Views of future Special Education teachers on teaching Natural Sciences during Practicum

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Abstract

This study explores the views of 91 students from the Department of Special Education at the University of Thessaly regarding the teaching of Natural Sciences during their practicum. Implementing a questionnaire adapted from the DAS instrument, this research focuses on student' views concerning the value of Natural Sciences, their sense of self-efficacy, the role of digital tools, and interdisciplinary approaches in science teaching. The results indicate that students hold positive views regarding their abilities and recognize the importance of engaging methodologies for inclusive Natural Sciences education. Implications for practicum design and teacher preparation programs are discussed.

Key words

Student practicum, self-efficacy, Natural Sciences/Science, digital tools, STEAM interdisciplinary approaches

Resumé

Cette étude explore les points de vue de 91 étudiants du Département de l'Éducation Spéciale de l'Université de Thessalie concernant l'enseignement des Sciences Naturelles durant leur pratique. En mettant en œuvre un questionnaire adapté de l'instrument DAS, cette recherche se concentre sur les opinions des étudiants concernant la valeur des Sciences Naturelles, leur sentiment d'auto-efficacité, le rôle des outils numériques, ainsi que les approches interdisciplinaires dans l'enseignement des sciences. Les résultats indiquent que les étudiants ont *une perception positive de leurs compétences et reconnaissent l'importance de méthodes pédagogiques engageantes pour une éducation inclusive en Sciences Naturelles. Les implications pour la conception des stages et les programmes de formation des enseignants, sont également discutées.*

Mots-clés

Stage d'enseignement, auto-efficacité, Sciences Naturelles, outils numériques, approches interdisciplinaires STEAM

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Introduction

Beyond academics, primary teachers are emphasizing the social, emotional, and creative development of students (Fayzullaeva, 2024; Gimbert et al., 2021) and play new roles such as planner-programmer, organizational-managerial, motivational, pedagogical-instructive, and advisory all in addition to traditional classroom roles. This shift supports broader educational goals. Indeed, teachers in Greece, teach many different subjects (Science, Mathematics, Language, History, Religion and in some cases Art). They also take part in various educational programmes and often together with their pupils, create new educational projects.

In recent years, a critical objective in the curricula has been the effective use and exploitation of Information and Communication Technologies (ICT) in the context of teaching individual cognitive subjects. When considering all the aforementioned elements, it becomes evident that the literature describes the direct or indirect involvement of primary school teachers with different subject areas, interdisciplinary approaches and digital tools. Teachers are involved in their teaching with subjects and projects belonging to the STEAM (Science, Technology, Engineering/Devices, Arts, Mathematics) education field (Papadakis & Kalogiannakis, 2024). Whilst the majority of teachers are acquainted with and incorporate project-based learning into their pedagogical approaches, their awareness of and training in STEAM education is limited (Olivato, & Silva, 2023).

However, teachers' attitudes towards different subjects can affect their teaching effectiveness and personal enjoyment. Studies have shown that lessons involving reading and spelling are more preferred than those related to science (Afifah et al., 2023; Feser & Michalik, 2023). Also, teachers' proficiency in teaching may vary by subject.

For example, in core academic subjects such as mathematics and language, teacher proficiency appears to be better in comparison to practical and art subjects likely due to systemic focus and the prioritization of core academic subjects in teacher training programs (Milić et al., 2022).

The aforementioned data highlight the need for further scientific study and research in the field of students' practical training in different disciplines. In the present research we focus on learning in the subjects of Natural Sciences (NS) in primary school, which are diverse (Environmental Studies, Geography, Physics as well as Skills Labs) in the Special Education Department (SED) in Greece.

To lead to useful conclusions, current research in the field of teaching practicum must include questions about future teachers' attitudes and opinions and their self-efficacy towards science itself (Afifah et al., 2023), the use of interdisciplinary approaches and the use of digital and various teaching tools in NS learning (Hrynevych et al., 2021), which as a whole and complementary are the building blocks for effective NS teaching (Shulman, 1986).

