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ORIGINAL ARTICLE

The Pre-service Teachers' Perceptions of Integrated Teaching, Inquiry Learning, using ICT and Real-life Examples in Science Classes

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ABSTRACT

The study was conducted as a case study to enhance pre-service science teachers' readiness for integration, inquiry-based learning (IBL), the use of Information and Communication Technology (ICT), and the application of real-life examples during their teacher training courses. The objective of the research was to explore pre-service science teachers' perceptions of integrated teaching, inquiry learning, and the use of ICT in science education, drawing on their experiences in teacher training. It also aimed to examine potential differences in their viewpoints and the evolution of their perceptions over time. A questionnaire was developed to gather insights from 50 pre-service science teachers regarding their views on the integration of science subjects before and after their 2-year teacher training courses. The collected data were analyzed using a qualitative approach with the QCAmap software, followed by a quantitative analysis utilizing the Microsoft Excel software. The findings revealed significant variances in perceptions among pre-service teachers based on the number of science subjects they studied during their training. Those who studied two or more subjects placed greater emphasis on the value of integration, IBL, ICT use, and real-life examples in science education, and exhibited more significant changes in their views throughout the 2 years of teacher training. Furthermore, the study found that nearly half of the pre-service teachers did not view IBL in science classes as crucial, and only about a quarter recognized the importance of ICT utilization.

KEY WORDS: Information and communication technology; inquiry learning; integrated science teaching; pre-service science teachers; QCAmap program; qualitative content analysis

INTRODUCTION

The primary objective of science education is to enhance students' scientific literacy, preparing them as informed future citizens. Over recent decades, the emphasis on scientific literacy as a goal of science instruction has steadily increased (Almeida et al., 2023). Teacher training programs should equip pre-service teachers with a diverse array of teaching strategies and approaches, including inquiry-based learning (IBL), differentiated instruction, and formative assessment techniques (Darling-Hammond and Bransford, 2007). It is essential to ensure that pre-service teachers possess adequate content knowledge, pedagogical skills, and opportunities for continuous professional development to facilitate effective science teaching (Darling-Hammond and Youngs, 2002). Continuous professional development is required to keep the teachers updated with the ever-evolving Information and Communication Technology (ICT) tools and IBL methodologies (Garet et al., 2001).

Training courses should be grounded in educational research to ensure the approaches used are evidence-based and effective. A multifaceted approach to teacher training, which includes strong content preparation, pedagogical training, practical experience, and ongoing professional development, is necessary for preparing science teachers to meet the diverse needs of their students and the demands of modern science instruction (Cochran-Smith and Zeichner, 2009).

According to the NGSS (Topic Arrangements of the NGSS, 2013), science topics are physical sciences (e.g., physics and chemistry), life sciences (e.g., biology), and earth and space sciences (e.g., geography). This approach aims for a holistic understanding of natural systems, emphasizing the interconnectedness and implications of natural phenomena (Pourdavood and Yan, 2021).

Moreover, science education is critical as it directly impacts students' real-life decisions, perceptions, and understanding of the world. It fosters problem-solving skills, strengthens critical thinking, promotes awareness of conservation, and guides rational decision-making (AlMuraie et al., 2021).

In addition, science education should aim to enhance students' awareness of future careers and opportunities in science. Despite the Program for International Student Assessment indicating a high level of science knowledge and skills among students (Schleicher, 2019), there remains a minimal interest in pursuing science-related careers. Effective science teaching should thus create a classroom environment that

encourages students to independently expand their knowledge through social interaction, collaboration, and interdisciplinary integration (Masood et al., 2022).

The teacher training courses should include the following important aspects of modern science education:

Integrated Science Teaching

In contemporary science education, the importance of integrated teaching is increasingly acknowledged as a key method for fostering students' ability to cross disciplinary boundaries, engage in meaningful learning experiences, and prepare for future careers in a rapidly changing world. Integrative science teaching is a pedagogical strategy that transcends traditional disciplinary limits by merging various scientific disciplines or combining science with other subjects such as mathematics, technology, engineering, and the arts. This approach is particularly significant in integrating biology, geography, chemistry, and physics. Integrative teaching enhances the illustration of the real-world relevance and applications of scientific concepts, demonstrating how different disciplines interconnect and are applicable to real-life situations (Fortus et al., 2005).

