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Construction and Validation of a Survey on the Technological Difficulties in Italian Secondary Schools: The Mathematics Teacher Case

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Abstract: (1) Background: This study explores the technological difficulties of mathematics teachers in Italian secondary schools, focusing on the factors that influence their ability to integrate technology in teaching. (2) Methods: A questionnaire was developed and administered to a pilot group of 45 mathematics teachers from vocational secondary schools in Sicily and Veneto, followed by a larger survey with 557 mathematics teachers across Italy. The structural model was analysed using the maximum likelihood method via AMOS software (v.22 SPSS Inc., Chicago, IL, USA). (3) Results: The results highlight the importance of personal commitment in the school context and students' problem-solving skills as key factors influencing the teachers' technological challenges. The findings also indicate dissatisfaction with the school institution and families, as well as personal resistance to using information and communication technologies (ICT) in more advanced educational activities. (4) Conclusions: The study underscores the significant impact of these technological difficulties on teachers' effectiveness in fostering students' problem-solving abilities, calling attention to the need for better institutional support and strategies to reduce resistance to ICT use in education.

Keywords: educational technologies; mathematics teachers; secondary school; instrument validation; technological difficulties

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1. Introduction

The 21st century is characterised by rapid changes caused by new technologies as support tools in all components of society [1]; with the introduction of the computer, these changes have affected the school world since the 1980s, becoming a key issue in education since the early 1990s [2]. The introduction of information and communication technologies (ICT) has imposed a systematic change in the learning environment, involving the classroom and social infrastructures [3] and the teaching–learning process, necessitating the search for innovative teaching models (Ortega (2014) cited by [4]). Many studies have identified ICT as a tool capable of increasing the quality and quantity of learning [5,6]; the continuous innovation of digital tools influences the knowledge acquisition of students and teachers by improving their teaching–learning processes [7]; the possibility of interaction with the teacher and peers without distance limits [8] along with the ability to retain and share materials determine the active construction of students' knowledge [5,9,10], transforming learning into a social activity [11] where each student intentionally builds new learning strategies under the fundamental guidance of the teacher [12]. Thus, the use of ICT is directly related to the educational context (Ortega, 2014, cited by [4]) and supports the transition from teacher-centred knowledge-based teaching to student-centred skills-based teaching [13,14]; therefore, ICT acts as a learning enhancer. The attempts to implement technologies in a traditional learning environment are hindered by the resistance to the novelty that different components offer [15,16], including, on the one hand, the personal beliefs of the teacher [17], and on the other, the obstacles that the school context poses in educational, relational, technical, and practical terms [18]. Incorporating technology into school activities can influence daily well-being, resulting in an increased workload for the teacher and levels of 'technostress' (stress induced by the pressure to integrate technology into teaching without adequate preparation or support) [19], which can become a source of tension and anxiety [20]. The school context can influence the integration of ICT into teaching activities; in particular, the vision of school leaders affects the support (pedagogical and technical) and technological infrastructures used to promote teachers' pedagogical practices [21,22]. Several studies have investigated the factors determining teachers' difficulties in using and disseminating new technologies; however, few have specifically addressed mathematics teachers in Italian secondary schools; this study is one of them.

Mathematics demands precision, structured reasoning, and the development of problem-solving skills, and technology can have two sides: support and holdup [7]. Unlike other subjects where ICT may serve a more general function, technology integration must align with the cognitive demands in mathematics. It requires students to engage with abstract concepts, formal proofs, and symbolic reasoning, which present distinct challenges when mediated through digital tools.

For example, dynamic geometry software offers significant potential by enabling students to visualise complex geometric transformations and interact with mathematical models in real-time [8]. These tools, which include software like GeoGebra, allow students to explore and manipulate shapes and figures, thereby developing a deeper understanding of spatial relationships. Similarly, simulations and modelling tools allow students to experiment with variables and observe how these variables may influence mathematical equations and functions, particularly in areas like algebra and calculus [5]. This interaction can significantly enhance students' problem-solving abilities and foster active learning environments [23].

However, these benefits often go together with more challenges specific to mathematics education. Teachers frequently fight with the specialised nature of software designed for mathematical instruction, such as computer algebra systems (CASs) like Mathematica, Maple, and Maxima or statistical analysis programs like the Statistical Package for the Social Sciences (SPSS), R, and Statistical Analysis System (SAS). These tools require a high degree of technical proficiency from teachers, and without adequate training or institutional support, their use can be limited [18]. If teachers are not comfortable or familiar with simple ICT tools, there is a risk that they will underutilise them or use them in ways that do not fully leverage their potential to enhance learning [17].

Thus, while technology can simplify certain mathematical processes, it can also diminish students' understanding of fundamental concepts. For instance, calculators and graphing tools can make it easier for students to perform complex calculations. However, if used excessively, they can prevent students from developing a solid understanding of the underlying mathematical principles [24]. Thus, mathematics teachers always need to carefully balance the use of technology, ensuring that it enhances rather than undermines core mathematical skills related to their students.

Another important aspect is the technostress that mathematics teachers experience as they attempt to integrate these complex technologies into their classrooms [20]. Unlike more general ICT tools, which might be easier to adapt to different subjects, mathematics technologies often require higher technical knowledge and preparation. If teachers 'get stuck' using general technology, we imagine they could feel overwhelmed when using specific technology for mathematics. It is necessary to stay updated with new software, adapt their teaching methods, and ensure their students still develop essential mathematical skills in this digital environment. This causes stress and is often exacerbated by inadequate school infrastructure and insufficient professional development opportunities, which are critical in supporting effective technology integration [21,22].

Moreover, mathematics frequently relies on step-by-step procedures and precise logical reasoning, and the structured nature of mathematics instruction can sometimes clash with the open-ended, flexible nature of digital tools, which are better suited for exploratory or collaborative learning [13]. Therefore, the challenge for mathematics teachers is not only to become proficient in using ICT but also to find ways to integrate these tools to preserve the rigour and procedural learning essential to mathematics education.

Lastly, while technology holds great promise for enhancing mathematics instruction, the challenges mathematics teachers face in using these tools are unique compared to other subjects. These include mastering specialised software, balancing technology use with the development of fundamental skills, and managing the stress associated with technological change [17,18]. Addressing these issues requires targeted professional development and greater institutional support to ensure that technology truly enhances the teaching and learning of mathematics.