Theoretical background

The importance of Science in education

Science plays a key role in the development of integrated education systems worldwide. They provide students with essential skills related to critical thinking, problem solving and understanding the natural world (National Research Council, 2012; OECD, 2018). Science is at the core of creative and analytical thinking. According to Dewi et al. (2017), the study of science enhances critical thinking and innovation skills, while research by Suhirman et al. (2020) shows that NS foster the ability to solve problems through analysis and reasoning.

Ravanis (2022) highlights the convergence of various theoretical approaches to study how young children interact with materials, objects, and natural phenomena. He identifies key research trends, including the study of children's mental representations, the development of teaching activities, and the preparation of educational materials. This multidisciplinary effort seeks to understand the mechanisms through which children begin to grasp scientific concepts (Ravanis, 2005). Ravanis (2022) has also explored educators' professional development, particularly in early childhood science education. His research emphasizes the importance of equipping teachers with effective strategies to introduce scientific concepts to young learners.

As far as primary school is concerned, Science is crucial in shaping students' broader knowledge base and developing their creativity (Newton & Newton, 2010). Through science activities, students learn to think creatively, ask questions and seek answers through the experimental process (Fleer, 2009). The emphasis on observation, experimentation, and discovery helps the development of critical thinking skills, which are essential not only for their scientific careers but also for meeting the challenges of everyday life (Klahr & Nigam, 2004; Silva et al., 2022).

On the other hand, research has shown that students' attitudes towards subjects such as mathematics or NS can influence their performance in these fields and their choice to pursue related studies or related careers (Osborne et al., 2003; Quintana & Saatcioglu, 2022). Education students often have diverse attitudes towards Science, which are shaped by previous experiences, self-efficacy and the importance of the subject for their future career (Alim et al., 2019; Getie, 2020; Toma & Greca, 2018). Understanding these attitudes is critical as they can influence how these future teachers will teach NS in their classrooms (Beier et al., 2019). More specifically, a positive attitude towards Science can enhance students' interest in scientific research and improve their performance in these subjects (Guo et al., 2022; Maltar Okun et al., 2022). Similarly, negative attitudes can act as a barrier, discouraging students from engaging in the subject or even cultivating skills in it (Eccles & Wigfield, 2002; Naganuma, 2023).

Self-efficacy and teachers' training

Two important concepts play a role in the cognitive development of new teachers: self-efficacy and self-doubt. The relationship between self-doubt and self-efficacy is quite complex. Self-efficacy, as defined by Bandura (1997), refers to an individual's belief in his or her ability to organize and execute the actions required to achieve specific goals, an element that is enhanced after a number of achievements. Self-efficacy and self-doubt are interrelated concepts (Markova, 2021) and self-efficacy influence teacher performance (Burić et al., 2024).

Stylos et al. (2022) explored the efficacy beliefs of Greek pre-service primary teachers in physics teaching, highlighting factors that influence their confidence and effectiveness in delivering science education: Stronger efficacy beliefs were associated with better subject knowledge, teaching experience, and positive attitudes toward physics. Lack of practical teaching opportunities and insufficient subject knowledge were identified as barriers.

The relevant literature in the field reports that students of pedagogical departments with high self-efficacy tend to be more willing to adopt innovative teaching practices and persevere in the face of challenges (Awang, et al., 2023; Woolfolk Hoy & Spero, 2005). In terms of factors affecting self-efficacy in NS, these include, among others, previous experience and success (Palmer, 2011), observation of role models (Bandura, 1997, 2012; Liepa & Ročāne, 2024), verbal reinforcement (Nielsen et al., 2024) and emotional state, since anxiety and doubt can work negatively (Klassen & Durksen, 2014) and, on the other hand, teachers with high self-efficacy experienced reduced anxiety and built stronger teacher-student relationship (Hajovsky et al., 2020).

A similar picture is described in the literature for (in-service) teachers, where self-efficacy is crucial for the effectiveness of teaching and the success of their students. Teachers with high self-efficacy are more likely to implement innovative teaching methods and adapt their instruction to meet the needs of students (Sodergren et al., 2023). On the other hand, feeling prepared to teach cross-curriculum skills, such as creative thinking, critical thinking, and problem solving, had a positive effect on teacher self-efficacy (Sodergren et al., 2023).