Developing of critical thinking and problem-solving skills encourages students to utilize critical thinking and problem-solving skills as they navigate complex, interdisciplinary problems (Tseng et al., 2013). Integrative science teaching can foster student engagement and motivation by making learning more relevant and interesting (Stohlmann et al., 2012). Many modern careers require an interdisciplinary understanding and the ability to apply knowledge in a cross-disciplinary manner. Integrative science teaching prepares students better for such careers (Sanders, 2008). By exposing students to interdisciplinary connections, integrative teaching encourages creativity and innovation, which are essential skills for modern scientific and technological advancements (Henriksen et al., 2016).

The integration of science teaching, when combined with practical tasks and ICT, exerts a significant influence on science educators and pre-service teachers alike. Furthermore, the scientific literacy of teachers is pivotal for ensuring that students achieve similar levels of literacy. The influence of teachers' scientific literacy is intrinsically linked to their proficiency, communication skills with fellow educators, collaborative capabilities, and their aptitude for interpreting and comprehending basic quantitative data. This holistic approach not only enhances the educational experience but also prepares both educators and students for the complexities of modern scientific understanding (Shaffer et al., 2019).

Interdisciplinary learning also promotes collaboration and communication as students often work in teams to solve complex problems, mirroring the collaborative nature of real-world scientific and technical endeavors (Denson et al., 2015). Integrative teaching can promote equity by making science education more accessible to all students, regardless of their background, and by connecting science to their lived experiences (Calabrese Barton and Tan, 2018).

IBL

The main aspect that unites science subjects, bringing them together through integration between subjects and the use of ICT, is inquiry learning (Yang et al., 2022). When teaching science, the emphasis is on different active learning activities. Educational research has shown that inquiry learning, improves pupils' performance and positive attitudes toward science (Haynes et al., 2023), as well as developing critical thinking skills, the ability to observe and appreciate the natural world around them, and thus a more holistic understanding of science (Lu et al., 2021). Global reform in science education over the past two decades has emphasized the importance of teaching science through inquiry (Ramnarain et al., 2022), but some researchers have found that teachers are increasingly valuing the use of digital tools in their teaching, but that integrated teaching of science has not been on the rise. Researchers have mentioned that it is difficult for students to deal with problems they face in life if they lack a holistic understanding (Wang et al., 2018). Lederman and Lederman (2019) have provided therefore an example of a systematic professional development project designed to build capacity for the teaching of the nature of science and scientific inquiry, while not sacrificing the learning of more traditional science subject matter and meet the demands of the twenty-first century.

Inquiry refers to a learning and teaching process in which students undertake different activities, such as posing questions, identifying problems, investigating, collaborating, justifying decisions, coming up with solutions to the issues or answers to the questions, and communicating conclusions, all considered an important skill of the 21st century. IBL has been recognized as a salient pedagogical method not only enhancing students' interest and achievement but also providing students with a chance to discover how scientific knowledge has been constructed and developed by scientists. It has been proved that through the IBL process, students can learn and develop higher-order thinking skills consisting of critical thinking, problem-solving, decision-making, and creative thinking skills so that they are prepared as lifelong learners and scientifically literate citizen (Kang, 2022).

The development of learning theories, the demands of current society, and the positive effects of IBL on learning reported from empirical findings in the relevant literature support the proposition that IBL is essential for teaching and learning and worthy of considering IBL to improve science learning (Berie et al., 2022). The creation of high-quality learning resources for IBL, with a focus on science literacy as a strategy to promote active learning, has emerged as a prevalent trend in education. The development of critical thinking skills is essential as a strategy to enhance students' competencies in problem solving and discovery, which are fundamental aspects of science education. This approach not only supports the acquisition of knowledge but also fosters the application of such knowledge

in practical, real-world situations, thereby aligning with the overarching goals of science learning (Sutiani, 2021).

A shift from traditional teaching methods is requested and the IBL might face resistance from both teachers and students. It also necessitates well-structured guidance to ensure effective learning (Berhanu and Sheferaw, 2022; Singh and Al, 2020; Ünlü and Dökme, 2020). Inquiry activities, as defined by Hwang et al. (Hwang et al., 2012), are those in which students are encouraged to build scientific knowledge and understanding through an interactive process based on building, critiquing, and refining the experiences they gain. Students enjoy scientific activities while improving their ability to establish assumptions, make observations, and interpret data based on these observations. The teacher plays a key role in the inquiry process; therefore, it is important to try to strengthen the science teacher's role in inquiry teaching, especially in the context of professional development (Dobber et al., 2017).