This research describes the process of constructing and validating a survey on the technological difficulties of mathematics teachers in Italian secondary schools; the starting hypothesis is that these difficulties, according to Jaber & Moore (1999) [25], are influenced by sociodemographic work factors (e.g., age, gender, education level, years of teaching, and work environment characteristics) and by motivational and psychological factors capable of influencing school practices and the school environment [26], linked to the perception the teacher has of themselves and their role in the classroom [27]. The study highlighted the importance of teachers' personal commitment to significantly influence the process of ICT implementation and educational change (Teknikdelegationen, 2010, cited by [28]). The research also confirms the impact of the school context on the relationship between peers; in particular, it highlights the importance of the school manager in promoting innovative teaching methodologies regarding the pedagogical use of ICT, acting on improving teaching and the relationship between teachers, and on technical–practical innovation and technological infrastructures [21,22]; this study, according to Tamim et al. (2011) [23], also highlights that teachers' commitment to using ICT can improve students' problem-solving skills. Finally, the research revealed the difficulty teachers have in integrating new technologies into high-level activities: the reasons are believed to be related to personal resistance to change [29], lack of training and specific instructions [30], and inadequate teacher professionalisation [20].

Most of the time, the "teacher" factor, more than the technology itself, can influence its effective use in schools [31]. The school principal is an important indicator of teacher well-being as a predictive factor of teacher behaviour, motivation, dedication, and teaching practice [32].

2. State of the Art

The arrival of ICT in education, particularly since the 1980s, has resulted in a deep transformation in the teaching and learning environment, including mathematics [33,34]. Using computers, digital tools, and online resources has made it possible to reimagine and reinvent pedagogical practices, enabling new ways to engage students in problem-solving and learning. In mathematics education, the integration of ICT has been both a way of innovation and a source of new challenges since it requires teachers to adapt to technologies that are often more complex than those used in other subjects [35].

One of the key challenges for mathematics teachers is the need to align digital tools with the highly structured nature of mathematics since it relies heavily on logical reasoning, precise computations, and symbolic representation, all of which require tools that are not just user-friendly but also technically sophisticated and more complicated. For example, dynamic geometry software like GeoGebra and advanced tools such as CAS like Mathematica or Maple provide valuable opportunities for enhancing students' understanding of abstract mathematical concepts. On the other side, the learning curve related to these tools can be complicated, and without adequate professional development, many teachers struggle to implement them effectively in the classroom [24,36].

Despite all efforts to increase the availability of technological resources in schools, a considerable barrier remains regarding the professional development required to equip mathematics teachers with the necessary skills to use ICT effectively. Many report insufficient training in specific digital tools tailored to the subject [18]. This lack of training is further complicated by technostress [19]. Mathematics teachers, in particular, may experience higher levels of technostress due to the complexity of the tools they are expected to master and the pressure to ensure that this technology enhances rather than diminishes students' understanding of core mathematical principles [20].

The research has shown that teachers' attitudes and beliefs towards technology significantly influence their ability to integrate ICT into their classrooms [21]. This is particularly important for mathematics teachers, as introducing technology often requires a shift from traditional teaching methods to more interactive, student-centred learning environments. This shift is challenging for a long time, as it requires teachers to dominate new tools and rethink their approach to teaching mathematical concepts. Studies have demonstrated that teachers who are more comfortable with ICT tend to use it more effectively to foster problem-solving skills in their students [18,23].

However, resistance to change has remained a giant barrier, and many mathematics teachers express concerns that over-reliance on technology could undermine students' ability to perform basic calculations or solve problems manually [37]. This concern is particularly pronounced while using calculators and graphing tools, which can simplify complex computations but may also discourage students from developing a deeper understanding of the underlying mathematics. Teachers must, therefore, find a balance between using technology to enhance learning and ensuring that students still engage in critical, manual problem-solving processes [23,24].

Additionally, institutional support is crucial in determining how effectively mathematics teachers can integrate ICT into their classrooms. Research highlights that school leaders who prioritise technological innovation and provide appropriate support, including time for professional development and collaboration with peers, significantly improve teachers' ability to use ICT effectively [21,22]. Without such support, even the most motivated teachers may have problems incorporating ICT to enhance students' learning experiences.

2.1. National Digital Development Plans in Italy and the Digital Economy and Society Index

School policies significantly influence teachers' use of information technology in the classroom [38]; since the 1980s, significant investments have been made to enrich Italian schools with state-of-the-art technological equipment, directly involving teachers and influencing their attitudes and methodological conceptions [39]; since 1985, a series of initiatives in line with the dictates of the European Commission, supported by the Government and the Ministry of Education, as well as increasing economic investments such as "PNI2", "PSTD", "eEurope", "ForTic", and finally in 2015 the "PNSD" [33] have involved the school system at different levels to develop the implementation of new technologies in pedagogical and organisational processes in schools and improve the digital skills among Italian teachers [34,35]. Despite the enormous economic investments in technology, more than half of Italians still highlight the lack of basic digital skills, and the level of digitalisation certified by the Digital Economy and Society Index 2022 (DESI 2022) places Italy 18th among EU countries [36]. According to Das (2019) [5], greater economic investments are needed to promote the integration of ICT in the school context by improving structures, expertise, training, and the digital skills of Italian teachers; some authors [24,34], however, argue that although the availability of digital resources in schools has increased, not all expected benefits have always been achieved.

2.2. Curricular Reform and ICT Planning in Teaching Activities

The need to integrate ICT into the school context has led to a curricular reform requiring schools to create a unique method capable of supporting the generation of ICT curriculum for each year or phase, starting from the iteration of general operations on information and provision of suggestions on content, skills, and tools [40]; moreover, it became necessary during the planning phase of teaching activities that teachers build the necessary mechanisms for the implementation of ICT [4].