Therefore, how self-efficacy (or self-doubt) influences future teachers in their career path has to do with the professional training followed, positive feedback and the observation of successful role models (Strutyńska & Karwowski, 2022) and of course the different personalities and abilities of prospective teachers (Makopoulou et al., 2021). Teachers who have managed to have strong personal beliefs and positive self-concept are more likely to benefit from professional development programs and improve their self-efficacy (Baggott la Velle, 2020; Perera et al., 2019).

Interdisciplinary approaches and digital tools in teaching Science in Primary Education

Science teacher education increasingly foregrounds digital tools alongside constructivist, inquiry-based, and culturally responsive pedagogy (Mafugu et al., 2022; Nor & Halim, 2023). In primary schooling, STEAM-oriented interdisciplinarity treats phenomena as complex systems and frames learning around authentic problem solving that synthesizes methods and representations from multiple disciplines (Ampartzaki et al., 2022; Barbosa et al., 2024). They also establish pathways to lucrative, multidisciplinary careers and align with primary teachers' across-subject mandate, with practice improved iteratively through co-working (Brown et al., 2024; Gresnigt et al., 2014; Lee, 2020; Nguyen & Ng, 2020).

Digital technologies have the capacity to reformulate science learning goals and create real-world abstractions through engaging technologies of doing and experiencing (Kalogiannakis et al., 2021; Kilag et al., 2022). Training is linked to positive approaches and uptake by candidates, and when an entire and holistic toolkit to make mobile apps, collect and visualize data, and utilize feedback tools is understood and apprised as an entire and holistic toolkit at minimum, the full affordances for differentiation, communication and collaboration, and for richer analytics choices are open; yet the instructors still need support (skills, preparedness, incentives, policy fit) (Karagiannidis et al., 2022; Pozas & Letzel, 2023; Sebastián-López & González, 2020; Spiteri & Chang Rundgren, 2020).

In Greece, we have not located similar studies investigating pre-service teachers' experiences of practicum and attitudes about using digital technologies to teach Natural Sciences; therefore, this gap - along with the rapid development of Generative artificial intelligence (Spasopoulos et al., 2025) - provides a timely impetus to reconceptualise program objectives and to (re)design the teaching practicum in an era of rich digital possibilities for science education.

Teaching Practicum and student teachers

Studies from across the globe highlight that practicum is an important part of primary school teacher preparation for teaching natural sciences. Good quality practicum experiences, especially if thoroughly linked to the science pedagogy methods course and supported by mentoring and reflective practice, are linked with higher teacher self-efficacy beliefs, using inquiry-based pedagogies, and better outcomes for students in science (Fishman et al., 2017; Kenny, 2010). In recent years, the relevant literature in the field has increasingly highlighted the important contribution of practicum to teachers' education and professional development (indicatively Ji et al., 2022; Lawson et al., 2015; Poveda García-Noblejas et al., 2023; Raikou et al., 2016; Schulz, 2005).

In this context, as an integral part of studies in pedagogical departments, students are given the opportunity to act as teachers themselves in a real school environment, taking an empirical approach to their profession (Filippidi et al., 2019; Raikou, 2014a, 2014b). Having in mind that teaching is a complex and multifaceted activity (Schulz, 2005), practicum becomes a scientific field of particular value. It is a holistic process of professional learning (Raikou et al., 2017), the main aim of which is the acquisition of research, reflective and collaborative skills, as well as the possibility for the teacher to become a self-directed and active leader (Schulz, 2005).

In our setting (SED-University of Thessaly), the four-year curriculum blends general and special pedagogy, Natural Sciences, and educational technologies. Core modules include "ICT in Education and Special Education" and "Introduction to Science Education", which precede or run alongside early school placements. Science/TPACK (Technological, Pedagogical Content knowledge) electives such as "Experimental Teaching of Science Education", "Science Education Didactics", "Development of ICT Applications for Learning and Special Education", and "Concepts of Science Education in Early Childhood" provide multiple, scaffolded exposures to science content and pedagogy. A dedicated Laboratory of Natural Sciences, Technology and Environmental Studies support experimental teaching of science with appropriate equipment and activities. These elements indicate that students' views are formed cumulatively across coursework and laboratory experiences and are expressed and refined during practicum rather than originating there de novo.