Incorporating ICT in Science Teaching and Learning

ICT has emerged as a fundamental component of modern society, and by extension, plays a crucial role in science education. It has been observed that a majority of teachers exhibit optimism toward the integration of ICT in their teaching methodologies. This trend underscores the growing recognition of the potential benefits that ICT can offer in enhancing the educational experience and facilitating more effective learning outcomes (Kazmi and Mohammad, 2023). The integration of ICT significantly enhances student performance and achievement. Utilizing ICT in teaching facilitates constructivist learning opportunities, catering to students' preferences for highly personalized information that is relevant to both context and practice. The incorporation of ICT in education transforms the dynamics of teaching and learning, leading to qualitative improvements for 21st-century learners. This shift is associated with the emergence of new pedagogical practices that alter the traditional role of teachers and grant students' greater autonomy over their learning, fostering self-regulation and collaborative learning. Such a strategy moves away from conventional lesson formats, which are primarily focused on the transmission of information, toward more student-centered approaches that emphasize active participation and engagement (Villena and Caballes, 2020).

Integration of ICT will assist teachers to the global requirement to replace traditional teaching methods with technology-based teaching and learning tools and facilities and the teachers' well-equipped preparation with ICT tools and facilities is one of the main factors in the success of technology-based teaching and learning. It was also found that professional development training programs for teachers also played a key role in enhancing students' quality learning (Jadhav et al., 2022). Using the technological resources effectively requires inevitably the teachers' competency of ICT (Tondeur et al., 2012).

Digital literacy should be one of the most important learning objectives in science lessons, as it involves scientific information retrieval, in which the student is able to navigate between sources, and in the process develops creative thinking and a holistic view of the environment (Pedaste et al., 2021). The advancement of ICT within the school system prompts educators to adopt or devise innovative tools and methodologies. This effort is aimed at assisting students in developing a comprehensive and integrated perspective of science. Through the strategic incorporation of ICT, teachers are able to facilitate a more nuanced and interconnected understanding of scientific concepts, thereby enriching the educational experience and fostering a deeper appreciation of the subject matter (Hladun, 2020).

Real-life Examples in Science Teaching and Learning

Links to everyday life can bridge the gap between theoretical concepts and real-world examples can be challenging, and require a good understanding of both the science and the real-world context (Aikenhead, 2006). Facilitating students' understanding of the real-world application of scientific concepts can enhance learning and retention (Rivet and Krajcik, 2008).

Science education may sometimes feel disconnected from the everyday experiences familiar to students, creating a sense of alienation. Research in science education has largely framed the divide between students' daily experiences and science learning as a challenge encountered in the comprehension of scientific concepts and the identification of instructional strategies that can facilitate this learning. However, the manner in which individuals relate to the world on a day-to-day basis extends well beyond mere conceptual understanding. There exist comprehensible methods through which students can link the process of learning science to their everyday lives and its inherent common-sense perspectives. This recognition underscores the importance of integrating real-world contexts into science education, thereby bridging the gap between abstract scientific concepts and students' lived experiences (Kervinen et al., 2020). That's why the real-world examples make the learning experience in science education more engaging and meaningful for students, for instance: Using everyday examples like car crashes to explain the principles of momentum and energy conservation (Etkina et al., 2021); vaccination against severe acute respiratory syndrome coronavirus 2 (Liu et al., 2021), etc.

For the education of students as science-literate individuals, it is imperative that they acquire foundational scientific knowledge, apply this knowledge to real-life situations, and utilize it to address issues or problems they face. In this context, prospective teachers, who represent the future of education, bear significant responsibilities in nurturing science-literate individuals. This study aims to gather the pre-service science teachers regarding the process of integrating science topics with everyday life experiences. Through this exploration, the study seeks to understand how future educators perceive the connection between scientific principles and practical applications, highlighting the role they play in preparing

students to navigate and solve real-world challenges with scientific insight (Çepni et al., 2017).

The theory of teacher change (Fischer et al., 2018; Yang et al., 2022) assumes that improved teacher orientation and teaching performance (e.g., attitudes, knowledge, and skills) and enhanced classroom teaching subsequently increase student learning outcome. However, this assumption has not been sufficiently and empirically examined with large sample sizes and that's why needs to be investigated further (Chen and Terada, 2021).

In summary, the integration of ICT, examples from real life, and IBL are crucial for effective science teaching.

The research questions of the current study were posed as follows:

1. What are the pre-service science teachers' perceptions about developing inquiry skills depending on the subjects studied?
2. What are the pre-service teachers' perceptions of the needs for the application of ICT depending on the subjects studied?
3. What are the pre-service teachers' perceptions of the needs for the application of real-life examples depending on the subjects studied?
4. Do the pre-service teachers' perceptions about the integrated teaching of science subjects depend on the subjects studied during the teacher training?