2.3. ICT and Student Outcomes

Teachers' use of information technology in the classroom positively impacts student performance [23]; these results may vary depending on the educational system, institution, and gender. Gerick et al. (2017) [41] found that the correlation between ICT and students' learning outcomes varies significantly between different educational systems; moreover, the presence does not necessarily influence the improvement in students' ICT performance or routine use [42], and number of years of ICT in schools [34,43]. A study conducted in Italian technical and vocational secondary schools observed greater use of ICT by students with lower performance due to the greater possibility offered to them to carry out personalised activities; the same study reported worse learning outcomes for males; in contrast, Meggiolaro (2018) [37] observed better results among male students in mathematics. Some studies have highlighted that the use of ICT within the educational system allows the training of technologically literate students capable of effectively competing in the labour market because they can use computers, the Internet, and other related technologies [5,44]; according to Brancaccio et al. (2015) [45], in Italy, this does not happen because digital skills and those in Mathematics and Science are insufficient.

2.4. Factors Influencing Teachers' Difficulties with New Technologies

The use of new technologies is capable of determining a change in teaching or pedagogical models and in the computer training of students (Ortega, 2014 cited by [4]), allowing the strengthening and broadening of teachers' professionalism through the acquisition of technical skills necessarily concerning the educational and didactic field [46]; the use of ICT is a complex and multifactorial phenomenon that depends on prior knowledge and skills, teachers' learning theory, and their representations of ICT [4], and is capable of influencing the perception of one's own and students' motivation [24]. Wozney et al. (2006) [47] highlight a certain variety of levels of integration of technological tools by teachers; among the factors conditioning teachers to use innovative educational practices are sociodemographic work, motivational, and psychological factors [25]. Among the main sociodemographic-work factors are age, gender, education level, socioeconomic status, years of teaching, and work environment characteristics; another important factor has been identified in the lack of adequate teacher training aimed at developing technological skills [48] capable of improving the teaching–learning process and transmitting to students the necessary tools to manage emotions and overcome problems [20]. Some authors [49] have classified motivational factors leading teachers to use technology by distinguishing between two types of barriers: external and internal. Ertmer et al. (2012) [50] highlighted that the strongest barriers preventing teachers from using technology are their attitudes and beliefs towards technology, as well as their current levels of knowledge and skills; the main causes that emerged essentially linked to personal resistance to change were the lack of time, lack of preparation, stress induced by the use of ICT, and discomfort from changing habits [29].

2.5. Value-Based Resistance to the Use of ICT and Training

Legrottaglie & Ligorio (2014) [29] detected the presence of value-based resistance from teachers to the use of ICT in teaching, being perceived as an obstacle to the development of students' reasoning and as something futuristic; Suárez-Rodríguez et al. (2018) [51] highlighted that teachers make greater personal–professional use of ICT than with students in class, using it in low-level activities (mainly basic applications) and to a lesser extent in high-level activities integrating it with lesson content and skills to be developed. The elimination of the aforementioned resistances involves training that allows the teacher to master basic ICT skills implementing them in teaching (Rodríguez, 2019 cited by [4]); teacher training should involve, on the one hand, the most competent teachers to socialise their knowledge with the less competent through ad hoc activities; on the other hand, it should teach the use of innovative tools for designing educational activities such as gamification platforms to induce meaningful learning in students through playful activities [4].

Approaching new technologies with curiosity, without fear or scepticism, Legrottaglie & Ligorio (2014) [29] determined the advantage of better understanding students' needs, promoting deep learning [52].

2.6. ICT and Teachers' Personal Well-Being

The rapid changes due to the introduction of new technologies in the educational field have led to an increase in the amount of work to be done by teachers, causing chronic fatigue for many of them, which has turned into work-related stress; the specialised literature describes this phenomenon as "technostress" and "burnout syndrome". Maslach (1999) [53] highlighted that prolonged exposure to chronic stressors at work leads to "burnout," a state of emotional, physical, and mental exhaustion [54] that is detrimental to individual workers and the organisation employing them because exhausted workers negatively impact service quality [55,56]. In education, burnout is linked to productive teaching and learning environments [57]; when teachers feel overwhelmed by the demands of their work and believe they do not have sufficient resources to meet these demands successfully, they are at greater risk of burnout [58]. Technostress and burnout syndrome are reduced when teachers have higher levels of pedagogical and technological knowledge [59].

3. The Research

This study adhered to strict ethical guidelines throughout the data collection process. All participants who responded to the questionnaire provided informed consent before their participation. Before any data were collected, each participant was required to review and accept a formal consent form outlining the study's purpose, their rights, and how their data would be used. The data were collected anonymously to ensure the privacy and protection of the participants.

To obtain a general picture of teachers' difficulties in using and disseminating new technologies, a survey study was conducted, particularly a sample of mathematics teachers from Italian secondary schools. The research tool was a questionnaire composed of 54 questions preliminarily tested on a pilot sample of 45 mathematics teachers from vocational secondary schools in Sicily and Veneto and then administered to the rest of Italy's regions to 557 mathematics teachers of the same level. The process that determined the structural model was based on empirical data and the theoretical assumption that the technological difficulties of mathematics teachers in Italian secondary schools are conditioned by personal beliefs [17] and the obstacles posed by the relational, technical, didactic, and practical school context [18]. The full study is reported below.

3.1. The Preliminary Study

The preliminary study by [33] investigated mathematics teachers' difficulties in using and disseminating new technologies in vocational secondary schools in Sicily and Veneto, identifying their attitudes and behaviours. Data were collected by administering an anonymous questionnaire composed of 54 ad hoc questions created from existing questionnaires [60–63]. The questions gathered information on the perception of (a) one's didactic-relational and digital skills of low/high level; (b) students' problem-solving abilities; (c) one's own stress level; (d) one's own effectiveness in relationships with various components of the educational environment (students, management, colleagues, school staff, educational institution, families); (e) satisfaction within the reference school context. The preliminary study essentially confirmed the importance of personal beliefs [17] and the obstacles posed by the school context from a relational, technical, didactic, and practical point of view [18] capable of improving student learning.

3.2. The Questionnaire

3.2.1. The Different Sections

The questionnaire was divided into 10 sections; the 54 questions rigorously considered the factors that influence integrating new technologies into teaching activities (identified in

Sections 2.4 and 2.5) and teachers' personal well-being (Section 2.6). In detail, the sections are composed as follows (section nos. 2 to no. 6 are shown in Table 1).

Table 1. Questions nos. 1 to 13 (Sociodemographic Characteristics) are divided into sections (2 to 6).

