (Koycheva et al., 2019). In this context, the use of HSETs in students' educational activities has been an important area of research.

In recent years, youth health issues have become a very urgent problem, because there is a decrease in their motor activity, associated with many factors, and primarily with the use of modern achievements in the world of electronics (Nesi, 2020). Modern training programs and requirements for students have significantly changed their lifestyle: physical labor is practically absent, physical activity is minimized (Morrow et al., 2022; Woessner et al., 2021). In this regard, the use of HSETs in educational activities of students is one of the most urgent scientific problems. Therefore, it's critical to develop techniques for integrating physical activity with modern Technologies (Dao, yHong, 2024). The trend toward a more sedentary lifestyle calls for innovative teaching approaches that support young learners' physical and academic demands simultaneously (Cai et al., 2024). Reversing the trend of youth declines in motor activity may require integrating movement-based learning into the academic framework and scheduling regular breaks for physical activity.

The significance of student health and well-being in the demanding context of modern education cannot be emphasized (Marsh et al., 2023). Although there is substantial evidence linking academic achievement to health, educational institutions frequently have difficulty incorporating health promotion into their curricula (Blackford et al., 2022; Madsen, Bell, 2012; Wylie, Leedham-Green, 2017). This oversight may inadvertently cause students to experience higher levels of stress (Williams et al., 2015), physical inactivity (Fletcher et al., 2018), and related health hazards. Adding to the issue, neglect of this kind might worsen mental health problems and socio-emotional challenges, which are becoming more common among students (Upreti et al., 2024). In addition, the absence of a methodical approach to health promotion in educational institutions could exacerbate health equity disparities, especially for students from disadvantaged socioeconomic backgrounds (Lesser et al., 2024).

Analysed in this context, the aim of the study is the scientific justification of the psychological and pedagogical conditions for the impact of HSETs in improving students' mental activity. The aim of the formative (educational) stage of this experimental study is the theoretical and experimental substantiation of the effectiveness of the use of HSETs to improve mental activity and pedagogical conditions for their application in the educational process. In this regard, the research is aimed at identification and analysis of the level of formation of HSETs, identification and analysis of the level of teachers' competence, identification of pedagogical conditions that determine the effectiveness of the organisation of the process of improving mental activity through HSETs.

2. Methods

Research Model

This longitudinal study evaluates the impact of HSETs on the educational outcomes of 325 university students. In the study, G-Power (University of Düsseldorf, Düsseldorf, Germany) programme was used to determine the minimum sample size. Accordingly, when α=0.05, power (1- β = 0.80), and effect size = 0.29, it was calculated that at least 296 people should participate in the study. In this context, voluntary 325 participants who regularly attend formal education at universities were determined by random method. The study was designed to track changes in health habits, mental activities and general health status of the identified groups of students.

32 educators observed the development of students throughout their educational process and their use of health-protective educational technologies for three years. The educators were selected from among experienced teachers and academics who have a direct educational relationship with the students. Observers took regular notes on students' engagement, level of interaction, health awareness and use of technology.

Since this research is a longitudinal research, necessary arrangements were made by following the same sample group in order to ensure the integrity of the data. In this context, the awareness levels of the participants regarding health-saving educational technologies were examined at 3-year intervals. As environmental variables, the change in the duration of using these technologies was taken into consideration. In this context, the observers will record the changes in the participants during this period. The observers methodically recorded the impact of health-protective educational technologies used in students' in-class and extracurricular activities. Observations were standardized using structured observation forms and the objectivity of the

educators' notes was maintained. In addition, students' academic performance, class participation, and health-related behavioral changes were examined through regular questionnaires and assessments.

Research Group

A total of 325 university students from departments affiliated to the faculty of education voluntarily participated in the study. The students remained the same throughout the study and were not subjected to any selection criteria. The confidentiality of the participants was protected in accordance with ethical rules and standards set by the university. The study included undergraduate students who are actively studying at this university. Participants with absenteeism, studying in another department, double majors were not included in the study. All participants were informed about the purpose, reason and possible effects of the study. The entire study was conducted in accordance with the principles set out in the Declaration of Helsinki.

Observation Analysis Approach

In this study, the effectiveness of health-protective educational technologies used to improve the mental activities and healthy lifestyles of 325 university students will be observed by 32 teachers for three years. Students' progress will be analyzed through four criteria (Cognitive, Active, Motivational-Need, Moral-Value) and four different levels (Optimal, Adequate, Acceptable, Critical).

Evaluation Criteria and Levels

Cognitive Criterion: The student's theoretical knowledge about healthy living and health protective technologies.

Active Criterion: The student's ability to independently solve problems related to healthy living and apply these technologies to different educational activities.

Motivational-Needs Criterion: Motivation to use health-protective technologies to improve mental activity.

Moral-Value Criterion: Level of perception of healthy living as a value.

Each student will be evaluated on these four criteria according to a scoring system of 10 (Optimal), 8 (Sufficient), 6 (Acceptable) and 4 (Critical).

Data Collection Procedure

Teachers will assess students' performance at regular intervals using a standardized observation form. Observations will be made on students' use of health-protective technologies, mental activity levels, health knowledge, and adoption of healthy lifestyles. For each criterion, the observation form will clearly describe and score the behaviors demonstrated by the learner and the knowledge, skills, motivation, and values they embody. In order to ensure the validity and reliability of this observation form, firstly, content validity was ensured by consulting expert opinions, and then the form was tested in a pilot group and its construct validity was analyzed. In order to ensure the reliability of the measurements, independent observations were made on the same students by different teachers, and the coefficient of concordance between the scores (Cronbach's Alpha) was calculated as 0.85. This value shows that the observation form has high reliability and that the student's knowledge, skills, motivation, and values towards health protective technologies are measured objectively.

Statistical Analysis

The data collected will be used to observe each student's progress at the beginning and at the end of the intervention. Each observer will analyze their own observations to identify changes and improvements in students' performance, and these observations will be compared with each other to identify an overall trend. This process will be used to evaluate the effectiveness of health-protective educational technologies, and the findings will shed light on the process of students' adoption of healthy lifestyles. In this context, the normality analyses of the participants' data were performed with Kolmogrov Smirnov Test, and it was determined that the data showed normal distribution. Since there is only one group and 2 different time measurements in our research, the data of the participants were analyzed with Paired Sample T test. The significance level in the study was determined as 0.05. The effect size (ES) magnitude was defined as follows: < 0.2 = trivial, 0.2 to 0.6 = small effect, >0.6 to 1.2 = moderate effect, >1.2 to 2.0 = large effect, and > 2.0 = very large.

3. Results

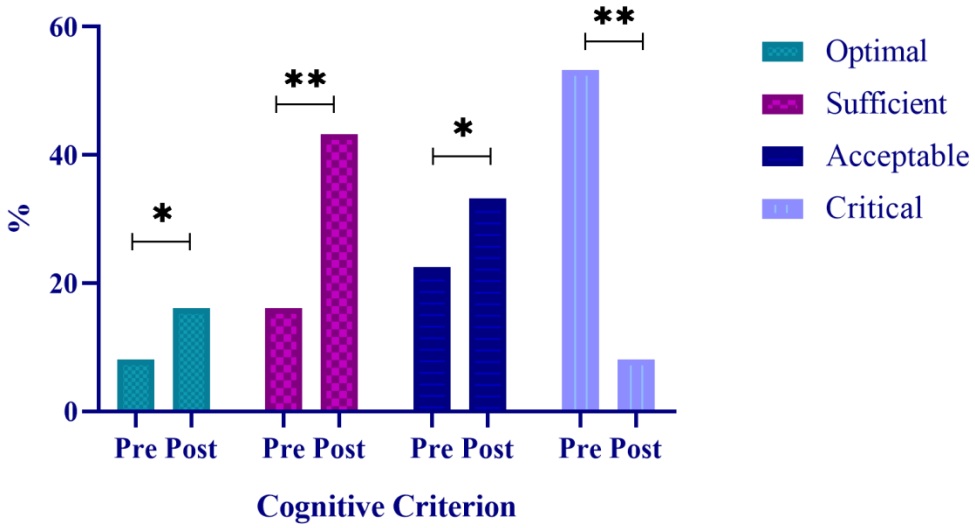

Fig. 1. Characteristics of the level of organization of the process of improving the mental activity of students through health-saving technologies (according to the cognitive criterion):
* p < 0.05, ** p < 0.001

Characteristics of the level of organization of the process of developing students' mental activity through health-saving technologies, were studied according to the cognitive criterion (Figure 1). Accordingly, the number of participants at the optimal level in the first measurement was 8.1%, and in the last measurement, it increased to 16.1 % (t = 2.897, p = 0.034, Cohen's d = 043). The number of those at the Sufficient level increased from 16.1 % to 43.3% (t = 9.567, p < 0.001, Cohen's d = 075). The number of those at Acceptable level increased from 22.5 % to 33.2 % (t = 3.927, p = 0.004, Cohen's d = 068). The number of those at the Critical level decreased from 53.3 % to 8.1 % (t = -7.895, p < 0.001, Cohen's d = 097).

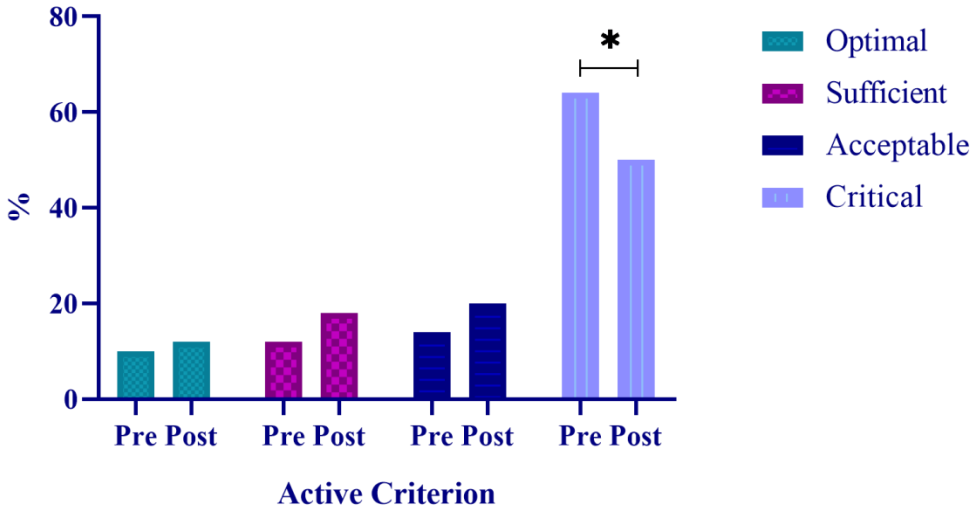

Fig. 2. Characteristics of the level of organization of the process of improving the mental activity of students through health-saving technologies (according to the active criterion):
* p < 0.05, ** p < 0.001

In Figure 2 the characteristics of the level of organization of the process of developing students' mental activity through health-saving technologies are analyzed according to the active criterion. Accordingly, the number of participants at the optimal level increased from 10 % before the observation to 12 % after 3 years, from 12 % to 18 % at the sufficient level, and from 14 % to

20 % at the acceptable level (p = 0.05). Those at the critical level decreased from 64 % to 50 % (t = -3.453, p = 0.009, Cohen's d = 0.072).

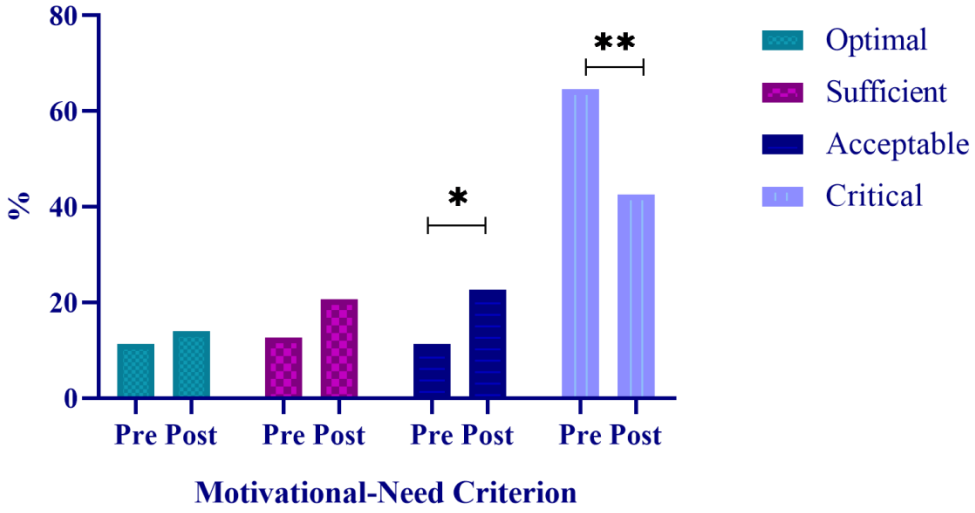

Fig. 3. Characteristics of the level of organization of the process of improving the mental activity of students through health-saving technologies (according to the motivational-need criterion):
* p < 0.05, ** p < 0.001

In Figure 3 the characteristics of the level of organization of the process of developing students' mental activity through health-saving technologies are observed according to the criterion of motivational need. Accordingly, the number of participants who were at the optimal level before the observation increased from 11.3 % to 14 % (p > 0.05), at the sufficient level from 12.6 % to 20.6 % (p > 0.05), and at the acceptable level from 11.3 % to 22.6 % (t = 3.026, p = 0.022, Cohen's d = 0.52). The number of critical levels decreased from 64.6 % to 42.6 % (t = -5.677, p > 0.001, Cohen's d = 0.88).