METHODOLOGY

Sample

The study's sample consisted of 50 pre-service teachers who were undergoing training in various science disciplines to become upper secondary school teachers. The curriculum for "The Upper Secondary School Science Teacher" is designed to allow candidates to achieve specialization in one or more areas of science teaching, with a maximum of four specializations available. Accordingly, the sample included 30 pre-service teachers who were pursuing a single specialization within the science teaching curriculum. In addition, 17 participants were specializing in two science subjects, and three were focusing on three science subjects during the period of the pre-service courses under investigation.

Instrument

The current study used an 8-item open-ended questionnaire as an instrument for the data collection. The first four questions of the questionnaire were meant to collect the background information that concerned the curriculum of science subjects of the pre-service courses, previous teaching experience and previously taught subjects, and the school grades.

The second part of the questionnaire, comprising four essay-type questions, delved into the students' perceptions concerning the integrative approach to science teaching. This approach emphasizes the unification of various scientific disciplines—namely, biology, geography, chemistry, and physics—thereby reflecting a comprehensive educational strategy. In addition, the questionnaire addressed key elements of contemporary science education, which include IBL, the integration of ICT in science education, the application of real-life scenarios in science teaching, and the significance of integrated science teaching and learning. These components were examined in the context of a diverse array of science subjects that are traditionally taught as discrete entities within both lower and upper secondary education systems.

The concluding query within the questionnaire sought to gather insights into the students' perspectives on the holistic teaching of science. Specifically, it asked, "In your opinion, how should the different science subjects be taught to most benefit the students in their (future) lives?" This question aimed to aggregate a conclusive assessment regarding the pre-service teachers' views on the value of integrated science teaching and learning methodologies.

This questionnaire was administered to the pre-service teachers at two critical junctures: At the commencement and on the completion of their 2-year pre-service course. This dual-point distribution was strategically employed to evaluate the evolution of their perceptions regarding integrated science education throughout the course of their studies.

Data Analysis

The method of data analysis for this research was inductive qualitative content analysis using the QCAmap interactive software program. This content analysis reduced the textual material by paraphrasing and categorizing. The pre-service teachers' responses were read through several times before categorizing. As the categories were continually revised, sub-categories emerged that could be linked into coherent codes. The data collected during the survey was used to answer the research questions based on the perceptions of pre-service science teachers. After transcribing the questionnaire responses into an MS Word document, the data were saved in the correct text file (.txt) with the correct code (Unicode) and loaded to the QCAmap program (QCAmap.org), and the subsequent data analysis was carried out using the program. In the qualitative content analysis program, some preliminary work had to be done before coding. Codes were generated for each question and later grouped into categories. The QCAmap program is based on the theory of (Mayring, 2000). After using the QCAmap program, the results were loaded from the program into MS Excel for further analysis. Excel allowed sorting of the data obtained and statistical comparison of the data.

Validation of Qualitative Content Analysis

For validating the results of a qualitative content analysis, Cohen's kappa statistic was used to assess the level of agreement between two reviewers. The inter-rater reliability based on the calculated Cohen's kappa value (0.79) indicated substantial agreement between the two reviewers (Sabharwal, 2021). First, the contingency table was set up, entering the data in two separate columns (one for each rater) and then

SPSS statistical software was used to compute Cohen's Kappa according to the test procedure in SPSS Statistics (Martins et al., 2023).

RESULTS

The Pre-service Teachers' Perceptions about Integrated Science Teaching

In the beginning of the study, the qualitative content analysis emerged two main categories – pre-service teachers preferring (1) subject-centered teaching and (2) integrated science teaching. The sub-categories included the specialization of the number of science subjects, obtained during studies, and the coding was based on different science subjects that are all illustrated in Table 1. The preliminary results showed that the pre-service teachers, preferring the subject-centered teaching style, were only two teacher training students out of 34 who mentioned indirectly the concept of integrated learning (e.g., holistic view of nature). Among the pre-service teachers who preferred integrated science teaching, there were nine respondents out of 16, who highlighted the integrated learning and teaching in the beginning of the pre-service courses.

Three sub-categories of pre-service teachers emerged, categorized based on the number of subjects they taught — namely, one, two, and three subjects — regarding their perceptions of the importance of integrated science teaching (Figure 1). The answers to the question: "How do you think different science and science subjects should be taught to be of most benefit to students in their (future) lives?" were analyzed and the results revealed a substantial difference between single and multi-subject pre-service science teachers.

