The Role of Continuous Training in Enhancing the Use of Technologies in Mathematics Education

Eulália Santos
Department of Maths and Natural Sciences
Higher School of Education and Social Sciences of the Polytechnic of Leiria (IPLeiria)
Leiria, Portugal
eulalia.santos@ipleiria.pt

Conceição Nogueira
CMAT and Department of Mathematics, School of Technology and Management, IPLeiria
Leiria, Portugal
conceicao.veloso@ipleiria.pt

Paula Faria
Department of Mathematics, School of Technology and Management, IPLeiria, Centre for Rapid and Sustainable Product Development (CDRSP)
Leiria, Portugal
paula.faria@ipleiria.pt

ABSTRACT
Continuous teacher training has proven essential for the effective integration of digital technologies in education, particularly in the field of mathematics. With technological advancements, the need to prepare teachers to efficiently use technological resources in the educational environment has become increasingly urgent, contributing to more dynamic and student-centred pedagogical practices. This study aims to analyse the perceptions of mathematics teachers regarding the training they have undergone and the use of software in mathematics lessons. A quantitative methodology was employed, based on a questionnaire survey conducted with 15 mathematics teachers who participated in specific training in the field of mathematics using technology. The results show that teachers perceive both the training they attended and the use of software in mathematics lessons positively. Additionally, it was found that teachers who perceive the training positively tend to place greater value on the use of software in their classrooms.

Author Keywords
Technology; teacher training; pedagogical innovation mathematics.

ACM Classification Keywords
Mathematics of computing – Mathematical software

Applied computing – Education

INTRODUCTION

Technologies are increasingly being integrated into the educational context [25]. In the 21st century, technology and mathematics are deeply interconnected, making the presence of technology in mathematical practice inevitable [28]. The incorporation of technology is an ongoing challenge, as it requires exploring the various existing technological applications and identifying which can provide significant benefits to the student's learning process [16].

According to Dahal et al. [4], to help stimulate students' interest in mathematics, teaching this subject should not focus solely on theoretical approaches but should be based on a variety of methods, including the use of pedagogical tools. The Essential Learnings in Mathematics (ELM) for Secondary Education, which will come into effect in the 2024/2025 academic year, aims to develop students' ability to identify relevant mathematical concepts to solve real-life problems, apply appropriate mathematical procedures, and interpret results in various environments [5]. In this context, the integration of technology is also crucial in teacher training, as it contributes to improving the quality of teaching, particularly in subjects such as mathematics [6]. Technology can facilitate access to innovative pedagogical tools and support continuous professional development. Moreover, the use of technology allows for greater personalisation of teaching, where teachers can utilise educational software, e-learning platforms, and digital resources to meet the specific needs of students [18]. Thus, for mathematics teaching and learning to be effective, teachers must use technology in the classroom [2].

Despite the growing interest in integrating technology into education, there is a gap in studies investigating how continuous training directly influences teachers' perceptions of the use of software in mathematics classes. The systematic literature review conducted by Silva et al. [25] highlights a significant interest in developing studies related to the use of digital technologies in the training of mathematics teachers. Therefore, the present study aims to analyse mathematics teachers' perceptions of the training they attended and the use of software in mathematics lessons. Following this introduction, a literature review is presented, addressing teacher training and the use of software in mathematics lessons. Subsequently, the methodology used is described, followed by the presentation and discussion of the results. Finally, the study's main conclusions are presented.

LITERATURE REVIEW

Teacher Training

Continuous training is essential to ensure that teachers remain up to date with the latest advancements and discoveries in their field of study [6]. Such training not only guarantees mastery of specific content but also promotes the development of pedagogical skills, such as the ability to dynamise the classroom, motivate students, and effectively use educational technologies [18]. Learning new technologies and adopting them for classroom use can enhance teaching practice and facilitate student learning [6]. Therefore, teacher training is fundamental to ensuring the quality of education and the holistic development of students.

According to Mota et al. [18], well-trained teachers are better equipped to apply innovative pedagogical methods, adapting to students' needs and the demands of a contemporary world that increasingly requires digital and technological skills. Additionally, proper teacher training is crucial for addressing the challenges brought by rapid changes in the educational field, such as the growing use of digital tools and the need to personalise teaching for different learning profiles.

The new EML for Secondary Education is based on nine key ideas: 1) Problem-solving, modelling, and connections; 2) Mathematical reasoning and logic; 3) Systematic use of technology; 4) Educational tasks and resources; 5) History of Mathematics; 6) Enriching practices and creativity; 7) Organisation of students' work; 8) Mathematical communication; and 9) Assessment for learning [5]. To implement these ideas in classrooms, teachers must receive adequate and up-to-date training on technological and methodological integration.