The formation of teacher perspectives is thus shaped by both coursework and practicum, but each plays a distinct and complementary role. The integration - and quality - of all aspects ultimately defines success. Coursework in science and science methods provides preservice teachers with subject-matter knowledge and introduces inquiry-based, research-informed ways to teach; the number and quality of science courses are linked to more robust content knowledge in specific areas (for example, evolution), but there is no guarantee that these courses cover all science topics in a comprehensive manner (Nixon & Swain, 2024). Science methods courses allow preservice teachers to practice developing initial capacities in scientific inquiry and pedagogical content knowledge, PCK (Pardo et al., 2024).

Following these courses, preservice teachers are positioned to "put that learning into practice" during practicum experiences. When practicum experiences align with the science methods course's theoretical preparation, they evidence enhanced self-efficacy, context appreciation, and deeper understanding of research-led science teaching practices (Subramaniam, 2022; Ulvik et al., 2018). Challenges associated with practicum, like inadequate mentorship, limited resources, and failures to align coursework objectives with practicum experiences, can reduce inquiry-based enactments and limit experiences across the breadth of science teaching (Fuentes-Abeledo et al., 2020; Koc, 2012; Ulvik et al., 2018). Although practicum is one aspect of preservice teachers' professional learning, it is important for developing practical skills in the act of teaching, reflective practice, and adaptive expertise for various classroom realities (Koc, 2012; Subramaniam, 2022).

Consistent with the SED curriculum, participants had prior attendance of NS didactic/ICT courses before their first practicum placements in general-education primary schools; therefore, the views reported here should be interpreted as the combined effect of whole-program study plus practicum, not of practicum alone. In the third year, candidates engage in teaching observation and experimental teaching in general-education schools, accompanied by seminars on planning, feedback, and reflection; in the fourth year, practicum is conducted in special-education schools. In our context, experimental teaching and related lesson planning offered explicit opportunities to apply science-education ideas and (where feasible) digital tools during the third-year general placements, with subsequent special-education practicum focusing on adaptations and inclusive practice that continue to draw on primary science pedagogy.

Meanwhile, research has highlighted the established role of a practicum in futuring a teachers' self-efficacy specifically in teaching strategies, classroom management, and student engagement (Altarawneh et al., 2023). Nevertheless, the impact of school experience itself is not reinforcing by nature; rather the preservice teacher must imaginatively discern the quality of their relationships with mentors, partner schools, classroom teachers and most importantly students, as well as how those relationships were encapsulated in the enacted curriculum. Creating a practicum provided with support, gradual responsibility increment, and reflection is key to mitigate stress and enhance self-efficacy (Klassen & Durksen, 2014).

Therefore, ICT-enriched and supported, practicums in science, offers opportunities for continuing collegiality and collaborations; data collection/visualization; and authentic inquiry, while the mentors' pedagogical practices, and the school ecosystem itself, are largely responsible for the competences that preservice teachers eventually exhibit (Rodríguez et al., 2022; Savec, 2017).

The teaching Practicum of the Department of Special Education at the University of Thessaly is staged:

(a) a third-year practicum in general education (observation + experimental teaching + concurrent seminars on preparation, planning, feedback, and reflection), followed by

(b) a fourth-year practicum in special-education schools.

This design operationalizes practicum as a context for enactment and consolidation of competencies built across science/ICT coursework and lab experiences, and explains why our study discusses primary science teaching even though students are enrolled in a Special Education department: their curriculum includes general-pedagogy and primary-science coursework and early general-education placements, with the special-education practicum building upon and adapting that foundation. In this article, the empirical data and analyses concern general-education preservice teachers and their experiences/attitudes in primary-school contexts.

Methodology

Research questions

The present research aims to record and investigate the views of future special education teachers regarding teaching NS. After reviewing the relevant literature, the research questions of this study were formulated as follows:

1. What are the views of future special education teachers on the value and role of Natural Sciences in primary education?
2. To what extent do students' academic training and practicum experience collectively shape their self-evaluation and perceived self-efficacy in teaching Natural Sciences?
3. What are their views on the use of digital tools for effective and inclusive science teaching?
4. How do they perceive the application and value of interdisciplinary (STEAM) approaches in teaching Natural Sciences?