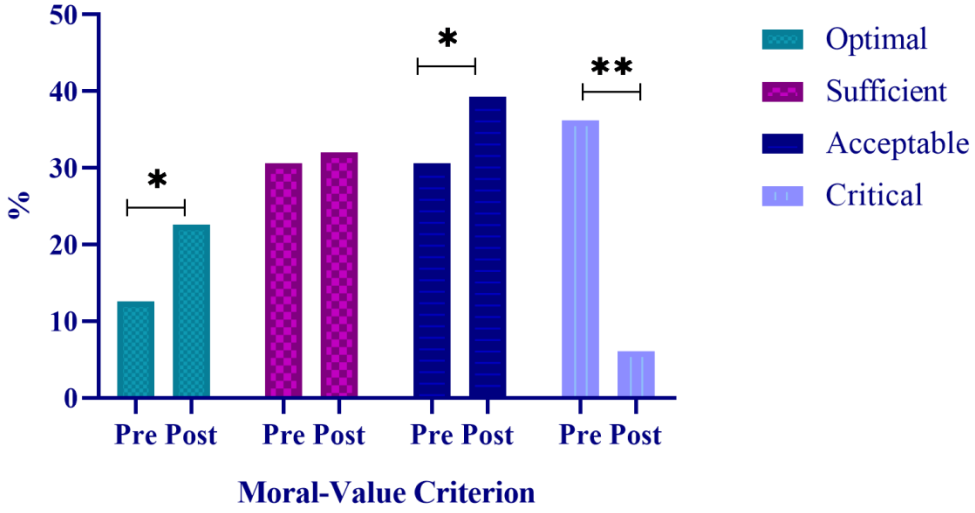

Fig. 4. Characteristics of the level of organization of the process of improving the mental activity of students through health-saving technologies (according to the moral-value criterion):
* p < 0.05, ** p < 0.001

In Figure 4 the characteristics of the level of organization of the process of developing students' mental activity through health-saving technologies are analyzed according to the criterion of moral value. Accordingly, before the observation, the number of participants at the optimal level increased from 12.6 % to 22.6 % (t = 3.269; p = 0.021), at the sufficient level from 30.6 % to 32 %

($p > 0.05$), at the acceptable level from 30.6 % to 39.3 % ($t = 2.925$, $p = 0.032$, Cohen's $d = 0.37$). The critical level decreased from 36.2 % to 6.1% ($t = -8.969$, $p < 0.001$, Cohen's $d = 0.91$).

4. Discussion

Important trends and implications for faculties of education are illustrated by this long-term survey of university students' cognitive and instructional abilities with reference to HSETs. In the participants' theoretical understanding and systematic knowledge of health saving technology, the number of those with a critical level of cognitive criteria decreased from 53.3 % to 8.1 %, while the number of those with an optimal and sufficient level increased. This allowed us to conclude that the educational activities provided at the faculty of education had a positive impact on cognitive skills. At the same time, this significant increase in theoretical knowledge demonstrates the successful integration of HSETs into the curriculum, potentially reflecting the effectiveness of innovative teaching methods and the assimilation of these concepts into students' academic routines (Sepulveda Larraguibel, Venegas-Muggli, 2019).

In contrast, the level of active criterion showed a modest decrease from 64 % to 50 %, which can be interpreted as students maintaining a relatively low ability to problem solve and actively apply HSET knowledge in various educational activities (Onipko, Dyachenko-Bohun, 2018). The relatively high retention of practical skills compared to theoretical understanding may reflect the effectiveness of hands-on teaching methods or students' preference for practical learning experiences (Bakiko et al., 2023). Furthermore, the ongoing retention of practical skills would suggest that the curriculum's experiential learning elements are more successful and stick in students' memories. This conclusion is consistent with theories of education that highlight "learning by doing" as an essential element of more profound involvement and comprehension (Fadeke Adeola Atobatele et al., 2024). In order to overcome the identified gaps in cognitive criteria, educators could think about adding additional project-based assignments, internships, and simulation exercises to the curriculum. These activities would force students to use their HSET knowledge in real-world situations.

The number of those with a critical level of motivational need has decreased from 64.6 % to 42.6 %, although it is still higher in the current situation. While this decline is significant, the remaining level still reflects a moderately high motivation among students to engage with HSETs, which is encouraging for educators aiming to instill such values (Kondratska, 2023). This aspect of the findings highlights the importance of sustaining and promoting student interest and perceived interest in health-saving practices in educational settings (Kondrashova et al., 2020). It also highlights how important it is to create state-of-the-art teaching techniques that will engage students in health-saving behaviors and increase their interest over time (Stepanova et al., 2023). These tactics could include incorporating current health topics into the curriculum, encouraging student participation in the topics studied, and giving students the chance to observe how HSETs are used in the real world. In this way, the intrinsic value of these practices can be increased for both students and their future employers.

The decrease in the proportion of students exhibiting critical moral values towards HSETs from 36.2 % to 6.1 % and the increase in the levels of optimal and adequate moral values is an indication of a positive change in the ethical perception of HSETs in the student population. These results reflect a deeper integration of health awareness principles as core values rather than just academic concepts (Klymovych, 2019). The growth in optimal and adequate moral values underlines the potential success of pedagogical strategies aimed at promoting a values-based approach to health and well-being in the educational environment (Haydon , 2004). It highlights the importance of a values-based educational framework that not only conveys knowledge but also instills the moral imperatives of adopting and promoting a healthy lifestyle, which is crucial for the development of future educators and public health advocates.

5. Conclusion

Faculty members have noted a positive overall development in cognitive and educational capabilities toward HSETs. Though there has been a general reduction, the persistently high activity criteria and motivational need criteria indicate that some components of learning are more resilient than others. The requirement for an educational program that strategically addresses all domains – cognitive, active, motivational-need, and moral-value—in order to provide a thorough and well-rounded grasp of HSETs is highlighted by this differential resilience. Consequently, it is

advised that the curriculum emphasizes the integration of HSETs abilities with solid theoretical foundations and value-based education in addition to just requiring students to acquire these skills. Among the strategies might be more reflective and participatory teaching techniques that link theory to practice and help students develop a stronger sense of personal connection to the principles of a healthy lifestyle. Furthermore, using case studies, real-world problem-solving scenarios, and peer-teaching approaches may improve students' moral values, motivation, and cognitive comprehension of HSETs. It is recommended that more research be done to investigate the underlying reasons of the trends that have been seen and to identify the best remedies to deal with the decreases in moral-value and cognitive standards. External elements, such as cultural, socioeconomic, and institutional influences that transcend the classroom, should also be taken into account in this type of research since they may have an impact on student participation and perception.

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Optimizing Learning Management Systems for Student Success in Ghana: A Management Framework

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Abstract

The widespread adoption of Learning Management Systems (LMS) in higher education necessitates understanding their impact on student performance, particularly in understudied contexts like Ghana. This study examines the factors influencing LMS use and their subsequent impact on academic performance among Ghanaian undergraduates. A quantitative survey design involved 232 undergraduate students from diverse disciplines at a Ghanaian public university. Data were collected using a validated questionnaire measuring LMS utilization, system/information quality, service quality, user self-efficacy, student satisfaction, and academic performance. Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to analyze the relationships between these constructs. The results indicate that system quality, information quality, and user self-efficacy significantly influence LMS utilization, while service quality has a minimal direct effect. Furthermore, user self-efficacy and IT service quality are key determinants of student satisfaction. Both student satisfaction and LMS utilization strongly influence academic performance. These findings suggest that LMS effectiveness in the Ghanaian context relies not only on technology but also on user empowerment and support. Managerial implications include the need for Ghanaian universities to adopt a multi-pronged approach that prioritizes user empowerment, robust IT support, and faculty training to maximize LMS impact on student performance and satisfaction.

Keywords: learning management system, LMS, academic performance, student satisfaction, higher education management.

1. Introduction

Learning Management Systems (LMS) have proliferated in higher education, propelled by the growth of electronic learning (e-learning) and exacerbated by the COVID-19 epidemic. These digital

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platforms offer a virtual environment for academic pursuits, prompting questions about their impact on student outcomes. Although research validates the efficacy of LMS in supporting traditional learning (Emelyanova, Voronina, 2014; Kim, et al., 2019; Broadbent et al., 2023), its influence on academic performance, particularly in contexts like Ghana, remains less understood.

While defining 'academic performance' presents challenges (Burns, Darling, 2002; Habibah et al., 2011), this study focuses on its multifaceted nature, encompassing competence, productivity, efficiency, and knowledge acquisition (Aldholay et al., 2018). Building on existing research (Kuh et al., 2006; Ampofo, Osei-Owusu, 2015), we go beyond mere system usage (Isaac et al., 2017) to investigate the actual relationship between LMS engagement and performance at the University of Education, Winneba (UEW) in Ghana.

This study addresses a critical gap by investigating the impact of LMS on academic performance within the specific context of Ghanaian higher education. While concerns exist regarding adaptability and support for students (Ssekakubo et al., 2011; Park, Robinson, 2021), understanding the true potential of LMS is crucial for informing effective educational practices and policies in the e-learning era. Our findings will not only contribute to the broader LMS discourse but also provide valuable insights for Ghanaian universities navigating the transformative landscape of digital education.

2. Theoretical Review

Organizations implementing information systems (IS) often fall short of realizing their full potential in enhancing service quality, revenue, and consumer reach. To assess IS effectiveness, various models and tools have emerged, with the DeLone and McLean IS Success Models standing out as prominent contributors (DeLone, McLean, 2002; DeLone, McLean, 2003). The original D&M model (1992) identifies six constructs: system quality, information quality, system use, user satisfaction, individual impact, and organizational impact.

System quality evaluates overall performance, while information quality assesses system output, directly impacting both system use and user satisfaction. These, in turn, influence individual users and the overall organizational impact. Responding to the need for ongoing refinement, scholars have expanded or modified the original model. Ten years after its inception, DeLone and McLean proposed a revised IS performance model, introducing information, system, and service quality, (intention to) use, user satisfaction, and net benefits as the six interconnected dimensions of IS success.

In the updated model, the quality of information, system, and service influences future usage and user satisfaction, ultimately leading to net benefits. The model suggests that the evaluation of a system rests on the quality of provided information, system, and service, influencing user intentions to use and satisfaction. The ensuing benefits, positive or negative, further impact user satisfaction and continued system use (DeLone, McLean, 2003). This framework offers a comprehensive understanding of IS success, guiding organizations in optimizing their information systems for enhanced performance and user satisfaction.

Study model and justification

In this study, the Technology Acceptance Model (TAM) serves to elucidate the independent variable, LMS Use, by explaining the factors contributing to its extensive adoption. Meanwhile, the DeLone and McLean Information Systems (D & M IS) Success Model, a comprehensive and heterogeneous framework, offers deeper insights into the elements defining a system's success.

Focusing on LMS utilization and its impact on academic performance, the D & M IS success model emerges as an apt framework due to its ability to assess the diverse characteristics of IS success. This model aligns seamlessly with both the independent variable (LMS Use) and the dependent variable (students' academic performance), encapsulated by the net benefit construct.

The versatility of the D & M IS success model is underscored by its application across various platforms, including mobile and internet banking (Koo et al., 2013), Learning Management Systems (Nawaz, 2019), and healthcare information systems (Ojo, 2017). Nawaz (2019) specifically employed the model to evaluate the effectiveness of the Moodle LMS, revealing a significant and positive correlation between system use, user satisfaction, and effective learning. Similarly, Mohammed (2015) explored e-learning usage in higher education institutions, finding that information quality, system quality, and service quality positively influence system use and user satisfaction.