Analysis of the results showed that only 17% of one subject teachers (6 out of 36) highlighted the importance of integrating science subjects. Of the pre-service teachers of two subjects, 77% (10 out of 13) mentioned the importance of integration. Pre-service teachers of three subjects felt that the benefits of teaching science greatest when it is done in an integrated way. All pre-service teachers of three science subjects (3) were in favor of integrated science teaching and learning.

Inquiry-Based Teaching and Learning

The second research question focused on the development of inquiry skills. In line with this objective, the perceptions of pre-service science teachers of one, two, and three subjects on the achievement of this objective in science classes were examined and illustrated in Figure 2.

The results showed that the development of research skills as a goal of science teaching is considered average by both single and multi-subject teachers. It was found that 43% of teachers of one subject, 46% of teachers of two subjects, and both teachers of three subjects perceive the development of inquiry skills as a goal of science teaching. The results showed a noticeable difference between single and multi-subject pre-service teachers.

Differences in subject teachers' perceptions indicated that targeting of inquiry skills is less popular among chemistry and physics teachers. This objective was suggested more by teachers of biology-chemistry and four-subject pre-service teachers. Teachers of biology-chemistry and three subjects valued the development of inquiry skills. The analysis revealed that there was a significant difference between biology-geography and biology-chemistry teachers.

Application of ICT in Science Classes

The pre-service teachers' perceptions of the need for the use of ICT in science classes according to their specialization(s) are illustrated in Figure 3, comparing the perceptions of pre-service teachers of one, two, and three subjects. The results showed that only 37% of pre-service one-subject teachers consider the use of ICT in science classes important. Among the two-subject pre-service teachers 57% valued the use of

Table 1: The categorization of pre-service science teachers (n=50), who highlighted the need for integration out of the max number of these pre-service teachers in the beginning of teacher training

Categories	Sub-categories	Codes	Pre-service science teachers (*N*/max)
Subject-centered teaching	Teaching one science subject	Biology	0/7
		Geography	0/7
		Chemistry	0/4
		Physics	0/2
	Teaching two science subjects	Biology and Geography	1/10
		Geography and Physics	0/2
	Teaching three science subjects	Geography, Chemistry and Physics	1/2
Integrated science teaching	Teaching one science subject	Biology	1/2
		Geography	1/3
		Chemistry	1/3
		Physics	1/2
	Teaching two science subjects	Biology and geography	3/4
		Geography and physics	1/1
	Teaching three science subjects	Geography, Chemistry and Physics	1/1

ICT and all (100%) of three-subject teachers considered ICT as a valuable tool in science classes.

The Need for the Application of Real-life Examples in Science Classes Depending on their Specialization(s) Studied

In a survey of pre-service teachers' perceptions of different subjects, it became clear that ICT tools need to be used in science lessons to make real-life connections (Figure 4). In addition, it was mentioned that real-life connections can be made through demonstration and constant interaction with students. The results revealed again, that the pre-service science teachers acquiring the specialization of three subjects advocate most (100%) for the real-life examples in science teaching; the one-subject teachers favor the real-life examples the least (66%), and the two-subject teachers favor the bringing the real-life into science classes at the medium level (85%). The average support for real-life examples is still considerably higher than for ICT devices.

The participating pre-service teachers who responded to the questionnaire also pointed to different teaching methods that result in connections with real life. In addition, the results showed that science teachers attach importance to making connections with real life in their teaching, but do not link the use of ICT and integrated teaching of science. Rather, making connections with life is more important than creating a passion or motivation.

The Changes in Pre-service Science Teachers' Perceptions of Integrative Science Teaching

The results of 2 years of pre-service science teacher training are illustrated in Table 2 and Figure 5. The pre-service science teacher training courses focusing on modern science education, an important aspect as integrative teaching and learning, were found to be successful, as the number of pre-service teachers' changes was significant (20 teachers out of 50 moved from the subject-centered teaching category to the integrated science teaching category). Eight one-subject science teachers remained unchanged, continuing to give preference to subject-centered teaching, except all four chemistry teachers. Four two subjects (biology and geography) teachers did not change their preferences to subject-centered teaching but two teachers, teaching both geography and physics, changed their perceptions toward integrated science teaching. Two of three subjects (geography, chemistry, and physics) teachers also changed during the studies their preferences in favor to integrated science teaching.