According to Modelski et al. [17], the use of technology in mathematics teaching should be promoted through small and large group discussions. The authors suggest that group interactions generate productive debates, where teachers share experiences, exchange ideas, and reflect on the practical application of technology in the classroom. The dynamics of these sessions, as highlighted by the same authors, help clarify pedagogical principles, enabling teachers to explore different approaches for integrating technological tools into mathematics teaching. In order to prepare students for the challenges of the modern world, teachers must value the importance of computational thinking as an essential skill to enrich their teaching practices [10]. Thus, it becomes important to provide secondary school teachers with adequate knowledge of computational thinking and how to incorporate it effectively into their teaching [29]. In this way, educators acquire new skills, such as computational thinking, which directly impact their professional practice, improving how they teach mathematical concepts and fostering students' motivation in the learning process. These experiences enrich the understanding of specific concepts and prepare teachers to face the challenges of modern teaching, promoting more dynamic and effective education [17].

Using software in maths classes

The introduction of technologies in the classroom does not replace the teacher, but it is an added value for students in terms of visualization and also for performing calculations [12]. According to Pritchard [20], the teacher is a facilitator who offers a set of challenges to their students, engages them in dialogue, and supports the development of their understanding. The study by Karim and Zoker [11] shows that teachers who take on roles as facilitators, mentors, and leaders are more likely to succeed in promoting the teaching of mathematics. Technology is particularly useful as a support in solving mathematical problems and challenges, and in conceptual development in mathematics [21].

Students accept the use of software not only as a tool that can increase the attractiveness of the class but also as a learning tool [23], and the majority of secondary school mathematics teachers also tend to use Information and Communication Technology tools to support their lessons [19]. However, Lyonga and Nkeng [14] suggest the need to encourage a more favourable attitude toward the use of technology in classrooms.

Collaborative activities focused on group reasoning sharing have improved creative reasoning [8]. Therefore, technology is used effectively when applied to create and design a learning environment that promotes collaboration and communication among students, allowing them to interact and work together [21].

In the new Secondary School Mathematics Curriculum (EML), considerable emphasis is placed on the introduction of computational thinking [5]. Computational thinking develops abstract thinking, problem-solving skills, pattern recognition, and logical reasoning [1]. Computational thinking increases students' confidence in dealing with complex problems, improves their ability to tackle complex issues, and collaborates with others to find a solution [22]. In this regard, the integration of computational thinking, mediated by software, can enhance students' real-world problem-solving abilities, tailored to their level [30].

The new EML for Secondary Education refers to the use of technological resources such as graphic calculators, spreadsheets, GeoGebra, and Python [5]. Marley-Payne and Dituri [15] consider the use of spreadsheets in classes important, as they allow students to deepen their understanding of both algebra and financial modelling. The results of the study by Santos et al. [24] showed that the use of GeoGebra software improves students' performance in group activities, and students have a positive perception of the use of this software. Using Python is effective for introducing fundamental mathematical concepts, as it not only teaches programming but also equips students with problem-solving skills [3, 27].

Teachers' attitudes and beliefs about the relevance of technology for student learning have a significant impact on the success of technological integration [7]. In the study by Taimalu and Luik [26], the pedagogical knowledge of teacher educators had a significant total effect on technology integration, and beliefs about the value of technology indirectly influenced technology. Niyibizi and [19] argue that to ensure all mathematics teachers develop confidence in using technology in their teaching practices, it is essential to update their training on technological integration. In addition to competencies, knowledge, and beliefs, which are decisive factors in technology integration, professional development is important to support teachers in using technology [11]. Training workshops focused on the integration of technology in mathematics teaching improve mathematics teachers' perception of its use [13]. In this regard, and based on the literature review conducted, the following research hypothesis was formulated:

Hypothesis: There is a positive relationship between teachers' perceptions of training and the use of software in mathematics classes.