Given the increasing demand for LMS in Ghanaian universities, this research adopts the D & M IS model to investigate the nexus between LMS usage and students' academic performance at a major public university, aligning with the model's proven efficacy in diverse educational contexts.

Review of related studies and hypotheses

System Quality

System quality directly impacts LMS usage and user satisfaction (Trentin, 2009; Abrego-Almazán et al., 2017). A user-friendly, reliable, and easy-to-navigate system encourages engagement and fosters positive user experiences (Petter, McLean, 2009; DeLone, McLean, 2003). While open-source and cloud-based LMS dominate the market (Dobre, 2015; Davis et al., 2009), customization by universities often raises usability concerns (Nawaz, 2019). Therefore, this study assesses the post-customization usability of widely used LMS and its influence on student perception and usage. Therefore, we hypothesize that;

H1: The System Quality of an LMS will positively relate to LMS usage.

H2: The System Quality of an LMS will positively relate to students' satisfaction.

Information Quality

Extensive research has explored information quality in e-learning platforms, highlighting its crucial role in learning outcomes and user satisfaction (Lee, Lee, 2008; Aldholay et al., 2018; Al-Azawei, 2019). Well-organized and engaging content, delivered through diverse channels (instructor-led, internet-based, quizzes, and assignments), fosters effective information delivery and learning (Gudigantala et al., 2011). Established criteria for information quality include proper content format, accuracy, relevancy, and clear presentation (Mtebe, Raisamo, 2014; Aldholay et al., 2018). Notably, studies suggest information quality surpasses both system and service quality as the strongest predictor of e-learning course effectiveness (Nawaz, 2019). Accurate, appropriate, up-to-date, and readily understandable information, as emphasized by Wang et al. (2007), is deemed essential for student success. Hence, we put forth the following propositions:

H3: Information Quality will positively influence LMS usage.

H4: Information Quality will positively influence students' satisfaction.

LMS Service Quality

Service quality can help an institution gain a competitive edge by adding value to its product that will delight customers (Santos, 2003). Service quality fortifies an organization's client base and separates it from its competitors (Ramya et al., 2019). Wang et al., (2007) evaluated service quality based on service delivery, providing adequate explanations and helpful assistance through an online medium. According to DeLone and Mclean (2003), the quality of service is described by the following characteristics: tangibles, dependability, responsiveness, assurance, accessibility, interactivity, and empathy. Regular consultation and discussions with existing customers and providing sufficient support for the system's end-users will help enhance service quality. The user's view of the system's service quality can also be affected by partial user involvement or problems during the actual use (Koohang, Du Plessis, 2004). Many students in Ghana or Africa, in general, are not used to many information technology systems (Ssekakubo et al., 2011). The fact that students are not used to IS systems is disturbing because it will affect students' interest in LMS. Almost all institutions have an information technology directorate or units that provide support services to online students to use an LMS more effectively. As a result, this construct is used to evaluate the quality of services provided by IT departments. Students who receive strong support from the IT department are expected to continue to use the LMS and have a positive attitude toward it. Recent research has shown that service quality has a strong association with actual usage and satisfaction (Chiu et al., 2016; Nawaz, 2019). Following from this, the study hypothesizes that;

H5: IT Service Quality of an LMS will positively influence LMS usage.

H6: IT Service Quality of an LMS will positively influence students' satisfaction.

LMS Users' Self-Efficacy

Students have the freedom to choose what they want to study, when they want to learn, and how long they want to learn when it comes to online learning. These self-directed learning attributes of e-learning are vital to a user's learning effort and progress (Alvarez-Risco et al., 2020). Self-efficacy is a crucial variable in technology use since human characteristics differ significantly

(Mahdavian et al., 2016). The self-efficacy concept can be applied to several circumstances. In general, self-efficacy refers to one's evaluation of their ability to succeed (Alvarez-Risco et al., 2020). According to the self-efficacy theory, individuals establish their understanding of their self-efficacy based on previous interactions with comparable tasks, watching others complete similar tasks, social persuasion, and emotional state, according to the self-efficacy theory (Staples et al. 1998). On the other hand, Shen et al. (2013) described it as a student's belief in studying effectively from an online course. According to a large body of studies, academic self-efficacy is positively linked to system use and satisfaction (Lee, Lee, 2008; Aldholay et al., 2018; Alvarez-Risco et al., 2020). LMS usage is in its infancy in Ghana. As a result, it will be critical to look into the link between student self-efficacy and LMS usage. The study hypothesizes that;

H7: LMS users' self-efficacy will significantly predict LMS usage.

H8: LMS users' self-efficacy will significantly predict students' satisfaction.

LMS Use

The learning management system has to be used to benefit from it (Lai et al., 2012; Abdullah, Ward, 2016). This construct measures the degree to which students use the LMS. Delone & Mclean (2003) posited that increased system use is a crucial predictor of LMS performance. Actual use in online learning often represents the regularity and length of use (Kim et al., 2017).) One of the most critical directions in technology utilization is assessing the influence of system use on IS success factors such as performance and satisfaction (DeLone, McLean, 2016). Some studies have looked into the impact of actual use on performance and satisfaction (Aldholay et al., 2018; Oguguo, 2021). Despite the mixed results, it was discovered that there is a positive relationship between system use, satisfaction, and performance (Kim, 2017; Aldholay et al., 2018). On the other hand, other research found that this relationship is insignificant (Wu, Wang, 2006; Ojo, 2017). In DeLone and McLean's (2003) model, "intention to use" was proposed as an alternative measure in some contexts based on the system's usage level. For the early stages of device implementation, "intention to use" has been suggested as a helpful metric (Nawaz, 2019). The Moodle LMS of the University is already in use; as a result, assessing the system usage would be more appropriate. Therefore, this study will use LMS usage to determine the system's benefits and students' academic performance. Hence,

H9: LMS use will significantly influence students' satisfaction.

H11: LMS use will significantly influence students' academic performance.

User Satisfaction

User satisfaction with Learning Management Systems (LMS) has been linked to both system utilization and academic performance. Several studies suggest a positive relationship between satisfaction and use, with fulfilled needs and positive assessments driving increased system engagement (Bokhari, 2001; Delone, McLean, 2003). This aligns with the notion that a system's perceived value motivates continued use (Zviran et al., 2005). User satisfaction also appears to influence performance, although findings are mixed. Mtebe & Raisamo (2014) and Isaac et al. (2017) observed significant positive effects, while Norzaidi et al. (2011) and Ojo (2017) found no significant correlation. Given this inconclusive evidence, this study hypothesizes that;

H10: Students' satisfaction will positively influence academic performance.

Students' Academic Performance

Students have the freedom to choose what they want to study when they want to learn, and how long they want to learn when it comes to online learning.

As an educational institution, a university plays a pivotal role in cultivating high-caliber graduates for the national workforce (Garkaz et al., 2011). Education, a cornerstone of individual, communal, and national development, imparts crucial skills, talents, and awareness (Kapur, 2018). Academic accomplishment enhances theoretical knowledge, skills, and competency, enabling individuals to contribute meaningfully to community well-being (Kapur, 2018).

Students' academic performance holds sway over their long-term aspirations, influencing the trajectory of their further studies and career prospects (Valli Jayanthi et al., 2014). Various factors, including class attendance, assignments, exams, and participation in extracurricular activities, impact academic performance. Schools respond to external pressures by implementing progressive techniques to enhance student performance (Kapur, 2018). Academic success profoundly affects

students' confidence, motivation, and persistence in their educational journey. Suboptimal performance correlates with attrition, reduced graduate throughput, and escalated educational costs (Waggoner, Goldman, 2005).

The repercussions extend to limited opportunities for tertiary education and advanced degrees, prompting educators' enduring interest in students' academic performance (Ali et al., 2009). Students, relying on universities as conduits to future success, seek the best programs to acquire optimal skills and knowledge (Waggoner, Goldman, 2005). In the contemporary job market, companies prioritize adaptable graduates with diverse skills and experiences, intensifying the demand for well-rounded individuals (Andon et al., 2010).

The concept of academic success involves multidimensional constructs encompassing students' abilities, attitudes, and actions, all contributing to excellence in the classroom (Hijazi, Naqvi, 2006). In the context of this study, the use of Learning Management Systems (LMS) and student satisfaction emerge as crucial factors influencing academic performance, warranting consideration as important variables in the research framework. The study's framework is shown in Figure 1 below.

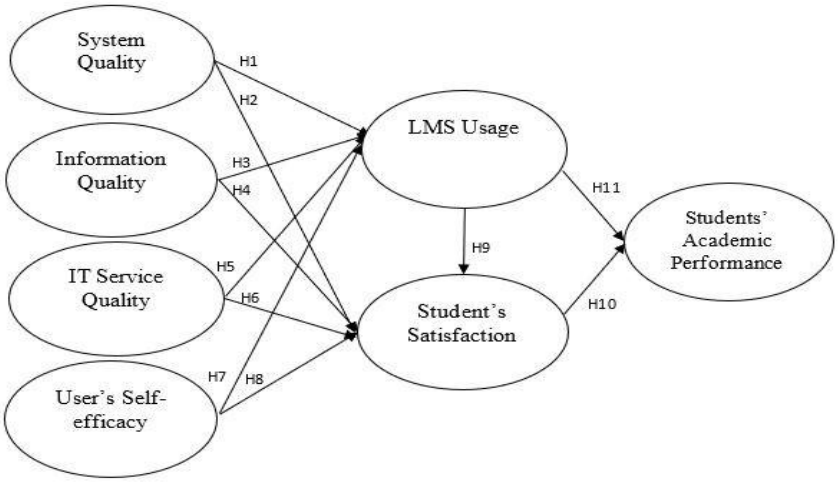

Fig.1. Conceptual framework

Methodology

This study adheres to a positivist philosophy, employing quantitative methods to systematically investigate the intricate dynamics between Learning Management System (LMS) usage and students' academic performance at a major public university in Ghana. An explanatory research design was adopted to elucidate causal relationships among various variables.

Data Collection

Data collection was done during the second semester of the 2022/2023 academic year. The principal instrument was a meticulously constructed questionnaire. The questionnaire was subdivided into four parts. The first part collected respondents' demographic data, including age, gender, and academic level. The second part gathered data on factors influencing students' LMS usage, with factors adopted from DeLone and McLean (2003), except for self-efficacy, which was adopted from Lee and Lee (2007). The third part assessed user satisfaction, while the fourth part evaluated students' academic performance, both using measures adopted from Aldholay et al. (2018).

Population and Sampling Technique

The study targeted a population of 1,892 regular undergraduate students at one of the university campuses. A simple random sampling technique was employed to ensure generalizability, allowing each student an equal probability of selection and thereby enhancing the sample's representativeness. Although a sample size of 320 subjects would be ideal for a 95 % confidence level and a 5 % margin of error, the final sample size consisted of 232 respondents. This adjusted sample size was determined based on practical considerations, including available resources, time constraints, and the need to maintain a balance between precision and feasibility.

Despite the reduced sample size, 232 respondents provided a sufficiently robust dataset, enabling meaningful insights into the research questions while preserving statistical significance. Additionally, the simple random sampling approach ensured the diversity of the student body was accurately reflected in the sample. Consequently, the study's findings are still generalizable within the context of the study, although the reduced sample size is acknowledged as a limitation.

Data Analysis

Data analysis was conducted using a two-phased approach. First, descriptive statistics were applied to characterize the sample demographics and other relevant factors, providing a clear overview of respondent profiles and establishing a basis for deeper analysis. Following this, Partial Least Squares Structural Equation Modeling (PLS-SEM) was utilized to rigorously test hypotheses and examine relationships between the constructs. The analysis was performed using SmartPLS version 4.0, chosen for its advanced capabilities in managing complex models and suitability for smaller sample sizes, aligning well with the study's objectives. This use of PLS-SEM allowed for an in-depth examination of the relationships between LMS usage, student satisfaction, and academic performance, ensuring a theoretically grounded and comprehensive exploration of the research questions.

3. Results

Demographic Characteristics of Respondents

Table 1 shows the demographic background of the respondents. The study comprises 232 university students, with a gender distribution of 53.4 % males and 46.6 % females, reflecting the gender composition of the total student population. In terms of age, the predominant age group among respondents is 18 to 30 years, encompassing 95.3 % of participants. Students aged 31 to 40 constitute 4.3 %, while only 0.4 % fall within the 41 to 50 age range. This age distribution reflects the evolving demographic landscape of undergraduate students, indicating a shift from an older demographic to an influx of younger students entering directly from secondary school.

Regarding academic levels, the distribution is as follows: 11.2 % in level 100, 39.2 % in level 200, 15.1 % in level 300, and 34.5 % in level 400. This inclusive representation ensures diverse perspectives from all academic levels at the public university, contributing to a comprehensive understanding of students' experiences with LMS usage and its impact on academic performance.