It is remarkable (Figure 5) that half of these changes (10 out of 20) took place in the perceptions about the integrative science teaching of one-subject teachers. The second in the number of changes occurred with pre-service science teachers teaching two subjects (four out of 16) and the smallest number of changes was observed in the perceptions of three-subject teachers (two out of three), but one teacher out of three believed in integrated teaching benefits already before the training

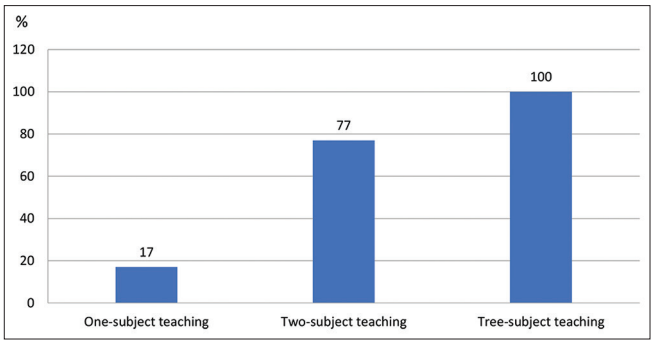

Figure 1: The pre-service teachers' (n = 50) perceptions of the importance of integration in science teaching depending on the number of specialized science subjects

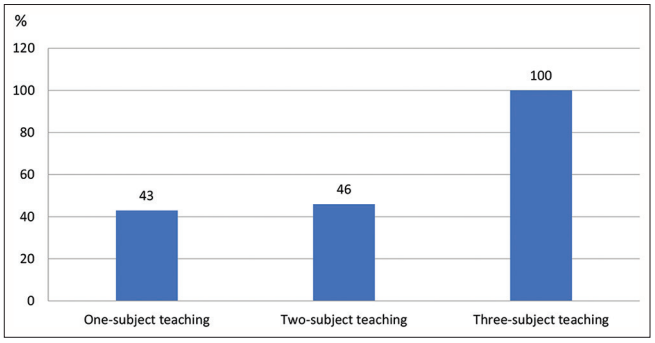

Figure 2: Pre-service teachers' (n = 50) perceptions of the development of developing the students' inquiry skills

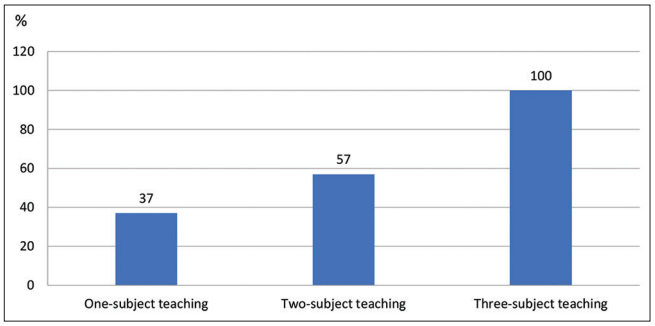

Figure 3: The pre-service teachers' (n = 50) perceptions of using information and communication technology in science teaching

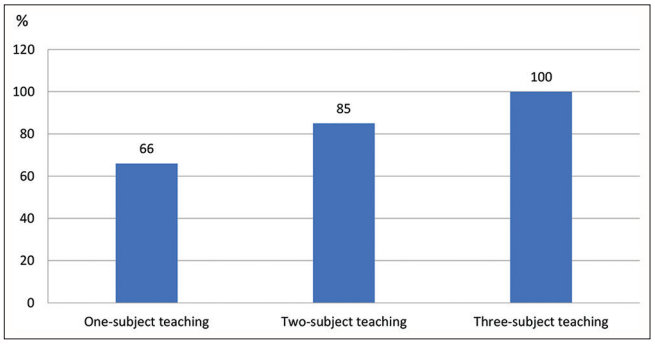

Figure 4: The pre-service teachers' (n = 50) perceptions of the need for the application of real-life examples in science lessons according to specialization have been studied

Table 2: The categorization of pre-service science teachers (n=50) according to the number of their studied science subjects before and after teacher training

Categories	Sub-categories	Codes	Before training (n)	After training (n)	Changes of categorical
Subject- centered teaching	Teaching one science subject	Biology	7	2	−5
		Geography	7	6	−1
		Chemistry	4	0	−4
		Physics	2	2	0
	Teaching two science subjects	Biology and Geography	10	4	−6
		Geography and Physics	2	0	−2
	Teaching three science subjects	Geography, Chemistry and Physics	2	0	−2
	Total		34	14	−20
Integrated science teaching	Teaching one science subject	Biology	2	4	+2
		Geography	3	6	+3
		Chemistry	3	6	+3
		Physics	2	4	+2
	Teaching two science subjects	Biology and Geography	4	10	+6
		Geography and Physics	1	3	+2
	Teaching three science subjects	Geography, Chemistry and Physics	1	3	+2
	Total		16	36	+20