Questionnaire Section Number	Initial Question Number	Questions
2	1	Indicate gender
	2	Indicate year of birth
	3	Indicate nationality
	4	Indicate marital status
	5	Indicate the number of children
	6	Indicate the total number of family members in your household
	7	Indicate your employment status
	8	Indicate how many years you have been teaching in a school context
	9	Is the place of employment located in one of the following regions?
3	10 (*)	Does the region where your workplace is located match your region of origin?
4	11 (*)	Do you intend to return to work in your region of origin?
5	12 (*)	Does the region where your workplace is located match your region of origin?
6	13 (*)	Do you intend to return to work in your region of origin?

(*) Questions no. 10 and no. 12 are the same, as are no. 11 and no. 13; respondents answered the pair of questions 10 and 11 if the place of employment indicated in request no. 9 was located in a northern Italian region, while they answered questions 12 and 13 if the response given to question no. 9 was a southern Italian region; no respondent found themselves in the ambiguity of answering all four questions from no. 10 to no. 13.

- Section 1: contains the name, subject, purposes, and instructions for completing the questionnaire and identifies the proposed topics;
- Sections 2 to 6: contain 13 questions extracted from the University of Bergamo questionnaire "The impact of the COVID-19 pandemic on schools: teachers' point of view" [60] and adapted ad hoc; they aim to collect sociodemographic work data (sections 2 and 3) and qualification data (sections 4, 5, and 6) to determine the relationship during the data processing phase with the difficulties posed by new technologies;
- Section 7: derives from the Maslach Burnout Inventory—Educator Survey (MBI-ES) [61] and was adapted ad hoc by eliminating some questions considered irrelevant or redundant; it collects data on stress related to teaching mathematics with new technologies and aims to measure teachers' burnout level. Responses were given on a 5-point Likert scale (from "none" to "a lot");
- Sections 8 to 10: contain questions derived from the University of Bergamo questionnaire "The impact of the COVID-19 pandemic on schools: teachers' point of view" [60], and only section 10 also extracted from the "INVALSI Test – Q-Teacher Methodological Note_17_18" [62]; these questionnaires were adapted ad hoc by eliminating questions considered irrelevant or redundant regarding the investigated aspect. Responses were given on a 5-point Likert scale (from "none" to "a lot"). In particular:
- Section 8 collects data related to the teachers' perceptions of their relationship with students or, in other words, the teachers' beliefs about their own pedagogica–didactic abilities;
- Section 9 collects data related to some personal beliefs of the teachers, such as perceived effectiveness in using new technologies in applied teaching practices and concerning teaching methods;
- Section 10 collects data related to the perception of the relationship with the various components of the school context and the technical–practical obstacles it generates.

3.2.2. Questionnaire Questions

Below are the 54 questions of the questionnaire used in the two studies, conveniently divided into two tables: Table 1 contains questions no. 1 to no. 13, divided into 6 sections, useful for collecting data on the sample's sociodemographic and professional characteristics;

Table 2 contains the remaining 41 questions, divided into 4 sections, showing both the initial numbering related to the preliminary study (no. 14 to no. 54) and the adapted numbering (Q1 to Q41) for the second part of the study. Questions no. 1 to no. 13 were not included in the analysis to identify the factors to avoid excessive complexity of the model.

Table 2. Questions from no. 14 to no. 54 divided into sections and new numbering.

Section Number	Initial Question Number	Adapted Question Number	Text of the Question
7	14	Q1	I feel tired when I go to school in the morning.
	15	Q2	I am enthusiastic about my job.
	16	Q3	My professional commitment feels heavy.
	17	Q4	I feel increasingly indifferent to my students' problems over time.
	18	Q5	Thanks to my efforts, the quality of my teaching has improved.
	19	Q6	During my work, I can reassure those around me.
	20	Q7	My work consumes my emotional and physical energy.
	21	Q8	By the end of the workday, I am completely exhausted.
	22	Q9	I feel that my work allows me to maintain a positive relationship with my students.
	23	Q10	I can handle problems that arise in the school environment.
	24	Q11	I come home at the end of a workday with a sense of achievement.
	25	Q12	I am often too tired to help solve my students' problems.
	26	Q13	My attitude towards some of my students lacks empathy.
	27	Q14	I am able to create a school environment conducive to learning.
	28	Q15	Being a teacher has made me lose sensitivity in interacting with others.
	29	Q16	Facing others in the workplace feels increasingly exhausting.
8	30	Q17	I find it challenging to motivate students who show little interest in online work.
	31	Q18	I have difficulty controlling disruptive behaviour among students.
	32	Q19	I can provide alternative explanations or examples when students ask.
	33	Q20	I help students evaluate online learning.
	34	Q21	I use computers to increase asynchronous exchanges between students in online courses
	35	Q22	I search online for links and resources to share with students in a course.
	36	Q23	I use my computer to process texts, conduct internet searches, and communicate via email.
9	37	Q24	I have difficulty effectively using new technologies in teaching due to limited time.
	38	Q25	The high technical requirements needed to teach with new technologies cause me stress.
	39	Q26	I feel pressured to change my teaching habits to meet current needs related to new technologies.
	40	Q27	I do not feel adequately prepared to manage complex situations that arise with distance education.
10	41	Q28	The school principal advocates for the use of new technologies.
	42	Q29	The school principal values both individual and group commitment.
	43	Q30	Families actively collaborate in the school's educational activities.
	44	Q31	The school supports the training needs of its teachers.
	45	Q32	The technological equipment in the school is adequate for teaching needs.
	46	Q33	The school organises internal discussions about teaching methodologies.
	47	Q34	The school promotes the exchange of materials useful for teaching.
	48	Q35	The school encourages the joint design and exchange of teaching materials.
	49	Q36	I am satisfied with my institute.
	50	Q37	The salary I receive is adequate.
	51	Q38	Relationships with colleagues are based on collaboration to define goals and objectives.
	52	Q39	Relationships among colleagues are based on mutual respect.
	53	Q40	Teachers in my school are able to experiment with innovative teaching methods.
	54	Q41	The skills development projects proposed by the school positively impact teachers' work.