Table 1. Demographic variables description

Demographic Variables	Frequency	Percentage
Gender		
Male	124	53.4
Female	108	46.6
Age		
18 – 30 years	221	95.3
31 – 40 years	10	4.3
41 – 50 years	1	.4
Academic Level		
Level 100	26	11.2
Level 200	91	39.2
Level 300	35	15.1
Level 400	80	34.5

Data Normality and Multicollinearity

In preparation for statistical analysis, the dataset underwent thorough screening, encompassing checks for missing data, outliers, and adherence to normality assumptions (Coakes, 2006). This process involved verifying the accuracy of data entry, identifying and handling missing values, and evaluating outliers within the research instrument items.

Missing data, and intentional or inadvertent non-responses in survey instruments, were meticulously addressed, and questionnaires with missing data were excluded from the analysis (Hair et al., 2014). To ascertain the normality of the dataset, a skewness-kurtosis test was conducted, assessing the irregularity and peakness of the distribution, respectively (Byrne, 2013;

Kim, 2019). All skewness and kurtosis values fell within the expected ranges, supporting the dataset's normality (Byrne, 2013).

Additionally, to mitigate multicollinearity, a Variance Inflation Factor (VIF) test was performed, with all VIF values found to be below the threshold of 5 (VIF < 5), indicating no significant issues of multicollinearity (Kim, 2019). This rigorous screening ensures the dataset's reliability and appropriateness for subsequent statistical analyses. Table 2 below presents the results of these tests.

Table 2. Loadings and normality of measurement

Items		Factor Loadings	VIF	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
SQ1	The LMS is easy to use	0.885	1.872	-0.858	0.16	0.274	0.318
SQ2	The LMS is user friendly	0.856	1.798	-0.981	0.16	0.131	0.318
SQ3	The LMS is easy to learn	0.795	1.584	-0.747	0.16	-0.127	0.318
IQ1	The course content in the LMS is accurate	0.73	1.41	-0.66	0.16	0.188	0.318
IQ2	The course content in the LMS is up-to-date	0.836	1.641	-0.836	0.16	0.081	0.318
IQ3	The courses have sufficient content required for me to complete learning process	0.822	1.348	-0.751	0.16	0.022	0.318
SEQ1	The staff in charge of LMS is committed	0.823	1.926	-0.382	0.16	-0.528	0.318
SEQ2	The staff in charge of LMS responds to my request quickly	0.892	2.507	-0.03	0.16	-0.943	0.318
SEQ3	The staff in charge of LMS has the technical ability to solve my problems	0.784	1.704	-0.254	0.16	-0.333	0.318
SEQ4	The staff in charge of LMS shows concern and empathy	0.845	2.079	-0.37	0.16	-0.563	0.318
SE1	I feel confident finding information on the LMS	0.812	1.658	-0.85	0.16	0.18	0.318
SE2	I feel confident downloading and	0.886	2.136	-1.061	0.16	0.417	0.318
SE3	uploading files on the LMS	0.879	1.963	-1.012	0.16	0.58	0.318
LU2	I use LMS to access leaning resources	0.82	1.29	-1.49	0.16	3.373	0.318
LU4	I use LMS to accomplish and submit my assignments	0.893	1.29	-1.834	0.16	5.037	0.318
SAT1	The LMS is better when compared with off-line lectures	0.845	1.953	-0.202	0.16	-1.29	0.318
SAT2	The LMS has met my	0.913	2.761	-0.143	0.16	-1.121	0.318

Items		Factor Loadings	VIF	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
	expectations						
SAT3	Overall, I am satisfied with the LMS learning	0.907	2.467	-0.373	0.16	-0.716	0.318
AP1	LMS helps me to learn more quickly	0.87	2.322	-0.45	0.16	-0.581	0.318
AP2	LMS makes it easier for me to complete my assignments	0.856	2.171	-0.799	0.16	0.011	0.318
AP3	LMS helps me acquire new knowledge	0.797	1.795	-0.705	0.16	-0.187	0.318
AP4	LMS helps to improve my overall academic performance	0.859	2.15	-0.895	0.16	0.007	0.318

Measurement Model Evaluation

Following the assessment of fit and construction of the measurement model, the next phase involved testing the structural model, and exploring the hypothesized relationships between latent constructs (Weston, Gore, 2006). This critical aspect of Structural Equation Modeling (SEM) emphasizes the interconnections and magnitudes of links between constructs, delving into the structural theory's specified relationships through a set of structural equations (Hair et al., 2012).

The theoretical model was subjected to scrutiny to ensure the validity and reliability of the measurement model, as emphasized by Bagozzi and Yi (2012). Confirmatory Factor Analysis (CFA) was employed to evaluate the measurement model, encompassing factor loading, Cronbach's Alpha, composite reliability (CR), average variance extracted (AVE), and discriminant validity utilizing Fornell-Larcker and Heterotrait-Monotrait Ratio (HTMT) (Henseler et al., 2015). To enhance the model's robustness, two items with low factor loadings were removed from the LMS usage constructs (LU1 = 0.439 and LU3 = 0.521), aligning with recommended thresholds (Gefen, Straub, 2005). The re-tested model demonstrated improved parameter evaluation (Figure 2).

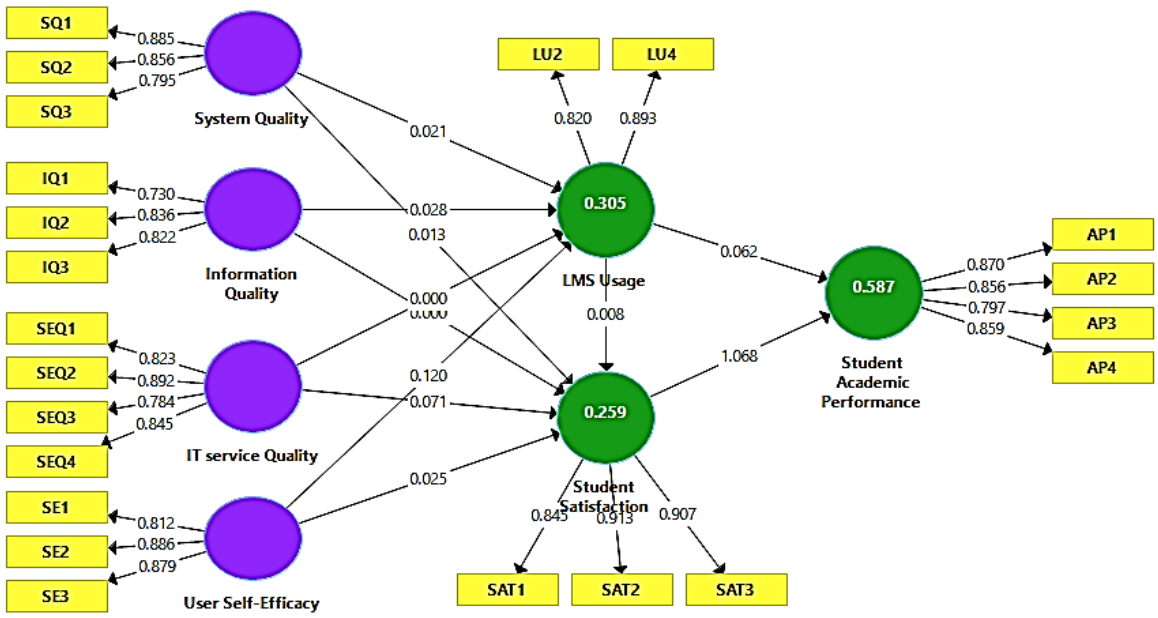

Fig. 2. Path analysis diagram

Internal consistency, assessed through Cronbach's alpha, and construct reliability, measured by composite reliability, surpassed the recommended thresholds, affirming strong construct reliability (Hair et al., 2010; Hu, Bentler, 1998; Hasan, Boa, 2020). Convergent validity, evaluated via Average Variance Extracted (AVE), met the requisite threshold of 0.50, indicating minor measuring errors compared to observed variance. Conclusively, all AVE values exceeded 0.50 (Henseler et al., 2015; Hair et al., 2012), attesting to the acceptable convergent validity of the research output (Table 3).

Table 3. Convergent, composite and internal consistency analysis

Constructs	Cronbach's Alpha (α)	Composite Reliability	Average Variance Extracted (AVE)
System Quality (SQ)	0.802	0.883	0.715
Information Quality (IQ)	0.718	0.840	0.636
Service Quality (SEQ)	0.857	0.903	0.700
Self-Efficacy (SE)	0.823	0.894	0.739
LMS Use (LU)	0.643	0.847	0.735
Students' Satisfaction (SAT)	0.867	0.919	0.790
Students' Academic Performance (AP)	0.868	0.910	0.716

Discriminant validity which explains how each construct is different (distinct) from each other, was also evaluated. This was done using Fornell-Larcker Criterion (Henseler et al., 2015). Discriminant validity is achieved if the Square root of AVE is greater than the inner correlation of the constructs (Table 4). From Table 4, the square root of the AVE value (bold) is seen to be greater than its inner correlation values, suggesting acceptance of discriminant validity among constructs.

Table 4. Fornell-larcker criterion (discriminant validity)

Construct	SEQ	IQ	LU	AP	SAT	SQ	SE
SEQ	**0.837**						
IQ	0.365	**0.798**					
LU	0.296	0.419	**0.857**				
AP	0.493	0.360	0.382	**0.846**			
SAT	0.434	0.285	0.307	0.749	**0.889**		
SQ	0.470	0.559	0.395	0.431	0.362	**0.846**	
SE	0.429	0.446	0.487	0.439	0.384	0.398	**0.860**

Another measure to support discriminant validity is the Heterotrait-Monotrait ratio (HTMT) criteria. For HTMT to be achieved, all correlation values should be values below the threshold of 0.900. Table 5 confirmed a perfect discriminant validity.

Table 5. Heterotrait-monotrait ratio (htmt)

	SEQ	IQ	LU	AP	SAT	SQ	SE
SEQ							
IQ	0.431						
LU	0.397	0.612					
AP	0.568	0.430	0.507				
SAT	0.497	0.329	0.407	0.857			
SQ	0.572	0.723	0.536	0.511	0.422		
SE	0.517	0.578	0.653	0.515	0.449	0.492	

Structural Model Evaluation

The research proved that the measuring model was accurate and trustworthy. The structural model has to be evaluated next. This involved analyzing the coefficient of determination and the model prediction accuracy and observing the link between the constructs. The coefficient of determination (R^2) usually measures the model predictive power of the structural model. It explains how the independent variable predicts the variance in the dependent variable. Three values of the coefficient of determination were evaluated (Table 6). One describes the variance in LMS usage (R^2_{LU}), the other explains the variance in Student Academic Performance (R^2_{AP}), and the last explains the variance in Student Satisfaction (R^2_{SAT}). The value of R^2_{LU} = 0. 305 indicates that system quality, information quality, IT service quality, and user self-efficacy explain 30.5 % of the variance in student LMS usage. It was also found R^2_{SAT} = 0.259 indicates system quality, information quality, IT service quality, and user self-efficacy, which explains 25.9 % of the variance in student satisfaction. Lastly, R^2_{AP} = 0.587 indicates that student LMS usage and student satisfaction explain the 58.7 % variance in student academic performance. The model's predictive accuracy was also estimated using Stone-Geisser Indicator (Q^2) (Henseler et al., 2015). The Stone-Geisser Indicator (Q^2) measures the model prediction relevance or model significance. A good prediction quality should have an indicator value greater than zero (Henseler et al., 2015). The standards of (Q^2) in Table 6 suggest that the model is correct and that the constructs are necessary for the model's general adjustment.

Table 6. Model predictive power and relevance

Construct	(R^2)	(Q^2)
LMS Usage (LU)	0.305	0.201
Student Academic Performance (AP)	0.587	0.407
Student Satisfaction	0.259	0.189

Hypotheses Testing

The model's fitness was evaluated using the Standardized Root-Mean-Square Residual (SRMR) and the Normed Fit Index (NFI). The SRMR assesses the mean of the differences between observed and predicted correlations, with values below 0.08 indicating a good fit (Henseler et al., 2015). The NFI compares the Chi-square value of the model to a null model, with values closer to 1 suggesting a better fit). Table 7 presents the model fit indices for the confirmed structural model.

The study investigated the relationship between LMS usage and students' academic performance. The study adopted D&M IS success model by adding users' self-efficacy to be one of the factors that influence LMS usage and student satisfaction among university students. The construct relationship was established using the Bootstrapping technique in Partial Least Square to estimate the significance level of the latent variables. The eleven hypotheses were all put to the test. The hypotheses testing findings are shown in Table 7 below.

