Investigating Technological Mathematical Knowledge Within the TPACK Framework: A Case Study of Syrian Math Teachers

تقصي المعرفة التكنولوجية الرياضياتية ضمن إطار TPACK: دراسة حالة معلمي الرياضيات السوريين

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ABSTRACT

Teachers are the backbone of the educational process. Therefore, many studies have investigated their technological and pedagogical content knowledge (TPACK) framework. This study aims to classify Syrian mathematics teachers' technological mathematical knowledge (TMK), which we define as (the knowledge of educational technologies hardware and software along with how to use them to represent, explain, solve and explore mathematical content, ideas or issues regardless of the educational pedagogy). Moreover, to assess the impact of demographic variables. A 24-item Likert scale survey was conducted using Google Forms with a random sample of 219 in-service secondary math teachers from Damascus City. The findings revealed that Syrian math teachers' TMK classification is below average, with the highest percentage of knowledge related to smartphones and their mathematical applications. The results also showed significant differences ($p < 0.05$) in teachers TMK based on gender in favor of the male group, significant differences based on academic qualifications in favor of the Master's degree group, significant differences based on training courses in favor of the MOOCs group, significant differences based on years of experience in favor of less experienced teachers and differences between the ADSL Network and the 3G/4G Network in favor of ADSL Network. Based on the findings, we recommend that the education ministries develop integrated teacher training programs to properly prepare teachers to deal with crises such as wars or pandemics. These programs should focus on developing teachers' skills in using modern mathematical software, the mathematical applications of smartphones and employing social media platforms and distance learning platforms in mathematics education. These programs can be extended to cover other educational materials.
Keywords: Math Teachers, Technological Mathematical Knowledge, Moocs.

الملخص

المعلمون هم العمود الفقري للعملية التعليمية ولذلك، بحثت دراسات عدةٌ في إطار معرفتهم بالمحتوى التربوي التكنولوجي KCAPT. وتهدف هذه الدراسة إلى تصنيف المعرفة التكنولوجية الرياضياتية لمدرسي الرياضيات السوريين، التي نعرَفها بأنها (معرفة التقنيات التعليمية "أجهزة وبرمجيات" وكيفية استخدامها لتقديم، شرح، حل، واستكشاف المحتوى والمفاهيم أو المسائل الرياضياتية دون التطرق إلى المنهجية التربوية). إضافة إلى تقييم أثر المتغيرات الديمغرافية. جرى استخدام مقياس ليكرت خماسياً مكوناً من 42 بنداً باستخدام نماذج جوجل مع عينة عشوائية من 219 مدرس رياضيات ثانوي في الخدمة من مدينة دمشق. وكشفت نتائج الدراسة أن تصنيف المعرفة التكنولوجية الرياضياتية لمعلمي الرياضيات في سورية هو أقل من المتوسط، مع أعلى نسبة معرفة تتعلق بالهواتف الذكية وتطبيقاتهاالرياضياتية. وأظهرت النتائج أيضاً وجود فروق ذات دلالة إحصائية عند مستوى دلالة (p= ٠,٠٥) في المعرفة التكنولوجية الرياضياتية استناداً إلى متغير الجنس لمصلحة مجموعة المعلمين الذكور، وجود فروق ذات دلالة إحصائية استناداً إلى متغير المؤهل الأكاديمي لمصلحة مجموعة المعلمين حملة درجة الماجستير، وجود فروق ذات دلالة إحصائية استناداً إلى متغير الدورات التدريبية لمصلحة مجموعة المعلمين المتبعين لدورات التعليم عبر الإنترنت، وجود فروق ذات دلالة إحصائية استناداً إلى متغير سنوات الخبرة لمصلحة مجموعة المعلمين الأقل خبرة (سبع سنين وما دون)، ووجود فروق ذات دلالة إحصائية استناداً إلى متغير الوصول إلى الإنترنت لمصلحة مجموعة المعلمين الذين يستخدمون الشبكة المنزلية (ADSL). واستناداً إلى النتائج، توصي الدراسة وزارات التعليم أن تضع برامج متكاملة لإعداد المعلمين – على نحو أفضل– للتعامل مع الأزمات مثل الحروب أو الأوبئة. ويجب أن تركز هذه البرامج على تطوير مهارات المعلمين في استخدام البرمجيات الرياضياتية الحديثة والتطبيقات الرياضياتية للهواتف الذكية واستخدام منصات التواصل الاجتماعي ومنصات التعليم عن بعد في تعليم الرياضيات. ويمكن توسيع نطاق هذه البرامج لتشمل مواد تعليمية أخرى.
الكلمات المفتاحية:معلمي الرياضيات، المعرفة التكنولوجية الرياضياتية، الدورات التعليمية الضخمة المفتوحة على الإنترنت.