Sample

The sample consists of 91 students from the Department of Special Education (SED) of the University of Thessaly, who were in their 3rd or 4th year of studies and had completed the teaching practicum programme in (general education) primary schools in Volos. Sampling was conducted through a convenience process (convenience sample) of student volunteers who had completed (at least) their Practicum in General Education schools and had previous attendance of NS didactic courses in their curriculum.

Research tool

The questionnaire was based on the *Dimensions of Attitudes Toward Science (DAS)* instrument by van Aalderen-Smeets & Walma van der Molen (2013).

For the reliability of the coding process, two independent researchers with extensive experience in science education coded all of the Units of Meaning. Agreement was established through comparison of coding results and discussion until consensus was reached (Kanaki & Kalogiannakis, 2023). Based on international studies, this has proven to be an effective research tool for identifying and explaining the various components of the perspectives that NS teachers hold regarding NS teaching. It includes 27 Likert-type (1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree and 5=strongly agree) statements organized into three main sections (which are listed in the following three tables).

- Views on the value of NS (Table 1),
- Self-evaluation and self-efficacy (Table 2),
- Methods/techniques for active participation through the use of technology, and reports on interdisciplinary approaches and techniques (Table 3).

The research process

The research was conducted between May and June 2024, with the electronic completion of the questionnaire (Google Forms). Initially, a pilot study was conducted beforehand to test validity and reliability. Then, after the necessary modifications were made, the final questionnaire was distributed online for completion. In order to ensure maximum participation from students who had already completed the general practicum program - typically concluded by early May each year - the link to the questionnaire was posted on the eclass platform of three courses from the 3rd and 4th year of study, including the practicum course.

Access to the questionnaire remained open for three weeks, with two interim reminders sent to students via course announcements on the eclass platform. In accordance with ethical requirements, it was emphasized to the participants that their cooperation was voluntary, and their responses were anonymous and confidential, and that data would only be used for this study (Petousi & Sifaki, 2020).

Results

In this section, we will present the results of our study. 91 students of SED participated in the present survey. The vast majority of the participants were female (95%), and in terms of age, 75% were up to 22 years old and 18% were over 25 years old. When the questionnaires were checked, it was found that there was no missing data (it should be noted here that all questions were required to be completed) and statistical processing was implemented using SPSS v29. The questionnaire was checked for reliability and showed for all 27 questions, acceptable internal reliability (α=0.718) was above the threshold of 0.7 as the Cronbach's alpha value which is a dependable estimator of scale reliability.

In examining the initial set of questions presented in Table 1, it becomes evident that participants tend to hold more definitive attitudes, either positive or negative, towards a number of issues. The greater consistency of responses to some questions appears to indicate the presence of strong, shared perceptions or experiences. The increased dispersion observed in other questions suggests that there may be issues with greater objective variation in participants' views. All responses are characterised by a median and mode value. A rating of 4 or 5 indicates the students' agreement with the statements in the questions, except for Question 6 (the Complexity of the Topics of the NS to be Taught), where values of 3 and 2, respectively, were given. This indicates that the students do not view the topics of the NS as particularly challenging/complicated.

As illustrated in Table 1, participants' perceptions of the value of teaching NS are relatively high. This is evidenced by the high mean values for questions 1 and 4, which are 4.41 and 4.16, respectively. This confirms the recognition of the importance of NS in teaching. Furthermore, children's creative and critical thinking receives the highest mean value (4.47), with a median and mean value of 5. This indicates that respondents consider that NS has a strong role in promoting these skills. The mean values for Questions 2 and 5, which pertain to the physical education and career choice, respectively, are 3.7 and 3.6, respectively. These values indicate that there is a divergence of opinion among the student respondents about these two subjects.

Regarding the students' views on self-evaluation and sense of self-efficacy (Table 2), it seems that again their responses are above average. The highest values are found in the opinions regarding the sense of joy they felt while teaching NS (3.95 mean) and that they were able to carry it out in a learning beneficial way for the students (3.82 mean).

At the same time, however, they express the relative difficulty they face when teaching NS in the context of practicum (3.80 mean), although most of them consider that they were able to deal effectively with the students' questions (3.69 mean). The lowest response (but still slightly above average) was the belief that gender differentiates interest in experiments, with female students being more enthusiastic than male students in NS (2.66 mean).