Table 7. Path coefficient and p-values

Structural Relationship	Hypotheses	Standardized Beta (B)	T-Statistics (*t*-Value > 1.99)	P Values	Status of the Hypothesis
SQ → LU	H1	0.155	2.122	0.034**	Supported
SQ → SAT	H2	0.129	1.527	0.127	Not supported
IQ → LU	H3	0.175	2.184	0.029**	Supported
IQ → SAT	H4	-0.002	0.024	0.981	Not Supported
SEQ → LU	H5	0.012	0.190	0.849	Not Supported
SEQ → SAT	H6	0.274	4.124	<0.0001**	Supported

Structural Relationship	Hypotheses	Standardized Beta (B)	T-Statistics (*t*-Value > 1.99)	P Values	Status of the Hypothesis
SE → LU	H7	0.343	5.153	<0.0001**	Supported
SE → SAT	H8	0.170	2.172	0.030**	Supported
LU → SAT	H9	0.092	1.292	0.197	Not Supported
SAT → AP	H10	0.698	19.575	<0.0001**	Supported
LU → AP	H11	0.167	3.448	0.001**	Supported

The construct relationships were analyzed using the Bootstrapping technique in Partial Least Square (PLS) to estimate the significance levels of the latent variables. Hypotheses H1 to H11 were tested (see Table 7). System quality showed a significant effect on LMS usage (β = 0.155, t-value = 2.122, P < 0.034), thus supporting H1. System quality had an insignificant effect on satisfaction (β = 0.129, t-value = 1.527, P < 0.127), so H2 is not supported. Information quality significantly affected LMS usage (β = 0.175, t-value = 2.184, P < 0.029), thus supporting H3, but had no significant effect on satisfaction (β = -0.002, t-value = 0.024, P < 0.981), leaving H4 unsupported. IT service quality did not significantly affect LMS usage (β = 0.012, t-value = 0.190, P < 0.849), hence H5 is not supported. However, IT service quality had a positive effect on satisfaction (β = 0.274, t-value = 4.124, P < 0.0001), supporting H6.

Self-efficacy was found to significantly influence LMS usage (β = 0.343, t-value = 5.153, P < 0.0001), supporting H7, and also positively affected satisfaction (β = 0.170, t-value = 2.172, P < 0.030), supporting H8. LMS usage did not significantly affect satisfaction (β = 0.092, t-value = 1.292, P < 0.197), leaving H9 unsupported. Satisfaction significantly influenced academic performance (β = 0.698, t-value = 19.575, P < 0.0001), supporting H10. Lastly, LMS usage positively affected academic performance (β = 0.167, t-value = 3.448, P < 0.001), supporting H11.

4. Discussions and managerial implications

Discussion

This research scrutinizes the multifaceted factors influencing Learning Management System (LMS) usage among university students. The initial hypothesis posits a positive correlation between LMS system quality and its usage, a well-established connection supported by Nawaz (2019) and Petter and McLean (2009). Their works underscore that an LMS's effectiveness, characterized by convenience, adaptability, and understandability, directly influences its utilization. This resonates with Trentin's (2009) argument that a poorly designed or operated LMS hinders the achievement of expected outcomes, emphasizing the organization's commitment to a robust LMS platform.

Contrastingly, the second hypothesis reveals an insignificant impact of system quality on student satisfaction, deviating from previous literature (Mtebe, Raisamo, 2014; Nawaz, 2019). This suggests that student satisfaction may not solely hinge on LMS system quality or that the system did not meet overall expectations, aligning with Bokhari's (2001) view that user satisfaction assesses an e-learning system's capability to meet users' requirements and ensure satisfaction.

The third hypothesis scrutinized the association between information quality and LMS usage, revealing a significant role in students' engagement with the learning management system. This aligns with prior studies by Al-Azawei (2019) and Mtebe & Raisamo (2014), establishing the significance of information quality in higher educational institutions. Al-Azawei (2019) linked information quality to content format, accuracy, relevancy, and current information, indicating that undergraduate students value complete, relevant, and accurate information on the LMS. Consequently, students demonstrate a heightened interest in using the LMS when information is sufficient, correct, and pertinent to their learning process.

However, hypothesis four revealed an insignificant relationship between information quality and student satisfaction, contrary to findings by Al-Azawei (2019) and Mtebe and Raisamo (2014). While these studies emphasized the positive impact of information quality on user satisfaction, the Ghanaian context suggests a lack of relevance in terms of completeness, accuracy, and relevancy influencing student satisfaction. This deviation may stem from students generalizing

their responses based on overall satisfaction with LMS usage, reflecting an ongoing adjustment phase for many students navigating learning management system utilization.

Hypothesis five failed to find support, presenting a deviation from studies by Chiu et al. (2016) and Nawaz (2019) that endorsed the connection between service quality and LMS usage. Service quality, denoting the support level for end-users, is pivotal in shaping students' LMS utilization, satisfaction, and learning effectiveness (Aldholay et al., 2018). While past research highlighted the positive influence of online service quality on LMS acceptance, use, and satisfaction, this study uncovered an insignificant relationship between information technology service quality and LMS usage. This discrepancy may be elucidated by students' inclination to seek assistance from peers rather than relying on the commitment, technical prowess, and empathy of the IT staff.

In contrast, hypothesis six yielded statistically significant results, aligning with research by Chiu et al. (2016), Nawaz (2019), and Ojo (2017) that supported the association between service quality and user satisfaction. Nawaz (2019) emphasized service delivery, encompassing adequate explanations and helpful assistance through online mediums, echoing DeLone and Mclean's (2003) multifaceted description of service quality. The significant relationship observed among IT service quality, student satisfaction, and LMS usage implies contentment with the services provided by the LMS staff. This suggests the staff's commitment, prompt response, technical expertise, and empathy positively impact student satisfaction, fostering increased LMS usage and a favorable attitude toward the system.

Hypothesis seven's investigation revealed a significant relationship between LMS users' self-efficacy and LMS usage, aligning with prior studies (Alvarez-Risco et al., 2020; Aldholay et al., 2018). Aldholay et al. (2018) highlighted that students' confidence in web navigation, email usage, and internet document downloading positively influences their capacity to engage with a learning management system. The observed significance suggests that students, equipped with self-assurance, are adept at locating and retrieving information from the LMS.

Building on prior research, our findings support hypothesis eight: students' satisfaction thrives when LMS users feel confident navigating the platform. This aligns with studies by Lee & Lee (2008), Aldholay et al. (2018), and Alvarez-Risco et al. (2020). This signifies that higher self-efficacy among undergraduate students in terms of information retrieval and file downloading positively correlates with greater satisfaction with the LMS. The implication is that students, feeling confident in utilizing LMS resources, not only exhibit elevated satisfaction but are also inclined toward increased LMS usage.

Our findings regarding LMS usage (hypothesis nine) diverged from some past studies (Aldholay et al., 2018; Oguguo, 2021). While a direct correlation wasn't found, this aligns with information systems research by Ojo (2017) and Al-Azawei et al. (2017). However, hypothesis ten revealed a positive and statistically significant connection between student satisfaction and academic performance. This aligns with Shneiderman (2010) and Aldholay et al. (2018), suggesting satisfied students at our university effectively utilized the LMS, potentially leading to faster learning, efficient assignment completion, and stronger knowledge acquisition. Essentially, satisfied students viewed the LMS as a valuable tool for academic success.

Ultimately, LMS usage demonstrated a significant influence on student academic performance. This result aligns with prior information system literature, such as the work of Isaac et al. (2017). The positive association indicates that increased LMS usage among undergraduate students correlates with improved academic performance, suggesting that the LMS facilitated rapid learning, knowledge acquisition, and assignment completion, motivating students to persist in its usage.

Implications for Educational Management

The findings of this study have significant ramifications for maximizing the potential of learning management systems (LMS) in public universities in Ghana. The significant weight attributed to factors like system quality, information quality, and users' self-efficacy provides actionable insights for managers of tertiary institutions. Focusing on enhancing user-friendliness, clarity of interface, and regular content updates by instructors can demonstrably increase LMS adoption and student satisfaction.

However, the curious disconnect between LMS utilization and student satisfaction necessitates further action. University management and lecturers must leverage the platform's communication features to cultivate a sense of community, replicating the valuable social aspects

of face-to-face interactions. Mere file exchange doesn't suffice; harnessing the platform's communication tools holistically is key to building student engagement and satisfaction.

Furthermore, the study identifies self-efficacy as a crucial predictor of both satisfaction and usage. This underscores the need for a holistic approach to LMS implementation, considering user confidence as an integral facet influencing its success. University administrators should consider expanding online activities to foster self-efficacy and maximize the benefits of online learning. The predictive power of both LMS use and student satisfaction on academic performance further validates the platform's significance. Universities must emphasize the pedagogical value of the LMS, invest in system quality, ensure faculty buy-in, and provide efficient support services to optimize student outcomes. These recommendations highlight the multifaceted impact of LMS on the educational landscape and the intricate interplay of factors shaping student success.

While this study provides valuable insights, it is essential to acknowledge several limitations. First, the sample size of 232 respondents, although robust, falls short of the ideal for achieving a 95 % confidence level with a 5 % margin of error, which may affect the precision of the findings. Additionally, potential response bias and the cross-sectional nature of the research present limitations that could influence the generalizability of the results. Future research should consider larger samples and a longitudinal design to further explore factors such as institutional performance, cultural influences, and the evolving impact of technological advancements on LMS usage. Such ongoing research is critical to help universities keep pace with the dynamic landscape of educational technology and fully realize the potential of LMS to benefit students and educators.

5. Conclusion

This study reveals that LMS usage is significantly influenced by system quality, information quality, and user self-efficacy, ultimately impacting student satisfaction and academic performance. While service quality positively correlates with student satisfaction, its direct impact on LMS usage is minimal.

To optimize LMS effectiveness, Ghanaian universities should invest in user-friendly systems, provide accurate and relevant information, and empower students through training and support. Building a sense of community within the LMS platform and fostering a positive user experience is equally crucial.

This research contributes to the understanding of LMS implementation in understudied contexts like Ghana. Future studies should explore the long-term impact of LMS on student outcomes and the role of institutional culture in shaping LMS adoption and use.

By prioritizing user-centric design, fostering a supportive learning environment, and continuously evaluating LMS effectiveness, institutions can harness the full potential of this technology to enhance student success.

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The History of Education

Sir Albert E. Worthington (1849–1915) in the Museum Collection of Cherkas Global University: Commemorating the 175th Anniversary of His Birth

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Abstract

This work commemorates the 175th anniversary of the birth of Albert Edwin Worthington (1849–1915), a member of the Masonic order of Knights Templar. It offers a biographical account of his life and examines a sword that used to belong to him.

The source base comprised the following three groups: 1) items of material culture from the museum collection of Masonic swords at Cherkas Global University; 2) personal documents from commercial US databases; 3) regional periodical press materials (specifically, those from the newspaper *Transcript-Telegram* for 1915).

The study's findings revealed that Albert E. Worthington (1849–1915) was a fairly well-rounded person. During his youth, he received a good education and was professionally engaged in choral singing as a tenor – eventually, he remained attached to the choir at his local Baptist church throughout his life. Around 1885, he joined Masonry (a local Masonic lodge and Springfield Commandery No. 6, KT). It is this period that his sword which is part of the sword collection at Cherkas Global University (Exhibit No. 036/KT032) appears to date to. As regards his personal life, A.E. Worthington married twice and had three children. To date, no photographs of A.E. Worthington have been found, leaving the search for a likeness of him ongoing.

Keywords: Albert Edwin Worthington (1849–1915), tenor singer in a church choir, musical education, biography, Springfield Commandery No. 6, Knights Templar, museum collection, private university.

1. Introduction

October 18, 1849, saw the birth of Albert Edwin Worthington, a member of the Masonic order of Knights Templar, in the city of Springfield, Massachusetts. Consequently, October 18,

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2024, marked the 175th anniversary of his birth. The Masonic sword collection at Cherkas Global University contains a sword that used to belong to him (Exhibit No. 036/KT032), and that is what adds relevance to the research reported in this paper.

2. Materials and methods

The source base comprised the following three groups: 1) items of material culture from the museum collection of Masonic swords at Cherkas Global University; 2) personal documents from commercial US databases; 3) regional periodical press materials (specifically, those from the newspaper *Transcript-Telegram* for 1915).

A valuable piece of material culture employed in this work was Exhibit No. 036/KT032 from the museum collection of Masonic swords at Cherkas Global University (Washington, DC, USA). This item is a rare Masonic sword (Figure 1), with a guard decorated with crosses and an ebony hilt.