3.3. Data Processing and Results of the Preliminary Study

Processing the responses to questions Q1 to Q41 allowed the preliminary study to identify 11 factors; some items were reversed to ensure that all results went in the same direction, meaning the higher the number, the greater the satisfaction/interest/preparation; internal consistency measured through Cronbach's alpha coefficient ranged from acceptable to very good, except in the two dimensions "Teacher's self-perception about colleagues and people" and "Teaching skills", for which it was unacceptable [33]. After conducting exploratory and confirmatory analysis, expanding the study to a sample of 557 teachers allowed us to resolve the problem of internal consistency.

The preliminary study results substantially confirmed the importance of personal beliefs [17] and the obstacles posed by the school context from a relational, technical, didactic, and practical perspective [18], capable of influencing and improving students' learning.

4. Subsequent Study (Sample of 557 Teachers)

New Factors

To allow the validation of the questionnaire, it was necessary to solve the problem of internal consistency related to the factors "Teacher's self-perception in relation to colleagues and people" and "Teaching skills" that emerged in the preliminary study. To do this, it was decided to expand the participation to mathematics teachers from all Italian secondary schools; authorisation was then requested from school principals to administer the 54-question questionnaire in their schools anonymously. At the end of the survey, the number of participating mathematics teachers was 557.

The factors identified in the preliminary study were reformulated using the principal components method; this resulted in the nine factors FA1 to FA9 listed in Table 3. The items of the questionnaire were redistributed from Q1 to Q41, as indicated in the same table. Conducting exploratory and confirmatory analyses resolved the internal consistency issue noted in the preliminary study.

Table 3. List of new factors and their correspondence with questionnaire questions.

Factors	Corresponding Questions
FA1 Development of the School Context	Q28, Q29, Q31, Q32, Q33, Q34, Q35, Q36, Q40, and Q41
FA2 Personal Commitment in the School Context	Q2, Q5, Q6, Q9, Q10, Q11, and Q14
FA3 High-Level Digital Skills	Q24, Q25, Q26, and Q27
FA4 Didactic-Relational Skills	Q17, Q18, Q19, and Q20
FA5 Self-Perception of Work Stress	Q1, Q3, Q7, and Q8
FA6 Students' Problem-Solving Skills	Q4, Q12, Q13, and Q15
FA7 Low-Level Digital Skills	Q21, Q22, and Q23
FA8 Relationship with Colleagues	Q16, Q38, and Q39
FA9 Satisfaction with school and family	Q30 and Q37

5. Results

5.1. Sociodemographic–Work Characteristics of the Sample: Data Analysis

Table 4 summarises the sociodemographic–work characteristics of the sample developed through the first 13 questions of the questionnaire; as mentioned, they did not analyse the factors affecting the use of new technologies by mathematics teachers in Italian secondary schools.

In Table 4, we see that most surveyed teachers are women (65.7%, n = 366), and almost all respondents are of Italian nationality. This percentage aligns with the updated 2021 figure of 35.6% of male teachers in Italian secondary schools [63] (p. 431). Age ranges from a minimum of 24 to a maximum of 66 years, with an average of 48.93 years and a standard deviation of 10.631 years. Most teachers are in a marital union (62.1%, n = 346), and the majority have one or two children (52.6%, n = 293). The household is mostly composed of three or four members. Concerning professional status, most have a permanent contract, (81.3%, *n* = 453), and 80.4% (*n* = 448) work in their region of origin. Of the 109 respondents who do not work in their region of origin, 20.2% (*n* = 22) want to return to their region. As for years of service, 55.7% (*n* = 310) have been teaching for over 15 years. Almost all teachers have a degree. Graduation grades are concentrated between 90 and 109 points. Regarding the region where they work, 65.0% (*n* = 362) are in Northern Italy, and the remaining 35.0% (*n* = 195) are in Southern Italy.

Table 4. Sociodemographic and professional characteristics of the survey respondents.

Characteristics		***n***	**%**
Gender	Female	366	65.7
	Male	191	34.3
Nationality	Italian	554	99.5
	Other	3	0.5
Age	Minimum = 24; maximum = 66; mean = 48.93; standard deviation = 10.631		
Marital status	Single	311	37.9
	Married	346	62.1
Children	Zero children	207	37.2
	One child	116	20.8
	Two children	177	31.8
	More than two children	57	10.2
Family members in household	One	92	16.5
	Two	96	17.2
	Three	146	26.2
	Four	168	30.2
	More than four	55	9.9
Professional status	Teacher with a fixed-term contract	98	17.6
	Teacher with a permanent contract	453	81.3
	Teacher with a different contract	6	1.1
Teaching in a school context	0 to 2 years	27	4.8
	3 to 8 years	157	28.2
	9 to 14 years	63	11.3
	15 to 20 years	75	13.5
	21 to 27 years	93	16.7
	28 to 34 years	99	17.8
	Greater or equal to 35	43	7.7
Working in their region of origin	No	109	19.6
	Yes	448	80.4
Wants to work in their region of origin	No	87	79.8
	Yes	22	20.2
Education level	Degree	555	99.6
	Diploma	2	0.4
Graduation Degree/Diploma	Between 60 and 79	5	0.9
	Between 80 and 89	21	3.8
	Between 90 and 99	125	22.4
	Between 100 and 109	244	43.8
	Between 110 and 110 with honours	162	29.1
Birthplace	Southern Italy	195	35.0
	Northern Italy	362	65.0

5.2. Data Analysis Procedures for Evaluating the Psychometric Properties of the First-Order Latent Variables of Service Quality