METHODOLOGY

The participants in the present study were the 15 mathematics teachers who took part in the training programme "*Promotion of Statistical and Financial Literacy in Mathematics Lessons Using Computational Thinking*" which took place in July 2024 at the Higher School of Technology and Management of the Polytechnic of Leiria. The training lasted 25 hours and covered concepts and problems related to the mathematical theory of elections, financial literacy, and statistical literacy, always seeking to integrate computational thinking into problem-solving where possible, using tools such as Excel, GeoGebra, and Python. Various open-ended tasks were planned and developed, in which students were required to engage in significant work on interpreting and formulating the questions to be solved, based on real-world problems that could be implemented in the classroom by the teachers who attended the training. Both individual tasks and group tasks were considered to promote collaborative work. The aim was to enrich pedagogical practices through strategies such as the integration of computational thinking using various tools and the diversification of the types of tasks proposed to students.

The ages of the 15 teachers ranged from 42 to 54 years, with a mean age of approximately 47 years (SD = 3.69). The majority (73.3%, n = 11) of the teachers have more than 15 years of teaching experience.

The questionnaire used in this study begins with a mandatory question regarding informed consent, and for those who agreed to participate in the research, it is composed of three sections. The first section assesses the general perception of the training. The second section evaluates the perception of software use in mathematics lessons. The third section pertains to sociodemographic and professional data (age and years of teaching experience).

To assess the teachers' overall perception of the training, ten items were used, as presented in Table 1.

The perception of software use in mathematics lessons was assessed using the twelve items presented in Table 2.

Evaluated aspects	Items
Suitability to needs	1. The training met my professional development needs.
Relevance of tasks	2. The tasks carried out were relevant and enriching.
Resources used	3. The resources used were appropriate.
Group discussions	4. Productive discussions were generated within the working groups.
Session dynamics	5. The dynamics of the sessions helped to clarify principles and pedagogical options for mathematics lessons.
Impact on professional practice	6. The skills acquired will impact my professional activity.
Application of knowledge	7. Following this training, I will apply the knowledge acquired in teaching and learning processes.
Use of educational technologies	8. The training contributed to enhancing the use of software in the classroom, considering the new Essential Learning Outcomes.
Relevance of content	9. The content of the training was relevant and applicable to my needs as a mathematics teacher.
Understanding of specific concepts	10. The training helped me to better understand the concepts of computational thinking.

Table 1. Perception of training scale.

Evaluated aspects	Items
Student interest	1. Students show interest in learning to use software in mathematics lessons.
Interactivity and engagement	2. The use of software in the classroom can make mathematics lessons more interactive and engaging.
Understanding of concepts	3. The use of software in the classroom can improve students' understanding of mathematical concepts.
Technical difficulties	4. Students encounter technical difficulties when using software.
Skill development	5. The use of software in the classroom can help students develop important skills for the job market.
Student interaction	6. When solving activities using software, there is interaction among students.
Student confidence	7. Students feel confident in solving problems using software.
Student preference	8. Students enjoy studying mathematics using software.
Role of the teacher	9. In solving activities using software, the teacher plays a facilitative role.
Teacher-student interaction	10. In solving activities using software, there is interaction between the teacher and students.
Development of critical thinking	11. The use of software in the classroom promotes the development of critical thinking among students.
Computational thinking and problem-solving	12. The integration of computational thinking in lessons with the use of software can enhance students' problem-solving abilities.

Table 1. Perception of software use in mathematics lessons scale.

The selection of items to be included in the questionnaire took into consideration the literature review conducted. The items were measured on a five-point Likert scale (1 - *strongly disagree*, 2 - *disagree*, 3 - *neither agree nor disagree*, 4 - *agree*, 5 - *strongly agree*). To ensure the quality and reliability of the questionnaire, it was pre-tested with three mathematics teachers. Based on the feedback provided by the pre-test participants, slight modifications were made to the questionnaire.

The ten items that assess the general perception of the training have a Cronbach's alpha value of 0.960, and the twelve items that assess the perception of software used in mathematics lessons have a Cronbach's alpha value of 0.945, indicating very good reliability (Hair et al., 2014). Therefore, the items can be confidently used to assess the general perception of the training and the perception of software use in mathematics lessons.

The questionnaires were administered during the final session of the training and were conducted using Google Forms. Participants were informed about the study's objectives, the anonymity, and the confidentiality of the information provided. Statistical analysis was performed using IBM SPSS Statistics 26. Descriptive statistical techniques were used to describe the sample and the teacher's perceptions of the training and the use of software in mathematics lessons. Cronbach's alpha was calculated to study the reliability of the constructs, and Spearman's correlation coefficient was used to test the formulated hypothesis.

RESULTS AND DISCUSSION

In addition to calculators, the majority of mathematics teachers regularly use software in the classroom (73.3%, $n = 11$), which is consistent with the findings of Niyibizi and Mutarutinya [19].