Fig. 1. Front and back views of the Knights Templar Masonic sword which belonged to Albert E. Worthington (Exhibit No. 036/KT032)

One side of the sword's blade features the name of its owner – Albert E. Worthington, and the other, the name of the commandery he served – Springfield Commandery No. 6, KT (Figure 2).

Fig. 2. Inscriptions on the sides of the sword's blade (Exhibit No. 036/KT032)

The sword's ebony hilt (Figure 3) and silver-colored scabbard attest that it used to belong to a member of the Masonic order of Knights Templar.

Fig. 3. Hilt and guard of the sword (Exhibit No. 036/KT032)

Thus, based on the inscriptions on the sword, it used to belong to a Knight Templar named Albert E. Worthington, who was a member of Springfield Commandery No. 6, Feeding Hills, Massachusetts.

A search for similar swords led to an indistinguishably similar sword of a Knight Templar which, likewise, belonged to Springfield Commandery No. 6 (Figure 4). This attests that the sword was not an exclusive (presentation) weapon belonging to the owner, but was one of those routinely issued to Springfield Commandery No. 6 officers.

Fig. 4. Similar sword belonging to a Knight Templar from Springfield Commandery No. 6

Use was also made of the commercial database Ancestry.com (Ancestry.com) to establish the man's full name and birth and death years and gain insight into various details of his life.

Specifically, it was established that Albert Edwin Worthington was born on October 18, 1849, in Springfield, Hampden County, Massachusetts (Ancestry.com. Massachusetts), to a 42-year-old father, Henry Worthington, and a 35-year-old mother, Henrietta Renton (Records of the Bureau of the Census, 1850: 80). He died on May 20, 1915, in Agawam, Hampden County, Massachusetts, at the age of 65, and was buried in the same city.

3. Literature review

The historiography dealing with biographical accounts of the lives of various figures in the Masonic movement spans nearly 200 years. One of the first such works is C. Staats's 'Tribute to the Memory of De Witt Clinton, Late Governor of the State of New-York' (Staats, 1828). De Witt Clinton (1769–1828) was the first Grand Master of the General Grand Encampment of Knights Templar for the United States of America. He occupied this post from 1816 until his death in 1828. A noteworthy work that came out a little later is W. W. Campbell's 'The Life and Writings of De Witt Clinton' (Campbell, 1849).

Fourteen years later, and that was during the Civil War in the United States, a work entitled 'Leaflets of Masonic Biography: Or Sketches of Eminent Freemasons' was published under the editorship of the Mason C. Moore (Leaflets of Masonic Biography, 1863). This collection of biographies comprises 13 biographical works, which include biographical accounts of the lives of famous Masons such as Joseph Warren, Christopher Wren, Thomas Smith Webb, Rev. James Anderson, and Benjamin Franklin. The authors, besides C. Moore himself, include W.P. Strickland, Sidney Hayden, and Henry C. Deming.

The increase in the number of members of the Masonic order of Knights Templar appears to have been accompanied by a sharp increase in the number of biographical works on them. Of particular note is J.D. Richardson's 'Tennessee Templars: A Register of Names, with Biographical Sketches, of the Knights Templar of Tennessee, and Brief Histories of the Grand and Subordinate Commanderies', published in 1883 (Richardson, 1883). The work contains biographies of the state's 13 famous Masons, including Henry M. Aiken, George S. Blackie, and George C. Connor. On a side note, it presents a history of the Grand Commandery of Tennessee.

Another work worthy of mention is G.A. Lawrence's 'Sir Knight Lee Stewart Smith, Most Eminent Grand Master of the Grand Encampment of Knights Templar of the United States of America, 1916–1919', published in 1920 (Lawrence, 1920). Among the 1960s works, of particular note is 'Eugene F. Falconnet, Soldier, Engineer, Inventor', written by H. L. Swint and D. E. Mohler about Sir Eugene F. Falconnet, a participant in the Civil War, engineer, and inventor (Swint, Mohler, 1962), who, among other things, was a member of Nashville Commandery No. 1 (Nashville, Tennessee).

The topic remains one of relevance today. It is worth mentioning here two of our own works related to it – the one on Sir Frederick S. Rogers (1847–1908), who was a member of Monroe Commandery No. 12 (Rochester, New York) (Cherkas, 2024), and the one on Sir Albert A. Marden

(1824–1919), who was Recorder of De Molay Commandery No. 26 (New Ulm, Minnesota) (Cherkas, 2024a).

4. Results

The afore-mentioned Masonic sword belonged to Springfield Commandery No. 6, part of the Grand Commandery of Massachusetts. Springfield Commandery No. 6 was one of the many different organizations in the city of Springfield, part of Hampden County, at the beginning of the 20th century. There are no dedicated publications on the history of Springfield Commandery No. 6, but there is a mention of it in the 1902 book '"Our County and Its People": A History of Hampden County, Massachusetts' ("Our County and Its People"..., 1902). Here is what it says about the organization: "Springfield Commandery Knights Templar is the only commandery in the county. Its present membership is more than six hundred and it has numbered among its members many of the leading citizens of the county. The movement for its organization was set on foot in the fall of 1825, there being a number of Knights in Springfield and vicinity who had received their knighthood in New York or Boston. On February 22, 1826, the movement took shape, and a meeting was held in the old Masonic hall which stood at the corner of Main and State streets in Springfield, the site of the present Masonic temple. At this meeting it was decided to petition the Grand Encampment for a charter. A petition already prepared was thereupon signed by Koswell Lee, Henry Dwight, Alpheus Nettleton, John B. Kirkham, Abiram Morgan, Major Goodsell, Arnold Jenckes, Amasa Holcomb and Hezekiah Cady.

Village Encampment of Greenwich, having jurisdiction over the territory in which the new encampment desired to be created, was requested to sanction the granting of a charter and its sanction was given. In June following the charter was granted, but for some reason, unknown to the present generation of Knights Templar, the charter was not signed until June 19, 1830, four years later. However, the delay in signing the charter did not operate to the disadvantage of the new organization, which has always ranked as of June 19, 1826 ("Our County and Its People"..., 1902: 477-478). Its relative position in order of precedence was retained when the change was made from encampments to commanderies of Knights Templar. Henry Dwight was the first Eminent Commander of the commandery or encampment. The commandery flourished until 1831, when in common with Masonic bodies it felt the anti-Masonic sentiment so strongly that it apparently abandoned work. From January 5, 1831, until July 4, 1851, the records are blank. In 1851, Sirs James W. Crooks, John B. Kirkham, Ocran Dickinson, Daniel Reynolds, Amos Call and James H. Call succeeded in reviving interest in the work, and from that date in July when the first meeting for twenty years appears to have been held, the interest in the knightly degrees has never flagged. But it was in 1861, when the late Judge W. S. Shurtleff was elected Eminent Commander, that the commandery took up the work with enthusiasm, his incumbency of the high office marking an epoch in the history of the commandery ("Our County and Its People"..., 1902: 478). This brief note gives us an idea of how Springfield Commandery No. 6 of Knights Templar developed. Albert E. Worthington, who was in his early 50s at the time, was one of the organization's 600 members as at 1900.

In terms of biographical information on Albert E. Worthington, the following was written about him in the newspaper *Transcript-Telegram* on May 21, 1915, the day following his death: "Mr. Worthington was born in Springfield, being the youngest son of Henry and Henrietta (Renton) Worthington. His parents came to Agawam when he was two years old and bought a farm of his uncle, Amos Worthington. A few years later he bought the farm about opposite. It had previously been an old tavern stand owned and carried on by another uncle, Ambrose Worthington. Here Albert Worthington grew to young manhood. He was educated in the public schools of the town and the Connecticut Literary Institution in Suffield, Ct. He developed considerable musical ability, and was under the instruction and training of Prof. Zuchtman in Springfield for some time. He had an unusually fine voice. He united with the Baptist church in May, 1864, and occupied the position of tenor singer in the choir of that church for many years. He followed the occupation of a farmer, being foreman on the large farm of L. L. Whitman for some years. May 30, 1878, he was united in marriage to Miss Mary A. K. Whitman, daughter of the late L.L. Whitman of Agawam. Mrs. Worthington died May 24, 1883, leaving a little daughter. Mr. Worthington was again married March 17, 1887, to Miss Evelyn E. Bitgood, who survives him. He leaves, besides his widow, two daughters, Mrs. Charles Relyea of Hartford, Ct., and Mrs. Guy Perry of Agawam, also one brother, Henry R. Worthington of Yarmouth, and one sister, Mrs. J.N. Cook of Agawam" (Transcript-Telegram, 1915). As we can see, the obituary

says nothing about A. E. Worthington's service in Springfield Commandery No. 6, and the reasons behind that are not known.

5. Conclusion

The study's findings revealed that Albert E. Worthington (1849–1915) was a fairly well-rounded person. During his youth, he received a good education and was professionally engaged in choral singing as a tenor – eventually, he remained attached to the choir at his local Baptist church throughout his life. Around 1885, he joined Masonry (a local Masonic lodge and Springfield Commandery No. 6, KT). It is this period that his sword which is part of the sword collection at Cherkas Global University (Exhibit No. 036/KT032) appears to date to. As regards his personal life, A. E. Worthington married twice and had three children. To date, no photographs of A.E. Worthington have been found, leaving the search for a likeness of him ongoing.

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Material Support of Maritime Educational Institutions in Kherson Gubernia (19th – early 20th centuries)

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Abstract

The article is devoted to the study and assessment of the material support of maritime educational institutions of the Kherson gubernia in the 19th – early 20th centuries. The evolution of state support for the maritime sector of vocational and technical education, provision of educational and visual materials, and sources of funding are shown.

The educational and methodological support and material support of maritime educational institutions were characterized by a certain diversity, which depended on the possibilities of funding from the local community. If, until the 1880s, maritime classes were insufficiently equipped, had poor libraries, and most subjects did not even have textbooks, then at the turn of the 19th century, educational institutions had good facilities and equipment, library funds sufficient for learning, and good support. Also, over time, the general support of most maritime schools had gradually improved, as evidenced by the enhancement of the arrangement of vocational schools in Kherson, Mykolaiv (Nikolayev), Odesa, which had turned into centers of maritime education in Southern Ukraine.

To summarize, the primary sources of funding for maritime educational institutions were: 1) state funds; 2) funds of the local community; 3) funds of public societies and associations; 4) assistance from large enterprises and professional associations (Volunteer Fleet, Black Sea-Danube Shipping Company, Russian Society of Shipping and Trade); 5) private assistance.

Thus, only a combination of state support and private and public initiatives in the funding of maritime education in Kherson gubernia made it possible to establish a specific network of

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educational institutions for training experts for the maritime field.

Keywords: Russian Empire, Ukraine, Kherson Gubernia, education, education policy, vocational education, maritime educational institutions.

1. Introduction

For the progressive and gradual development of all branches of the economy, there has always been a need to provide them with highly qualified human resources. Already at the end of the 18th century, the economy of the Russian Empire began to require more and more experts in various fields; their training, according to the old system – personal training of an apprentice by a craftsman, did not keep up with the growing pace of production. In the middle of the 19th century and later on, the personnel problem became increasingly acute and required immediate steps for its solution.

In Kherson gubernia, the first vocational educational institutions appeared just at the end of the 18th century – the School of Practical Agriculture in the village of Bohoyavlenskoe near Mykolaiv (Nikolayev) (1790) and Kherson School of Naval Architecture (1798). Their specialization testified to the priority sectors of the Black Sea region's economy – agriculture and shipbuilding. The establishment of Kherson School of Merchant Shipping in 1834 showed the third sector of the economy – maritime trade.

The key to a high-quality educational process in training professional personnel has always been sufficient funding and the availability of educational and methodological support for the educational process – textbooks, handbooks, and visual and methodological material. The study of this issue in the sectoral (maritime vocational training institutions and schools) and regional (Kherson gubernia) context provides the opportunity not only for an in-depth study of the scientific issue but also contributes to the identification of certain regional features of the development of maritime education.

2. Materials and methods

Achieving the set goal required the involvement of a wide range of sources, which are obtained from the State Archives of Kherson and Mykolaiv Oblasts (Ukraine), where the primary materials are the regulations and annual reports of the heads of maritime educational institutions of Kherson, Berislav, and Mykolaiv (Nikolayev) (SAKhR; SAMR). Separate reports are obtained in a published form in the libraries of Kherson, Mykolaiv, and Odesa (Otchet..., 1882; 1898; 1902). Data from the reference guide 'Vsya Odessa' (Vsya Odessa, 1914) are used to determine the financial role of the Society for Helping the Needy of Odesa School.