Amos software (v.22 SPSS Inc., Chicago, IL, USA) was used to analyse the measurement and structural models using the maximum likelihood method applied to the original items. To prepare the data for analysis, univariate normality was studied using measures of skewness and kurtosis, identifying possible outliers and eliminating values that cause noise. The obtained results were considered in the fit analysis: for the Comparative Fit Index (CFI), which should be greater than 0.9; for the Parsimony Goodness of Fit Index (PGFI), which should be greater than 0.6; and for the Root Mean Square Error of Approximation (RMSEA), which should be less than 0.10 to consider the fit quality good. Also, in confirmatory factor analysis, it is appropriate to evaluate the reliability and validity of measurement instruments. The instrument's reliability refers to the property of consistency and reproducibility of the measurement [64] (p. 174). An instrument is said to be reliable if it consistently and reproducibly measures a particular characteristic or factor of interest. The Cronbach's alpha coefficient and composite reliability are used as reliability measures. The latter receives more consensus among different authors, estimating the internal consistency of the reflective items of the factor or construct, indicating that they are consistent manifestations of the latent factor. Composite reliability values greater than 0.7 indicate adequate construct reliability. For Cronbach's alpha values between 0.7 and 0.8, internal consistency is reasonable; for values between 0.8 and 0.9, the consistency is good; and for values greater than 0.9, the consistency is very good [65]. Validity is the property of the instrument or scale to measure what it is intended to measure, operationalising the latent construct being evaluated. Validity consists of three components: factorial, convergent, and discriminant. The validity of factors is usually evaluated through standardised factor loadings; if these are at least 0.5, the factor is considered to have factorial reliability. The square of the standardised factor loadings indicates the individual item reliability; this is appropriate if the obtained value is at least 0.25. Convergent validity occurs when the items reflect a factor, i.e., they are highly saturated in that factor, meaning the behaviour of the items is essentially explained by that factor. This validity is evaluated through the Average Variance Extracted (AVE); if this value is at least 0.5, there is adequate convergent validity. In turn, discriminant validity evaluates whether the items reflecting a factor are not correlated with other factors.

5.3. Evaluation of the Psychometric Properties of the First-Order Latent Variables of Store Image Perception

The absolute values of skewness and kurtosis fall within the limits proposed by Kline (2005) [66] for all constructs, allowing the assumption of normality; therefore, according to Marôco (2010) [64], given a set of variables that present a univariate normal distribution, the conditional distribution of the variables is also multivariate normal. The estimated model fits well according to fit quality indicators: CFI = 0.876; PGFI = 0.730; RMSEA = 0.055 (Figure 1).

For the measurement model, convergent validity, composite reliability (CR), and average variance extracted (AVE) were calculated. Concerning the reliability of the constructs, the CR values range between 0.776 and 0.947, exceeding the acceptable threshold of 0.7, except for dimension FA9. However, given its importance for analysing the respondents' opinions, we did not eliminate it from the model. Reliability measured by Cronbach's alpha coefficient is also an indicator of good results in dimensions FA1 to FA7, acceptable in FA8, and unacceptable in FA9. As for the individual item reliability, the standardised coefficients show values greater than 0.5 (Table 5), translating into factorial reliability, except for items Q1*, Q15*, and Q16*, whose values are close, and the Q37 coefficient of FA9, which is notably low but has been maintained. The square of the standardised factor loadings indicates the individual item reliability; this is appropriate if the obtained value is at least 0.25, which is verified for all items in this study except those already mentioned (Table 5). Convergent validity is evaluated using the average variance extracted (AVE), which should be at least 0.5.

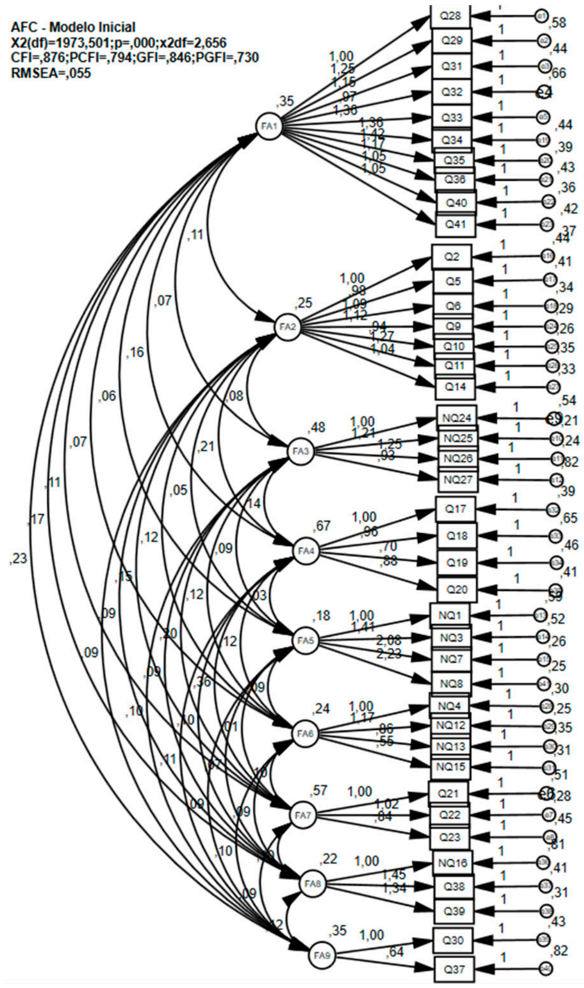

Figure 1. Proposed model.

Table 5. Statistics of the proposed model.

Items for Each Construct	SE	SE2
FA1 Development of the School Context		
Q28	0.632 ***	0.399
Q29	0.696 ***	0.484
Q31	0.717 ***	0.514
Q32	0.578 ***	0.334
Q33	0.771 ***	0.594
Q34	0.791 ***	0.626
Q35	0.787 ***	0.619
Q36	0.757 ***	0.573
Q40	0.691 ***	0.477
Q41	0.713 ***	0.508
FA2 Personal Commitment in the School Context		
Q2	0.604 ***	0.365
Q5	0.610 ***	0.372
Q9	0.616 ***	0.379
Q10	0.622 ***	0.387
Q11	0.628 ***	0.394
Q14	0.634 ***	0.402

Table 5. *Cont.*

Items for Each Construct	SE	SE2
FA3 High-Level Digital Skills		
Q24	0.686 ***	0.471
Q25	0.686 ***	0.471
Q26	0.869 ***	0.755
Q27	0.581 ***	0.338
FA4 Didactic–Relational Skills		
Q17	0.796 ***	0.634
Q18	0.699 ***	0.489
Q19	0.647 ***	0.419
Q20	0.747 ***	0.558
FA5 Self-Perception of Work Stress		
Q1	0.486 ***	0.236
Q3	0.639 ***	0.408
Q7	0.865 ***	0.748
Q8	0.885 ***	0.783
FA6 Students' Problem-Solving Skills		
Q4	0.670 ***	0.449
Q12	0.756 ***	0.572
Q13	0.582 ***	0.339
Q15	0.436 ***	0.190
FA7 Low-Level Digital Skills		
Q21	0.726 ***	0.527
Q22	0.825 ***	0.681
Q23	0.686 ***	0.471
FA8 Relationship with Colleagues		
Q16	0.458 ***	0.210
Q38	0.727 ***	0.529
Q39	0.743 ***	0.552
FA9 Satisfaction with school and family		
Q30	0.668 ***	0.446
Q37	0.384 ***	0.147

SE—Standardised coefficients (factor weight); SE2—Square of standardised coefficients; ***—$p < 0.001$.