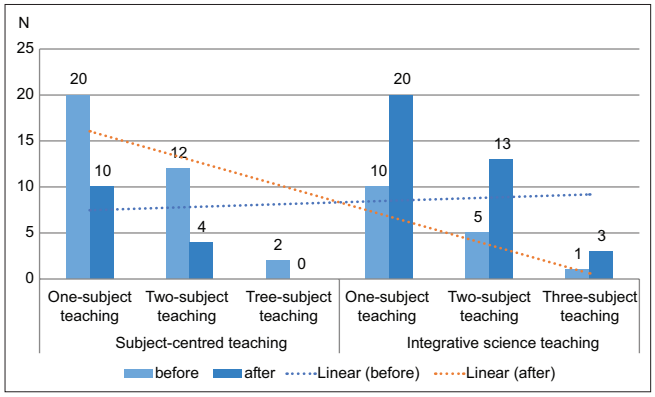

Figure 5: Changes in perceptions about integrated teaching of pre-service science teachers (n = 50)

courses started. The trendlines of the pre-service science teachers favoring integrative teaching are illustrating the outcome of the training courses, as before, the bigger number of teacher's favored the subject-centered teaching, and after the courses, the situation was reversed.

DISCUSSION AND CONCLUSIONS

The aim of this study was to find out what are the perceptions of integration in science subjects, what are the advantages of inquiry-based teaching, the application of ICT devices and tools, and real-life examples in science classes. The results showed that the pre-service science teachers of several science subjects emphasize the transfer of subject knowledge and the introduction of the prevailing connections in nature more than the pre-service teachers of one science subject but at the same time during the studies the one-subject teachers carried out major changes toward the integrated way of science teaching.

This teacher training course focused also on the development of inquiry skills. Implementation of the IBL model in the science teaching and learning activities has proven to be able to improve students' critical thinking skills that are needed as a strategy to build students competencies in problem solving and discovery as required in science learning (Sutiani, 2021). IBL that also stimulates and reflects scientists' authentic work among students has become the keystone of science education for the last decades. It is a less teacher-directed step-by-step instruction, rather, a more student-centered way of learning, which encourages to use learners' own experiences. IBL has been recognized as a salient pedagogical method not only enhancing students' interest and achievement but also providing students with a chance to discover how scientific knowledge has been constructed and developed by scientists. It has been proved that through the IBL process, students can learn and develop higher-order thinking skills consisting of problem-solving, inferring, estimating, predicting, generalizing, and creative thinking skills so that they are prepared as lifelong learners and scientifically literate citizen (Kang, 2022).

Consistent with these studies, the perceptions of pre-service science teachers, who specialized in one, two, or three subjects, regarding the attainment of research skill development within science classes were scrutinized. The findings indicated that both teachers specialized in a single subject and those teaching multiple subjects rated the enhancement of research skills through inquiry-based science teaching as moderate. It emerged that teachers responsible for one or two subjects viewed the cultivation of inquiry skills as a fundamental objective of science education similarly, with educators teaching three subjects also aligning with this perspective.

The results of the current study showed that there was no big difference between the perceptions of pre-service teachers

who study one and who teach several science subjects in favor of using ICT, but it turned out that biology and geography teachers placed more emphasis on ICT than chemistry and physics teachers and the results showed relatively unpopular use of ICT in science classes. Only a quarter of the pre-service teachers who responded to the questionnaire mentioned the importance of using ICT.

The third research question aimed to find out how science teachers relate to the implementation of ICT in science lessons. The results showed that there was no significant difference between teachers of one subject and teachers of several subjects. For both groups, about half of the respondents considered the need to use ICT. This study also showed that pre-service teachers of biology and geography emphasized more the need ICT but pre-service teachers of physics and chemistry remained more subject specific and the teaching methodology tended to be more lecture-based.

From the results, it can be concluded that only half of the respondents valued the importance of ICT implementation, including no difference in being a teacher of more than one subject.

The general purpose of teaching sciences is related to the development and advancement of students. Researchers have mentioned that the competencies that are being developed today are information and digital competencies (Starkey, 2020) that improve students' source-critical thinking. Based on this, the teacher has to use different teaching methods, such as applying ICT and integrating different science subjects. Integrated studies create a complete overview of the environment, based on context.