Decrees on the establishment of educational institutions and their teaching staff, published in the collection 'Polnoye Sobraniye Zakonov Rossiyskoy Imperiyi' (Full Collection of Laws of the Russian Empire) (PSZRI-1; PSZRI-2), has become an essential source for determining the state financial policy regarding maritime education.

Separately, it is necessary to single out the ego-source 'Poyezdka po Nizovyam Dnepra' (Journey over the Lower Dnipro), authored by Alexander Afanasyev-Chuzhbinskiy, the famous Ukrainian ethnographer and publicist – travel notes based on the materials of the historical and ethnographic expedition of 1856-1859. In his notes, the scholar describes the state of Kherson School of Merchant Shipping in the middle of the 19th century, based on his observations, providing a bright and vivid description of the educational institution and its students and teachers (Afanasyev-Chuzhbinskiy, 1859).

While working on the paper, we have used some general scientific and special historical research methods. The methods of deduction and induction are used during the search and concentration of materials on the topic of the study. The method of objectivity makes it possible to study properly the peculiarities of the functioning of maritime educational institutions in the studied region and to draw unbiased conclusions about their material support. Thanks to the comparative and historical method, it has become possible to follow the dynamics of qualitative changes in the financial conditions of studied institutions and their provision of teaching and learning aids.

3. Discussion

The first works on the history of maritime education in Kherson gubernia appeared in the middle of the 19th century. Adrian Weinberg's study about the Kherson School of Merchant

Shipping, published in 1857 in the collection 'Morskoy Sbornik' (Weinberg, 1857), occupies a special place among them. Being a contemporary, the author subjects the place and role of the School in the training of experts for the merchant fleet to devastating criticism: the lack of training of skippers for the cabotage fleet, the low salaries for teachers, insufficient training, and poor curricula. Thus, the mentioned study allows us to understand the difficulties experienced by the process of formation of maritime education in Kherson gubernia.

In the 1880s, the works of A. Nebolsin (Nebolsin, 1883) and K. Skalkovskiy, in the context of the general theme of the historical progress of vocational training, also raise the issue of training experts for the commercial fleet, focusing on the results of educational reforms of the 1860s and 1880s (Skalkovskiy, 1887). As the modern researcher O. Chornyy notes: "The basis of their works is a solid source base and statistical data uncovering the activities of educational institutions of the specified subject matter. The relevance of the studies is in the fact that they were conducted not only by contemporaries of the era but also by active participants in activities related to the reform of the sphere. The authors briefly describe the prerequisites for the reform, pointing out its positive and negative aspects, and also discuss in a fragmentary manner the process of formation of a new system of trade and maritime classes and schools" (Chornyy, 2009: 253).

Separately, it is necessary to note the works of V. Vinogradov (Vinogradov, 1908; Vinogradov, 1912), Head of the Department of Merchant Shipping, devoted to maritime educational institutions. The books contain rich factual and statistical material on maritime education until 1912. V. Vinogradov gives a historical review of the activities of maritime schools from the 18th to the early 20th century, using materials from the archives of the Ministry of Finance and the Ministry of Trade and Industry. The researcher also does not miss the Southern Ukraine region as well, presenting general information about the financial and material condition of all the vocational schools of the Black Sea basin and paying particular attention to Odesa School of Merchant Shipping. At the same time, the author notes that the School in Odesa ranks first in the Russian Empire among similar educational institutions in terms of expenses for both teaching staff and student upkeeping (as of 1910) (Vinogradov, 1912: 92-94).

Among the authors of the Soviet era, it is necessary to mention M. Kuzmin (Kuzmin, 1971), the classic of the history of vocational training. In his book, the researcher gives some information about the development of maritime education in Kherson gubernia: schools of merchant shipping in Kherson (p. 127-129) and in Odesa (p. 160-161), and also tells about the Berislav Maritime Class (p. 141). Unfortunately, the presented information is fragmentary and unsystematic, which does not allow us to create at least a partial idea not only about the activities of educational institutions but even about their financial conditions or educational process.

The last decades have been marked by the emergence of several exciting studies, which, to one degree or another, uncover the history of maritime education in Kherson gubernia. Ukrainian researcher O. Chornyy (Chornyy, 2007) was one of the first to address this issue and devote his dissertation to maritime education development in Southern Ukraine during the times of the Russian Empire. Unfortunately, his work has an exclusively historical orientation, and the issue of material support is presented by him very briefly.

In the context of the development of vocational training in Kherson gubernia, Ya. Nahrybelnyy and M. Honchar disclose the history of maritime educational institutions fragmentarily. At the same time, the work of Ya. Nahrybelnyy (Nahrybelnyy, 2012) is geographically limited to the territory of the present Kherson oblast and, accordingly, shows the historical development of maritime educational institutions only in Kherson and Berislav. In addition, like the dissertation of O. Chornyy, the research conducted by Ya. Nahrybelnyy also has a historical orientation, and the issue of material support has not been disclosed. The study of A. Vasylevych (Vasylevych, 2016) has a narrow geographical framework; the support of maritime educational institutions is disclosed only in the territory of the present Kherson oblast.

The dissertation of M. Honchar (Honchar, 2015) is devoted to the development of lower vocational training in a relatively wide geographical area – Kherson and Taurida gubernias, and a broad subject area – a wide range of lower rank educational institutions – craft, agricultural, maritime, and commercial, which has not led to the study of specific fields, but to broad generalizations.

In recent years, interest in the history of seamen vocational training has become active again. Here, it is necessary to mention several works by O. Trygub, S. Degtyarev, and V. Parkhomenko (Trygub et al., 2023a; Trygub et al., 2023b; Trygub, Degtyarev, 2023). In these works, the general

development of maritime education in the Russian Empire, its legislative base, and the teaching staff of educational institutions of Kherson gubernia are disclosed. On the other hand, the issues uncovered in the proposed paper continue to remain understudied.

4. Results

The first vocational and vocational and technical institutions focused mainly on the Western European system of training professional technical personnel. This is evidenced by the previously mentioned decree for Vice-Admiral Mordvynov dated February 28, 1792, which stated: "To establish at least a small vocational school of naval architecture and other related skills… providing the latest English and French books on shipbuilding, ship and warship plans…, to have teachers who know English and French languages and naval architecture, so that the students, learning from them and reaching the ability to understand and translate those books themselves, could thereby quickly gain the most thorough understanding of this science and all the rules of the theory, knowledge of which they now, due to the lack of such books in Russian, are getting through long-term studies…" (PSZRI-1. T. 23. № 17028: 314).

According to the staff, the teachers of the School of Naval Architecture received a fairly decent salary as for that time: a teacher of English – 500 rubles, a teacher of Russian – 300, a teacher of Drawing – 250, a professor of Mathematics – 900 rubles. For comparison, 9 kopecks were allocated for the upkeeping of students per day (PSZRI-1. T. 44 (1). № 18634: 327-328).

Funding for Kherson School of Merchant Shipping, established in 1834, was mixed – part of the students (24 people), natives of the Black Sea-Azov region, were supported by the State Treasury, while others, the so-called 'boarders' – from 10 to 14 people – had to pay 300 rubles for their upkeeping per year and received school supplies from the School (PSZRI-2. T. 9 (1). № 6788: 113). In 1845, the number of students was increased to 40 and 20, respectively, and the payment of the 'boarders' decreased to 94 rubles 28½ kopecks (Afanasyev-Chuzhbinskiy, 1859: 335-336; Chornyy, 2007: 92).

The annual budget from the Treasury was equal to 18 thousand rubles (at the same time, 5,000 rubles were additionally allocated for the arrangement of premises). That amount included the salary of the administration (inspector, senior observer, and three observers) – 3,500 rubles, 12 teachers – 4,200 rubles, upkeeping of students – 5,760 rubles (240 rubles per year per person), as well as for servants, maintenance, and repair of buildings, library, and educational materials – 4,540 rubles per year (PSZRI-1. T. 44 (1). № 18634: 327-328). However, if that amount was relatively small (even compared to the above-mentioned salaries of the School of Naval Architecture by the state of 1798, when the value of the ruble was twice as much), but enough as for the 1830-40s, then in the 1850s it was already not so adequate.

Researcher A. Weinberg noted that the small salary assigned by the Regulations of 1834 to teachers of languages and other humanitarian subjects, with the gradual increase in prices for life necessities, prevented the School from having good teachers since a teacher of Geography, History, and Russian language got 14 rubles per month, while some teachers got only 10 rubles, and "for such a price, it is scarce to find a good teacher who would zealously engage in his work, and if there was one, he left the School at the first convenient opportunity" (Weinberg, 1857: 299). That is why, at the request of Kherson Governor, 1,300 rubles were added to the annual allowance of 5,127 rubles allocated by the Ministry of Finance in 1842. The money was taken from the amount kept in Odesa Bank, which was made up of fines collected from Russian vessels that went abroad without Kherson School of Merchant Shipping graduates (Chornyy, 2007: 92).

The material support of the School could have been improved. In his travel notes, A. Afanasiev-Chuzhbinskiy noted that the three buildings of the Kherson Admiralty, where the School was located since 1834, in the middle of the 19th century, were 'poor buildings' (Afanasyev-Chuzhbinskiy, 1859: 334). That is why, in 1845, the decision was taken to start the construction of a new building of Kherson School of Merchant Shipping. In 1848, a layout of premises was approved, according to which the new building was calculated at 60,000 rubles together with the complete overhaul of the old premises, which were planned to be given for the needs of School employees. However, before the shutdown of the School in 1867, a new building had never been built (Afanasyev-Chuzhbinskiy, 1859: 339).

In addition, the primary means of visual and practical training – a mockup of a military brig, built in the middle of the schoolyard – became utterly unusable. Students used it to acquire practical skills in steering a sailing vessel: raising and lowering yards and topgallants, and setting

and making up sails. But in the 1850s, the brig almost completely rotted, making it impossible to conduct practical classes. According to A. Weinberg, it was necessary to purchase a real commercial brig for practical training, which would not only provide an opportunity to acquire high-quality practical skills both in steering a vessel and in its maintenance, like a preparation for new navigation, and ongoing repairs but also bring certain commercial profit (Weinberg, 1857: 302-304).

At that time, the situation with educational and methodological support was also difficult. As the Ukrainian researcher M. Honchar notes: "Due to the partial or complete absence of textbooks and handbooks for special subjects, the learning process was reduced to mechanical memorization of the information given by the teacher, while independent work was limited to doing sums in Mathematics, Astronomy, and Maritime Practice. Only in the 80s of the 19th century did textbooks for trade maritime educational institutions appear" (Honchar, 2015: 100).

So, we can see that compared to the previous time, educational, methodological, and material support improved, and the attention to providing visual professional training increased, which qualitatively changed the content of the educational process. However, at the same time, already in the middle of the 19th century, the realities of the time required drastic changes in the content of the educational process and the system of practical training of future sailors. Methodological support was especially in need of improvement since, as claimed by Professor M.I. Barbashev, the famous Soviet expert in the history of maritime education: "In trade maritime schools, teaching was conducted according to the textbooks adopted for naval schools, and mostly did not correspond to the curricula of trade schools; in addition, the teachers were not sufficiently familiar with the specifics of merchant shipping" (Barbashev, 1959: 137).

The reformist tendencies in the government and society, the rapid development of productive forces, and the increase in agricultural and industrial production led to the need for radical changes in the quality and content of education and training at all levels and types. That was especially vividly reflected in the development of vocational and technical training, which was closely interconnected with the processes of capitalization of the economy and the development of transport and communications.

Maritime education institutions were the first to undergo reforms in the field of vocational and technical training. In 1867, the 'Regulations on Maritime Classes' were adopted, which introduced specific changes in the educational, methodological support, and material support of the former trade maritime schools, which were transformed into maritime classes of various ranks.

According to the Regulations, the main burden of sailor training funding rested on the local community, which "declared its readiness to donate for the establishment of a maritime class". The state only supported it with financial assistance "if necessary". At the same time, the community's contribution had to consist of either a specified annual amount for the allowance of the Class, the allocation of suitable premises with heating and lighting, or, as a last resort, a one-time contribution for the arrangement of the class. The state, depending on the importance of the educational institution and the need for such subject matter experts, allocated from 500 to 1,000 rubles per year (PSZRI-2. T. 9(1). № 44771: 1049).

Before the reform of maritime education in 1902, the amounts allocated by the state almost did not increase. However, if they had such an opportunity, local communities increased expenditures from local budgets, which depended on inflationary processes in the state (see Table 1).

Table 1. Property and financial conditions of the maritime classes of Kherson gubernia in the late 19th century (Vinogradov, 1912: 29-30; 35-36)

Class/Classes	State Treasury funding	Local funding	Premises
Kherson	2000	2605	local community
Berislav	1000	372	rent
Nikolayev	1000	2160	rent
Odesa	30750	18600	own

As we can see, all the classes (except for Odesa Classes, which we will discuss below) received little state funding.