In Table 6, it can be observed that the lowest AVE value was 0.5 in dimension FA6, thus ensuring adequate convergent validity.

Table 7 presents a description using statistical size measures. It should be noted that theoretically, the expected average value is two, so the results reported above reveal respondents' satisfaction/agreement/knowledge. Analysing the mentioned table, we observe that in the dimensions FA6 3.50 ± 0.522, FA3 3.02 ± 0.836, FA2 2.89 ± 0.584, and FA8 2.81 ± 0.716, the obtained results are, on average, the highest. For FA9, the interviewed teachers are dissatisfied (1.25 ± 0.740).

The box plots and quartiles (Figure 2) reinforce the importance of FA6 and FA3 and the dissatisfaction with FA9.

Table 6. Reliability and Validity Measures, Correlations between the Dimensions of the Proposed Scale.

	Alpha	CR	AVE	FA1	FA2	FA3	FA4	FA5	FA6	FA7	FA8	FA9
FA1	0.912	0.947	0.642	**0.801**								
FA2	0.851	0.858	0.501	0.381 ***	**0.708**							
FA3	0.835	0.871	0.633	0.172 ***	0.226 ***	**0.796**						
FA4	0.813	0.883	0.654	0.340 ***	0.500 ***	0.253 ***	**0.809**					
FA5	0.810	0.880	0.659	0.236 ***	0.214 ***	0.307 ***	0.088	**0.812**				
FA6	0.708	0.793	0.499	0.246 ***	0.491 ***	0.342 ***	0.294 ***	0.450 ***	**0.706**			
FA7	0.784	0.868	0.687	0.244 ***	0.400 **	0.380 ***	0.582 ***	0.042	0.259 ***	**0.829**		
FA8	0.658	0.776	0.546	0.612 ***	0.407 ***	0.288 ***	0.254 ***	0.334 ***	0.392 ***	0.281 ***	**0.739**	
FA9	0.406	0.539	0.385	0.659 ***	0.298 ***	0.255 ***	0.236 ***	0.363 ***	0.342 ***	0.211 ***	0.454 ***	**0.621**

CR—Composite reliability; AVE: Average variance extracted; The diagonal values (in bold) correspond to the square root of the AVE, and the remaining values correspond to the correlations between the constructs. ***—$p < 0.001$; ** $p < 0.01$.

Table 7. Characterisation of dimensions.

Measure	Minimum	Maximum	Mean	Deviation Error
FA1 Development of the School Context	0.30	4.00	2.25	0.731
FA2 Personal Commitment in the School Context	1.17	4.00	2.89	0.584
FA3 High-Level Digital Skills	0.00	4.00	3.02	0.836
FA4 Didactic-Relational Skills	0.00	4.00	2.31	0.806
FA5 Self-Perception of Work Stress	0.00	4.00	2.24	0.787
FA6 Students' Problem-Solving Skills	0.50	4.00	3.50	0.522
FA7 Low-Level Digital Skills	0.00	4.00	2.76	0.809
FA8 Relationship with Colleagues	0.00	4.00	2.81	0.716
FA9 Satisfaction with school and family	0.00	4.00	1.25	0.740

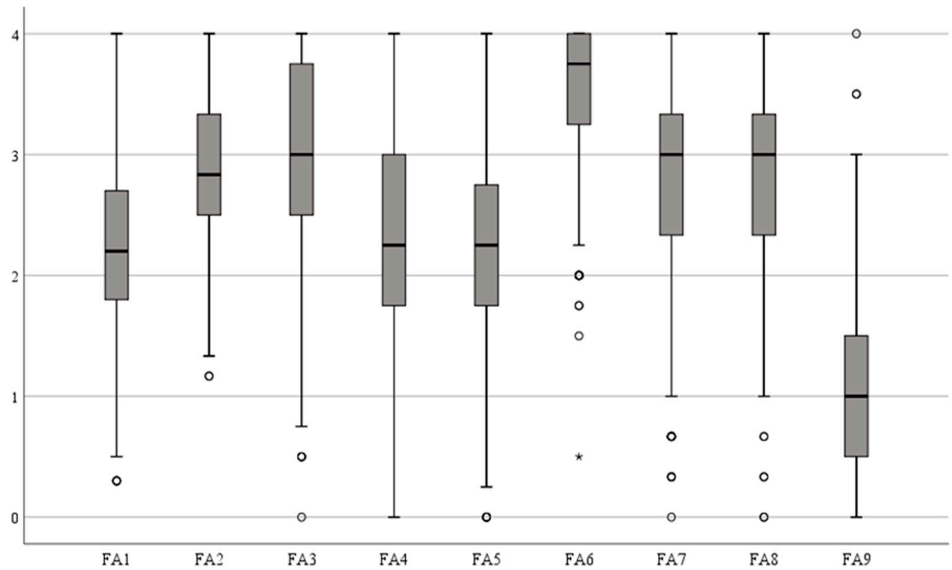

Figure 2. Box plots and quartiles of the dimensions.

6. Discussion

The research used quantitative methods for data analysis because they could simplify social reality [67]. Despite the loss of information due to the reduction of complexity, these methods allowed us to focus on some particular aspects of interest for this research.

This study did not aim to identify the teaching style of the interviewed teachers nor investigate how teachers could improve the way students work through ICT. Therefore, the study does not investigate the influence of ICT use on the teaching–learning process. On the other hand, it can be assumed that personal teaching theories and levels of ICT competence interact with each other through personal motivation; this increases the willingness to make a greater effort to become more competent, and when competent, it increases the teacher's motivation to try new strategies and roles (Wiener, 1994, cited by [24]). According to Player-Koro (2012) [28], "When attitudes are specific to a particular behaviour and derived from experience, they are much more likely to guide behaviour". Paraphrasing this author, it could be said that "a better attitude towards the use of ICT accompanied by greater experience with ICT can drive the use of ICT itself".