Table 1

Views on the value of NS

Q	Question	Mean	Median	Mode	SD
1	Teaching NS in primary education is important for children's development	4,41	4	5	0,649
2	NS should be taught in school as early as possible	3,70	4	4	0,810
3	NS can significantly help to foster children's creative & critical thinking	4,47	5	5	0,656
4	I believe that the teaching of NS is important and necessary to enable primary school students to participate in an effective way in problems related to technology & society	4,16	4	4	0,793
5	I believe that the teaching of NS in Primary Education can significantly help students to make good choices about their (future) studies	3,60	4	4	0,917
6	I find the NS subjects taught in Primary Education complex	2,73	3	2	0,990

Q1-Q3 Min=2, Max=5. Q5-Q6 Min=1, Max=5

All questions (except one: q7 with value of 2) have minimum values of 1 and maximum values of 5, indicating that there were participants who expressed the full range of possible answers. Median and mode are all 3 or 4 except for the question 1 (gender differentiation of students' enthusiasm in NS) with value 2 for both factors.

Questions 2, 4 and 6 have a high mean (3.95, 3.8 and 3.82 respectively), indicating general agreement in the participants' opinions. Questions 1, 10 and 11 have low mean (2.66, 2.95 and 2.91 respectively), showing a general tendency to disagree. The median and mode values confirm the results of the averages, giving consistency to the responses.

Question 2 has a relatively low standard deviation (0.935), showing uniformity in responses. Questions 5 and 9 have higher standard deviation (1.228 and 1.269 respectively), indicating greater variance in opinions.

Regarding the students' perspectives on active involvement in the NS and the methodologies employed to facilitate this, as evidenced in Table 3, the level of engagement is notably high, with the majority of responses scoring an average of 4 or above. The median and mode values for Digital Game and Simulation are 5 and 5, respectively.

Table 3 indicates a notable inclination among students to prioritize interactive and hands-on learning approaches, favoring tools and techniques that facilitate active engagement and critical thinking. More specifically, Table 3 relates to Research Questions (RQs) 3 and 4. Specifically, questions 3, 4, and 8 relate to RQ3, and questions 1, 2, 5, 6, and 7 relate to RQ4.

TABLE 2

Views on self-evaluation & self-efficacy

Q	Question	Mean	Median	Mode	SD
1	I find that primary school students are more enthusiastic about experiments than primary school students as I found during my practicum	2,66	2	2	1,360
2	During my practicum I felt happy when I taught a NS subject	3,95	4	4	0,935
3	I consider that my interest in the NS courses during my practicum was very high!	3,45	4	4	1,003
4	I think that most of us (future primary school teachers) encounter difficulties when teaching NS during our Practical Training	3,80	4	4	0,957
5	During my Practicum I felt stress when I taught a NS subject	3,19	3	4	1,228
6	During my Practical Training I was able to teach the subjects of the NS (with which I was involved) in a way that was beneficial to my students	3,82	4	4	0,739
7	During my Practical Training I was able to deal effectively with my students' questions about Science	3,69	4	4	0,812
8	The help from the teachers of the school(s) in the subject of NS was important for my Practical Training	3,11	3	4	1,140
9	The provision of material (notes, laboratory material) on the subject of NS, by the Teacher(s) of the school(s) was important for my Practical Exercise	3,11	3	4	1,269
10	I believe that I know the content of the NS course well enough to be able to teach it satisfactorily in my classroom in the future	2,95	3	3	1,089
11	I consider that I have sufficient knowledge of the teaching approaches of NS to be able to apply them in my classroom in the future	2,91	3	3	1,007

Q1-Q6, Q8-Q11, Min=1, Max=5. Q7, Min=2, Max=5

The topics related to Experiment (Q2) and Simulation (Q3) are considered to be of particular importance by students, as indicated by their high mean scores (4.75 and

4.53, respectively). Among the digital tools, digital games are the preferred option for active student engagement (4.40 mean).

Additionally, Problem Solving (Q1) and Constructions (Q7) exhibit elevated mid-range scores, underscoring a proclivity for practical application and active learning.