For example, in the 1870s, the Ministry of Finance allocated an amount of 1,000 rubles annually for the allowance of Nikolayev Classes, and the City Public Council – 500 rubles, which in

the 1877 – 1878 academic year was spent on the following items: teachers' salary: senior – 480 rubles; junior – 280 rubles; rent of premises – 144 rubles; hiring a servant – 120 rubles; heating, lighting – 90,5 rubles; for handbooks and classroom supplies – 112,29 rubles; issuing of diplomas and certificates – 12,32 rubles; stationery – 10 rubles (Krykalova). At the same time, it should be considered that the tuition was free.

A catastrophic lack of funds forced the administrators request help constantly. In 1883, the Head of the Class sent a letter to the Imperial Society for Promoting Russian Merchant Shipping and to the local community, where he noted the growing number of students wishing to study, which led to the hiring of larger premises, the need for more furniture and books, and the need to increase the financial remuneration of teachers (SAMR. F. 139. Op. 1. D. 4. L. 2back). The Headmaster's words were confirmed by the report of Boholiubov, the member of the Russian Steam Navigation and Trading Company, who in 1883-1884 visited the Black Sea and Nikolayev Classes and characterized them as cramped, poor, unattractive, lacking textbooks, and poorly equipped (Honchar, 2015: 100).

As a result, the Classes received an additional subsidy of 500 rubles from Mykolaiv City Public Council, which, together with 550 rubles from Nikolayev Municipal Council, amounted to a sum more significant than the state allowance. That made it possible to increase the salary of teachers and staff: the Head – from 480 rubles to 660 per year, the Head's Assistant– from 280 to 360 rubles, the clerk – from 30 to 36 rubles, the classroom servant received 144 rubles, and the rigging instructor – 24 rubles. The balance of over 900 rubles was spent on renting premises, heating, lighting, and cleaning, including 315 rubles 30 kopecks, which were paid for nautical instruments, educational books, nautical charts, and geographical maps (SAMR. F. 139. Op. 1. D. 4. L. 110-110back, 117).

On the eve of the reformation of Nikolayev Maritime Classes in 1902, their annual budget was 3,282 rubles 67 kopecks, which were formed at the expense of the State Treasury – 1,000 rubles, Nikolayev City Council – 1,460 rubles, Nikolayev Municipal Council – 500 rubles, Nikolayev Marine Pilots' Community – 200 rubles, and the balance amount of previous years – 122 rubles 67 kopecks (SAMR. F. 139. Op. 1. D. 10. L. 36). In 1906, the budget increased to 4,070 rubles, of which 1,000 rubles were allocated for additional training aids (SAMR. F. 139. Op. 1. D. 13. L. 14, 65). At the same time, it should be noted that tuition after the reform of 1902 was paid, although the Board of Trustees could exempt students from paying (in 1906, the tuition fee was only 5 rubles, in 1907-10, in 1908-25; thus, there were very few students who paid tuition) (Krykalova).

As of January 1, 1908, the school had the following educational furniture: 12 school desks, two blackboards, three teacher's desks, three bookcases, one table, 24 chairs, as well as 38 nautical charts and 178 textbooks were included in the list of training aids (SAMR. F. 139. Op. 1. D. 16. L. 2).

Since their establishment, Kherson Classes had received better annual funding both from the state (2,000 rubles) and the local community (1,605 rubles). The community also provided permanent premises for the Classes (SAKhR. F. 212. Op. 1. D. 6. L. 68). Those funds, according to the staffing table approved in 1879, were distributed as follows: to the Head of the Classes per year – 1,200 rubles, to a teacher of the middle class (also he was a teacher of Shipbuilding) – 800 rubles, to a teacher of the junior class – 600 rubles, housing for the Head – 350 rubles, hiring servants and small expenses – 200 rubles, teaching aids and classroom supplies (books, charts, and tools) – 455 rubles (SAKhR. F. 212. Op. 1. D. 6. L. 70). Since 1881, Kherson Povit Zemstvo also began to assist with Kherson Classes, allocating 1,000 rubles annually (Otchet..., 1882: 7). Kherson Mutual Credit Society (1,700 rubles), City Council (1,500 rubles), and City Public Bank (1,500 rubles) participated in the construction of the building for the Classes (Otchet..., 1882: 8).

Such global support from Kherson community led to the fact that in the early 1880s, a building for Kherson Maritime Classes was built, and it was on the balance sheet of the city community. The Classes had ordinary classroom furniture; the library (museum) had over 1,000 books of a scientific, historical, and narrative nature, but mainly handbooks on special marine sciences, 86 nautical charts, geographical maps, and ship body plans, small chronometer, two sextants, two compasses, barometer, thermometer, natural and artificial magnets, artificial horizon, globe, two spyglasses, marine hourglass, and five models of vessels of various types. In the 1880s, a life-size (70-foot-long) brig, 'Dabich', was also built in the yard, hands-on practicing the skills (Otchet..., 1882: 6).

By the end of the 19th century, the library had expanded to 1,837 copies of books in various fields, including 773 textbooks. Educational and methodological equipment was improved and appeared about 300 charts and ship body plans, a planetarium, an azimuth compass, a copy machine, a model of a steam engine, models of a screw steamer, a refractor, 19 stereometric models, and four models of commercial vessels. Unfortunately, the brig 'Dabich' was destroyed by a storm on May 29, 1894, and needed renovation (Otchet..., 1898: 2).

The primary textbooks on special subjects used by students of Maritime Classes were Navigation (Zybin, Popov), Nautical Astronomy (Zybin), Rectilinear Trigonometry (Dmitriiev), Spherical Trigonometry (Gerdt), Maritime Practice (Ansley), navigational tables, and textbooks in English and French. They took in some magazines 'Morskoy Sbornik' (Sea Collection), 'Rodina' (Motherland), 'Nov' (Newground), 'Vokrug Sveta' (Around the World), 'Russkiy Vestnik' (Russian Herald), and 'Russkoye Sudokhodstvo' (Russian Shipping), etc (SAKhR. F. 212. Op. 1. D. 16. L. 6-7; Otchet..., 1898: 3).

After the reform of 1902, the balance sheet of Kherson Maritime School of Deep-Sea Shipping increased significantly and amounted to 11,530 rubles (1907), and was formed from the following items: funds of the Ministry of Trade and Industry – 5,755 rubles, Kherson Gubernia Zemstvo – 1,000 rubles, Kherson City Council – 4,775 rubles (SAKhR. F. 212. Op. 1. D. 124. L. 10).

The library of Kherson Maritime School had also been significantly enriched in terms of educational literature. Textbooks on almost all general education and special subjects appeared: 'Catechism' (Filaret), 'Astronomy', 'Spherical Trigonometry' (Shulhin), 'Rectilinear Trigonometry' (Dmitriyev), 'Navigation' (Lukin), 'Commercial Geography' (Yanushevskiy), 'Meteorology' (Voyeikov), 'Shipbuilding and Ship Theory' (Shershev), 'Maritime Practice' (Vakhtin), 'Handbook on Maritime Practice' (Fedorovych, Berezin), 'Lotsia' (Khvostov), 'Steamship Mechanics' (Maslov, Perkovskyi), 'Legal Studies' (Struchkov), 'Geometry' (Davydov), 'Algebra' (Kyseliov), 'Russian Language' (Smirnovskyi), 'Russian Literature' (Dvornikov), 'Hygiene' (Rautenfeld), 'English Language' (Nurok, Ivanov). The only textbook that needed to be included was the 'Theory of Deviation' (SAKhR. F. 212. Op. 1. D. 124. L. 37-37back). As of January 1, 1912, the library contained 2,107 volumes; tools and models, drawings, and charts were available for each subject (SAKhR. F. 212. Op. 1. D. 165. L. 21, 28-31).

Other maritime educational institutions had a much smaller budget, which the budgetary limitations of local communities could explain. Thus, Berislav community added only 316 rubles 25 kopecks to 1,000 rubles given by the state. With such funds, as a trustee of Odesa Educational District, P. Lavrovskyi claimed that it was impossible to find "neither competent teachers nor to buy the necessary teaching aids for the success of the case" (Heyko, 1999: 210). He was also supported by Knyazev, the Director of Public Schools of Kherson Gubernia, who noted that "Berislav, which has only 5,000 native male residents and meanwhile spends 2,381 rubles 25 kopecks annually on public education... cannot add anything to what it gives" (Heyko, 1999: 214). At the same time, for 17 years, the budget of the Maritime Class had hardly changed. Beryslav town community had increased its expenses for the Class to 372 rubles 17 kopecks, which was more than three times less than Kherson Classes had. The lack of students and support from the community later led to the shutting down of that educational institution.

The material support of Odesa School of Merchant Shipping should be noted separately. Even before its establishment, it was under the guardianship of both the state and the local community and steamship companies that needed modern experts for the fleet. Only to cover the one-time costs for arranging the classrooms, 196,599 rubles 78 kopecks were allocated from the half-kopeck tax collected from goods passing through Odesa port, to which 57,000 rubles were added later from the same source. The Treasury allocated 30,750 rubles for the annual allowance of the newly established Classes, which was more than the allowance for all other classes in the region. In addition to that amount, annually, Odesa City Public Council allocated 20,000 rubles, the Voluntary Fleet – 5,000 rubles, which later decreased to 3,000 rubles, and the Black Sea-Danube Shipping Company – 600 rubles, the donation which was stopped after the Company was closed down (Vinogradov, 1912: 35-36). In 1900, the School's expenditures amounted to 53,942,98 rubles (see Table 2 for details).

Table 2. Expenses of Odesa Merchant Shipping Classes in 1900 (Otchet..., 1902: 55)

Expense item	Amount of expenses, in rubles		
	State amount	Special amount	In total
Salaries of teaching and training vessel staff	11276,45	1400	12676,45
The educational part of the theoretical course (including payment to teachers for lessons)	10941,74	1585	12526,74
The housekeeping part: rent of the building, its maintenance, stationery, and other expenses	-	7934,35	7934,35
Wages of the crew and servants on the training vessel	3613,50	2370,11	5983,61
Repair and maintenance of the vessel, navigation costs	-	11204,43	11204,43
Upkeeping of students on the training vessel	-	3617,40	3617,40
Total:	***25831,69***	***28111,29***	***53942,98***

After the reform of 1902 and the transformation of Odesa Classes into a vocational school, the annual budget received from the State Treasury was 81,927 rubles, of which 50,647 rubles were allocated directly to the School and 31,280 rubles to the training vessel, provided that all local subsidies for the School were paid to the state account. All that made it possible already in 1903 to complete the construction of the School, where workshops were also equipped: locksmith and turning, locksmith and mechanical, foundry, copper processing, boiler room, and engine room, which cost 208 thousand rubles (Vinogradov, 1912: 43-44). At that time, it was a considerable expense compared to other educational institutions, which became possible not only with the support of the state but also thanks to the interest of the city community.

At the School, there was the Society for Helping the Needy of Odesa School, where each member paid an annual contribution of 5 rubles. As of 1911, the Society provided scholarships to 17 students in the amount of 1,815 rubles, provided free lunches and tea in the amount of 565 rubles 06 kopecks, paid for the tuition of 18 students, and treated one student in the amount of 320 rubles, as well as provided some other types of assistance. By the beginning of 1912, the Society's capital, consisting of interest-bearing securities, available funds, and various properties, amounted to 42,191 rubles 89 kopecks (Vsya Odessa, 1914: 170).

5. Conclusion

The educational and methodological support and material support of maritime educational institutions were characterized by a certain diversity, which depended on the possibilities of funding from the local community. If, until the 1880s, maritime classes were insufficiently equipped, had poor libraries, and most subjects did not even have textbooks, then at the turn of the 19th century, educational institutions had good facilities and equipment, library funds sufficient for learning, and good support. Also, over time, the general support of most maritime schools had gradually improved, as evidenced by the enhancement of the arrangement of vocational schools in Kherson, Mykolaiv (Nikolayev), Odesa, which had turned into centers of maritime education in Southern Ukraine.

To summarize, the primary sources of funding for maritime educational institutions were: 1) state funds; 2) funds of the local community; 3) funds of public societies and associations; 4) assistance from large enterprises and professional associations (Volunteer Fleet, Black Sea-Danube Shipping Company, Russian Society of Shipping and Trade); 5) private assistance.

Thus, only a combination of state support and private and public initiatives in the funding of maritime education in Kherson gubernia made it possible to establish a specific network of educational institutions for training experts for the maritime field.

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