In general, most teachers highlighted positive aspects regarding using ICT within the school context to support teaching activities and foster relationships with colleagues. However, the study does not seem to confirm the dominant view that introducing ICT in schools globally changes how teaching is conducted and what happens in the classroom. The causes could be sought in a strong critical attitude towards its use and the reluctance to abandon traditional teaching.

The research has highlighted some factors influencing difficulties with new technologies where the results, on average, are higher: "Personal Commitment in the School Context" (Factor FA2), "High-Level Digital Skills" (Factor FA3), "Students' Problem-Solving Skills" (Factor FA6), and "Relationship with Colleagues" (Factor FA8). The characterisation of the dimensions (see Table 7) confirmed the considerable importance of factors FA3 and FA6, also highlighting the teachers' dissatisfaction with the school institution and families (Factor FA9). In particular, the study highlighted the effort made by teachers in integrating new technologies into their teaching process. However, conversely, in agreement with Suárez-Rodríguez et al. (2018) [51], this effort often translated into using ICT as a tool to support low-level teaching activities (Factor FA7). Indeed, Table 7 confirms the difficulty teachers have in using ICT in high-level activities (Factor FA3). According to Legrottaglie & Ligorio (2014) [29], the main causes that emerged, essentially related to personal resistance to change, were lack of time, lack of preparation, stress induced by the use of ICT, and discomfort with changing habits.

Despite the initiatives carried out over the past 40 years at the national and local levels in Italy to promote the dissemination of new technologies in the school context, the level of ICT training among mathematics teachers has not been homogeneous due to different epistemological and pedagogical visions and skills of teachers [24]. It is reasonable to think that teachers' classroom behaviour affects how students use ICT and positively impacts students' performance [23]. The research, in particular, highlighted that greater mastery of ICT skills by the teacher can influence the improvement of students' problem-solving skills (Factor FA6).

This study, in agreement with Teknikdelegationen (2010), cited by [28]), highlighted that the teacher's personal commitment (Factor FA2) is capable of significantly influencing the ICT implementation process and significant educational changes that help improve the school context (Factor FA1) and maintain a climate of respect and collaboration with colleagues (Factor FA8).

The initial theoretical model identified a correlation between factors FA1: "Improvement of the School Context" and FA8: "Relationship with Colleagues", highlighting that a climate of mutual respect and collaboration among colleagues can facilitate the dissemination and use of new technologies. This can be the subject of further research. Moreover, considering the need for many teachers to receive specific ICT training from more experienced colleagues [24], factor FA8 could indicate the quality of ICT training activities.

The initial structural model (Figure 1) also highlighted a strong correlation between "Improvement of the School Context" (Factor FA1) and "Satisfaction with the School Institution and Family" (Factor FA9). According to the theoretical framework [21,22], the research confirms the importance of the school principal in influencing the pedagogical use of ICT by teachers and in helping technical–practical innovation by promoting innovative teaching methodologies [21]. Even the mere feeling of receiving sufficient support from the school principal during work with ICT could improve teachers' willingness to become more competent [24]. Although not supported by specific data, the research tends to confirm that school leadership could be considered a predictive factor of teachers' behaviour, motivation, dedication, and teaching practice [32].

The study highlighted some critical issues related to the individual reliability of items Q1*, Q15*, Q16* and Q37. For items Q1*, Q15*, and Q16*, in the absence of specific data, we can hypothesise the influence on the responses given by personal work stress that teachers, on average, tend to ignore or minimise. For question Q37, it should be noted that the average salary of an Italian teacher is among the lowest in Europe [68], and that, particularly in the early years of their teaching career, it is very close to the poverty line [69]. This may explain the dissatisfaction with the school institution and the families of teachers (Factor FA9).

7. Implications for the Future

Based on our research, it appears that a similar survey has never been conducted and that the developed questionnaire has never been used. Therefore, this study provides initial results. This research contributes to advancing current knowledge about the factors that influence the use of new technologies by secondary school mathematics teachers in Italy, helping to identify those that negatively impact their well-being in the work environment.

The survey instrument used in this study could provide ideas to institutional bodies in each country dealing with education on how to improve teachers' working conditions in the school context.

8. Conclusions

The research aimed to investigate the technological difficulties Italian secondary school teachers face, focusing on the area of mathematics and their broader implications for integrating ICT into educational practices. The findings highlight several factors, including the importance of high-level digital skills, teachers' personal commitment, and the role of institutional support in overcoming these challenges. These results align with previous studies that emphasise the centrality of teachers' digital competence and the supportive role of school leadership in successfully integrating ICT in schools [21,22].

Some critical issues related to the individual reliability of questions Q1* of factor FA5, Q15* of factor FA6, Q16* of factor FA8, and Q37 of factor FA9 emerged and should be explored in more detail.

Specifically, the study underlines that technological integration has unique challenges in mathematics education. As a subject that requires precision, abstraction, and problem-solving, mathematics will demand tools and software that are often more complex than the ones used in other subjects. Thus, the starting point of the investigation process was with mathematics teachers. They must move forward, not only with the general challenges of ICT adoption but also with specific technologies such as computer-based simulations, dynamic geometry software, and other mathematical modelling tools [23,30]. Integrating these technologies into the mathematics classroom can simplify a deeper understanding of abstract concepts. Yet, the findings suggest that many teachers still face difficulties while using general ICT effectively, which could result in more complicated problems if we move to the specific use of ICT mathematics tools. These difficulties are often connected to inadequate training, time constraints, or resistance to changing traditional teaching methods [31].

The study confirmed that the dissemination of ICT in the school context is conditioned by the teacher's personal beliefs [17] and by the obstacles posed by the school context from relational, technical, didactic, and practical perspectives [18].

Although 40 years have passed since the introduction of the first computer in an Italian school, and despite the considerable investments made to increase the use of technology, the full integration of ICT into mathematics teaching activities is still far from being achieved due to internal and external factors that negatively influence the implementation of high-level activities by teachers. It would be advisable to effectively address contextual variables by updating teachers with the help of more experienced colleagues, making significant changes with the support of the school principal, and providing more adequate financial treatment.

The strongest barriers preventing teachers from using technology are their attitudes and beliefs towards technology and their current levels of knowledge and skills [50]. If we do not act accordingly, it will be difficult to change their traditional way of teaching.

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