Furthermore, the considerable standard deviation observed in questions such as Business (Q9) and Role-playing (Q10) (0.967 and 1.099, respectively) indicates a notable divergence in opinions, potentially attributable to disparate perceptions of their importance among students.

Finally, among the techniques of teaching NS (linked to interdisciplinarity), Constructions emerge as the most popular (4.46 mean), while argumentation/debate is the least preferred (but still at high levels) with a mean of 3.67.

TABLE 3

Views on active participation in learning in NS

Q	Question	Mean	Median	Mode	SD
1	To what extent do you consider Problem Solving important in order to actively engage students in the learning of NS?	4,08	4	4	0,718
2	To what extent do you consider the Experiment important in order to actively engage students in learning NS?	4,75	5	5	0,607
3	To what extent do you consider Simulation important to actively engage students in learning NS?	4,53	5	5	0,705
4	To what extent do you consider the Digital Game important in order to actively engage students in learning NS?	4,4	5	5	0,758
5	To what extent do you consider STEAM (Science, Technology, Engineering, Art, Maths) methodology important in order to actively involve students in the learning of NS?	3,99	4	4	0,738
6	To what extent do you consider the use of art important in order to actively engage students in learning NS?	3,77	4	4	0,895
7	To what extent do you consider Constructions important to actively engage students in the learning of NS?	4,46	5	5	0,75
8	To what extent do you consider the use of mobile devices (tablet, iPad, mobile phone) important in order to actively engage students in the learning of NS?	4,09	4	4	0,902
9	To what extent do you consider Argumentation/Debate important to actively engage students in the learning of NS?	3,67	4	4	0,967
10	To what extent do you consider role-playing & drama important in order to actively engage students in learning NS?	3,95	4	5	1,099

Q2, Q6-Q10 Min=1, Max=5. Q1, Q3-Q4 Min=2, Max=5. Q5 Min=3, Max=5

Students assign high value to NS (e.g., Q1=4.41; Q3=4.47; Q4=4.16) and do not see NS topics as especially complex (Q6=2.73). This stance is mirrored in practicum experiences: they report joy when teaching NS (Q2=3.95), perceive their lessons as beneficial (Q6=3.82), and feel able to handle students' questions (Q7=3.69).

The preferences are compatible with active and digitally mediated pedagogy, with positive ratings for Experiments (Q2=4.75), Simulations (Q3=4.53), Digital Games (Q4=4.40), Constructions (Q7=4.46), and Mobile Devices (Q8=4.09). Although there is only moderate sense of difficulty during practicum (Q4=3.80), as well as lower self-ratings in NS content knowledge (Q10=2.95) and pedagogy (Q11=2.91), it does indicate that enthusiasm potentially accompanies perceived gaps in subject-matter and pedagogical preparation.

Variation is non-trivial: higher SDs for Role-playing (Q10 SD=1.099) and Argumentation (Q9 SD=0.967) in Table 3, and for material provision (Q9 SD=1.269) and stress (Q5 SD=1.228) in Table 2, suggest heterogeneous placement and mentoring conditions. Importantly, the low endorsement of gender-based differences in enthusiasm (Q1=2.66) suggests a more inclusive view of engagement. In total, the practicum appears to enable positive attitudes in developing professional behaviors and engagement in activities/digital enactments. Targeted improvement of content/pedagogical preparation and contextual supports may help to reduce variability and reinforce self-efficacy.

Discussion and conclusions

In the context of modern educational reality, the teaching of Natural Sciences (NS) in primary education is closely linked to the development of students' critical thinking, problem-solving, and creativity skills. At the same time, according to literature (Abrahamsson et al., 2023; Horsley & Moeed, 2023), teachers with a strong background in NS are better equipped to enhance their students' curiosity and engagement. For future Special Education teachers, integrating NS presents an additional challenge, as they must adapt the content and methodology to the specific learning needs of their students.

The pedagogical practices of students in the Department of Special Education (SED) during their Practicum period are of particular importance, as they offer opportunities for reflection, application of theoretical knowledge, and contact with the demands of a real classroom. Specifically, understanding their views on the teaching of NS, the use of digital tools, and interdisciplinary approaches can contribute to the redesign of the Practicum and Teacher Education Curricula.