Research has shown that science teaching aims to help make connections with real life, but that connections can only be made through practical work, ICT, and integrated learning. The results of this work showed that most respondents value the connection with real life in the teaching of sciences, but the importance of ICT, and the integration of science subjects had been relegated to the background. It turned out that opinions about the connection of science subjects with real life do not differ between teachers who teach one and teachers who teach several science subjects.

The pre-service teachers' participating in this study and training courses also shared the understanding of previous researchers' perceptions of the needs for the application of real-life examples (Aikenhead, 2006; Rivet and Krajcik, 2008).

In line with the theory of teacher change (Fischer et al., 2018; Yang et al., 2022), the current study also spotted at the pre-service science teachers' positive changes toward integrative science teaching and the main aspects of modern science education which were the focus of pre-service courses and this study.

The main focus of this study was to examine the science teachers' perceptions about the integrated teaching of science, according to their acquired specialization and the number of science subjects to be taught. Literature has repeatedly stated that the teaching of science needs to be integrated (Kelley et al., 2020). From the results, it can be concluded that disciplines have a statistically significant effect on the perceptions of questionnaire respondents on the integration of science. Wang and his colleagues have found that teachers are increasingly valuing the use of digital tools in their teaching, but integrated teaching of science has not been on the rise (Wang et al., 2018).

Researchers have also mentioned that it is difficult for students to deal with problems they face in life if they lack a holistic understanding (Wang et al., 2018). Teachers' understanding of one subject may be related to the lecture-based method that has been used for decades, which places more importance on their subject and does not attempt to link with teacher collaboration (Masood et al., 2022). In contrast, only two of the three-subject teachers did not perceive the integration of science as important. While collaboration between teachers is the exception for single-subject teachers, multi-subject teachers are more aware of the importance of integration (Loogma et al., 2009). Multi-subject teachers who had highlighted the importance of integrating science subjects also mentioned the importance of using ICT, the demonstration of real-life connections, and the interrelated importance of using digital and active learning tools. The average support for real-life examples is still considerably higher than for ICT devices.

At the outset of this study, the integration of science subjects was not deemed significant, as evidenced by a pronounced discrepancy in perceptions. Nonetheless, a number of pre-service science teachers advocated for the integrated teaching of science, suggesting it fosters a comprehensive understanding of the natural world. They highlighted that such an approach facilitates students' comprehension of natural interconnections and implications. However, the findings revealed that merely six teachers specializing in a single-subject acknowledged the importance of teaching science in a unified manner. These single-subject teachers recognized several critical objectives, including fostering a holistic perspective, elucidating natural relationships, and promoting experiential learning. Yet, these aspirations were not explicitly associated with the concept of integration.

The analysis further demonstrated that the pre-service teachers' views on integrated science education were influenced by their specific areas of focus during their teacher training programs. A notable disparity emerged between the responses of teachers trained in a single subject and those prepared to teach multiple subjects, with the latter group placing a greater emphasis on the integration of science disciplines. It became apparent that, overall, the integration of science subjects was generally undervalued among pre-service teachers, suggesting a need for enhanced emphasis on this approach within teacher education programs.

During the teacher training courses, a significant shift in perceptions was observed among pre-service teachers over the course of their 2-year specialized studies, moving toward a more contemporary approach to science education. It can

be inferred that their enhanced focus on and acknowledgment of the importance of integrating science subjects have likely increased the probability of science being taught in an integrated manner. A pivotal finding of this research was the correlation between the change in pre-service teachers' perceptions regarding integrated science teaching and the number of science subjects they were prepared to teach. Future studies could investigate more thoroughly the effects of integrated science teaching on student achievements and their interest in learning science subjects in a cohesive manner.

In addition, examining whether a holistic approach to science education confers advantages to students in their future endeavors would provide valuable insights.

Limitations

There were several limitations that occurred during the work. A major limitation was the small sample size. Therefore, the reliability is lower as the conclusions are based on a small sample. However, this master's thesis provides a sufficient overview, as a result.

The most important outcome of this study was the dependence of the change in perceptions of pre-service teachers about science-integrated teaching on the number of science subjects to be taught.

Ethical Statement

This study was approved by the Scientific Education Centre of University of Tartu. All participants voluntarily and anonymously participated in the study and were informed about the content of the research and personally identifiable data were not collected. In addition, the corresponding author obtained written informed consent from all study participants.

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CONFLICTS OF INTEREST

No conflicts of interest exist. The authors confirm that there are no known conflicts of interest associated with this publication, and the financial support for this work did not influence its outcome.

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