Table 3 shows that teachers perceive the training positively, as all mean values are above 4.

Evaluated aspects	*M*	*SD*
Relevance of tasks	4.80	0.56
Suitability to needs	4.73	0.59
Resources used	4.73	0.59
Session dynamics	4.73	0.59
Group discussions	4.67	0.62
Impact on professional practice	4.60	0.63
Relevance of content	4.60	0.63
Use of educational technologies	4.60	0.74
Understanding of specific concepts	4.47	0.64
Application of knowledge	4.47	0.74

Table 3. Teachers' perception of training

The most highly valued aspects (Table 3) were the relevance of the tasks ($M = 4.80$, $SD = 0.56$), the suitability to their needs ($M = 4.73$, $SD = 0.59$), the resources used ($M = 4.73$, $SD = 0.59$), and the dynamics of the sessions ($M =$

4.73, *SD* = 0.59). These aspects align with the key ideas of the Mathematics Curriculum for Secondary Education (EML), which emphasises supporting learning through diverse tasks, contexts, and resources with the use of technology [5]. The least valued aspect is the application of knowledge (*M* = 4.47, *SD* = 0.74).

An analysis of Table 4 shows that teachers perceive the use of software in their lessons positively, as all mean values are above the midpoint of the scale. The aspects most valued by the teachers were student interactivity and engagement (*M* = 4.53, *SD* = 0.64), understanding of concepts (*M* = 4.47, *SD* = 0.74), and the development of mathematical skills (*M* = 4.47, *SD* = 0.74). These aspects not only make lessons more engaging but also facilitate learning [23]. The least valued aspect is students' preference, specifically their enjoyment of using software to study mathematics (*M* = 3.80, *SD* = 0.86).

Evaluated aspects	*M*	*SD*
Interactivity and engagement	4.53	0.64
Understanding of concepts	4.47	0.74
Skill development	4.47	0.74
Computational thinking and problem-solving	4.33	0.72
Teacher-student interaction	4.33	0.82
Role of the teacher	4.33	0.82
Development of critical thinking	4.33	0.90
Student interaction	4.20	0.94
Technical difficulties	4.07	0.80
Student interest	4.00	0.66
Student confidence	3.87	0.92
Student preference	3.80	0.86

Table 4. Teachers' perception of software use in mathematics lessons

A positive and statistically significant relationship is observed between the perception of the training and the perception of software use in their lessons (rho = 0.694, $p = 0.002 < 0.01$), which supports the formulated hypothesis. In other words, teachers who view the training positively are more likely to have a favourable view of using software in their lessons. Thus, teachers should update their training on the integration of technology in mathematics to develop confidence in using technology in their teaching practices [13, 19].

CONCLUSION

The results show that teachers perceive both the training and the use of software in mathematics lessons positively. During the training, the most valued aspects were the relevance of the tasks, the suitability to their needs, the resources used, and the dynamics of the sessions. Regarding the use of software in mathematics lessons, teachers highlight the interactivity and engagement of students, the improvement in understanding concepts, and the development of mathematical skills.

Teachers who have a positive perception of the training tend to place a higher value on the use of software in their lessons. This is important not only for motivating students to study and understand mathematical concepts but also for making teaching more effective and adapted to students' needs. The use of software can contribute to a more interactive and engaging learning environment, facilitating the understanding of complex concepts and promoting deeper learning.

In order to better understand the different approaches and challenges in integrating software into mathematics lessons, it would be useful in future studies to apply this questionnaire in various training sessions of this kind to increase the sample size, as well as to conduct interviews with teachers to gain a deeper insight into their experiences.

For future training of this kind, it would be beneficial to provide mathematics teachers with the opportunity to implement the various open-ended tasks planned and developed during the training in their classrooms. Subsequently, a session dedicated to discussing the results of implementing these tasks should be held. Based on this discussion, the relevance of reformulating or even potentially replacing the tasks identified can be evaluated. This approach would contribute to the continuous professional development of teachers and the improvement of educational practices.

In terms of practical implications and recommendations for improving the integration of technologies in mathematics lessons, initiatives are suggested that promote collaboration among teachers by creating communities of practice where they can share experiences and effective strategies in using educational software. It is also important to develop institutional policies that encourage and support the use of technologies, including the provision of appropriate technological resources and technical support in schools. To make technological tools more intuitive and accessible for students, it is essential to create partnerships between educators and software developers. Special attention should also be given to adapting technologies to different teaching contexts, ensuring that the software is used inclusively and meets the diverse needs and learning styles of students.

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