This study focuses on the views of students from the SED who completed their Practicum in General Education schools and examines the contribution of this experience to shaping their attitudes and perceptions regarding the teaching of NS. In our findings, the value of teaching NS and the role of digital technologies are systematically highlighted by participating preservice teachers during their teaching practicum—an environment that appears to contribute decisively to the formation of corresponding learning opportunities. This constitutes a distinct call both for practicum design in pedagogical departments and for modern curriculum design in teacher education.

The interpretation of the results is organized based on the four research questions:

1. *Value of Natural Sciences:* Students recognized the high value of NS for cultivating creative and critical thinking and expressed positive expectations for NS as a driver of overall education. They emphasized the joy they felt while teaching NS and perceived their lessons as beneficial for pupils, reinforcing NS as a fertile context for engagement and sense-making in primary classrooms.
2. *Self-efficacy:* The practicum strengthened participants' self-evaluation and sense of self-efficacy in teaching NS. Students reported feeling able to implement teaching that responded to learners' needs, while acknowledging challenges (e.g., content depth, choice of methods). These patterns align with established findings that authentic teaching experiences and progressively increasing responsibility foster teacher self-efficacy (Tschannen-Moran & Woolfolk Hoy, 2001; Woolfolk Hoy & Spero, 2005). In our context, this growth should be interpreted as the combined effect of whole-program learning plus practicum, not of practicum alone.
3. *Digital Tools:* Participants expressed a consistently positive stance toward digital tools, reporting the use of active techniques such as experiments and simulations, alongside individual digital tools (e.g., games, mobile devices). They also identified a need for further training to deepen and broaden technology-enhanced NS practice. The practicum context enabled concrete opportunities for technology-supported inquiry and differentiation—an emphasis that converges with recent evidence on the expanding role of emerging technologies in STE(A)M education (Leavy et al., 2023).
4. *Interdisciplinary Approaches (STEAM):* Students' views on STE(A)M were positive, especially for activities involving experiments, constructions, and collaborative learning. They highlighted benefits for critical thinking, creative problem-solving, and a holistic approach to learning—findings that converge with recent reports (Leavy et al., 2023; Voicu et al., 2022; Wised & Inthanon, 2024).

Overall, the study points to the importance of preparing future teachers to confidently and inclusively integrate NS, digital tools, and interdisciplinary methods into everyday classroom practice. In summary, this study highlights the need to enhance the Practicum by systematically integrating NS into both General and Special Education contexts. At the same time, the systematic integration of digital and interdisciplinary tools into teacher education curricula - combined with feedback from practical experience—can decisively contribute to strengthening the teaching competence of future NS educators.

Implications

Overall, the results indicate that a well-aligned practicum—explicitly connected to NS/digital coursework and supported by feedback-rich reflection - makes visible and amplifies the affordances of NS, digital tools, and STE(A)M for primary education.This involves (a) purposeful integration with NS over the practicum across General and Special Education contexts, and (b) purposeful integration with technology and interdisciplinary tools within teacher-education curricula with practicum based feedback loops. This alignment can significantly enhance the teaching competence of future educators of NS while providing the adaptable focus needed in Special Education.

Limitations and possible extensions of the research

This study is a single-institution case study of SED students completing general-education practicum within a bounded time window and relies on self-report, so findings are not generalisable. Future work should expand to multiple pedagogical departments and years of study and explicitly model heterogeneity by adding potential moderators/covariates: gender; prior academic achievement (overall GPA and science-course performance); completion/intensity of science and ICT coursework and lab experiences; interest in the teaching profession/vocational commitment; baseline attitudes toward NS and digital competence; prior classroom experience; and practicum features (mentoring quality, school context/resources, opportunity to teach NS, lesson autonomy). Beyond conventional tools, generative AI is already used for co-design, differentiation, and feedback in science education (Sotiropoulos & Kalogiannakis, 2025); future work should track its practicum use and examine equity, bias, and data-protection issues by comparing GenAI-supported and traditional groups under shared mentoring and assessment.

Finally, a parallel cohort in special-education placements will allow comparison with general-education practicum and tracing how AI-enabled and other digital practices shape trajectories of science-teaching self-efficacy and enactment across the programme.

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