INTRODUCTION

Our modern age is characterized by rapid and tremendous development in science and technology. Each learner has a smartphone and accessing the internet has become a daily need, a habit for some of us, and a source of income for others. And the development of (5G) networks has revolutionized technology and social networking for people and devices "Internet of Things". This has led to the imposition of modern requirements to prepare the individual to keep pace with the developments of this era in all the fields related to our lives. One of the most important fields is education, especially in mathematics because of its importance in the different fields of life, computer science and especially algorithms. With the advent of technology, mathematical technologies have appeared in education and proved their feasibility; the use of technological innovations in teaching math prepares learners for a High-Tech centric world and develops higher mental cognitive skills, such as problem-solving, thinking, data collecting, analysis and proof. Which fall within the scope of creativity and invention [1]. The fields of mathematical technology have diversified following the technological development of computers, mobile phones and the software used in them, in addition to other technologies such as interactive whiteboards, the spread of the Internet and the educational services and platforms it provides. Mathematicians have been able to use all these technologies in teaching mathematics. The benefits of mathematical technology are not only for students, but it also has an impact on teachers as it supports the creativity of teachers as learners and task designers and provides the opportunity to develop many new mathematical meanings [2]. Several scholars have investigated the technological pedagogical content knowledge (TPACK) for math teachers. Alternatively, a subset of them: Mailizar and Fan (2019) investigated the technological pedagogical content knowledge of Indonesian math teachers'. The study used a questionnaire, and the sample consisted of (341) math teachers. The results showed that the understanding of mathematical technology ranked low and suggested more training courses for teachers [3]. In Malaysia, Bakar, Maat and Rosli's (2020) study aimed to determine the math teacher's self-efficacy in integrating technology and (TPACK). The study used a questionnaire containing (71) items, and the sample consisted of (66) national secondary math teachers. The results showed no gender or educational experience differences [4]. In Kenya, Mukenya, Martin and Shikuku (2020) investigated the knowledge and skills of math teachers to integrate ICT into secondary school education. The study used a questionnaire, and the sample consisted of (218) math teachers and heads of departments. The results indicated that teachers need more knowledge and skills to use ICT. They suggested that the Ministry of Education should work on policies to develop teachers' ICT pedagogy and review the curriculum [5]. In Spain, the study of Gómez-García, Hossein-Mohand, Trujillo-Torres and Hossein-Mohand (2020) investigated the training and use of ICT in teaching mathematical concepts. The study used a questionnaire, and the sample consisted of (73) high school math teachers. The results showed differences in favor of teachers with less education experience and no gender differences [6]. Spangenberg and De Freitas (2019) in South Africa investigated the levels of (TPACK) and ICT integration barriers. The study used a quantitative questionnaire, and the sample consisted of (93) math teachers. The results showed poor technological content knowledge and suggested continuous professional development programs for teachers in specific ICT integration [7]. In Turkey, the study by Ozudogru and Ozudogru (2019) investigated the technological pedagogical content knowledge of math teachers. The study used a questionnaire containing (39) items, and the sample consisted of (202) math teachers. The results of the technological knowledge section showed significant differences in gender in favor of males and no differences in teaching experience or school level [8]. In addition, the study of Birgin, Uzun and Akar (2020) investigated Turkish mathematicians' perceptions of their proficiency in using ICT in teaching. The study used a descriptive survey; the sample consisted of (242) math teachers. The results showed that teachers' knowledge of mathematical software is low, and there are no gender differences. However, there are differences in favor of teachers with less experience in education in terms of efficiency [9]. In China, Tan and Jiang (2021) aimed at the mathematical technological knowledge of elementary school math teachers. The study adopted the qualitative paradigm and a sample of (24) math teachers. The results showed that the teacher's knowledge and use of technology classification are good. The previous research has yet to study the relationship between teachers' knowledge and teachers' training courses, academic qualifications, and teachers' Internet access. Accordingly, this study will contribute to filling this research gap.

Technological Mathematical Knowledge (TMK)

In 1986, Shulman came out with the (Pedagogical Content Knowledge) framework, which teachers need in terms of knowledge and tools to teach specific content. He considers educational technology a tool that facilitates teaching [11]. After the advent of E-learning and E-class design, Kohler and Mishra 2006 added technology as an independent regard of knowledge and not as a helping tool for teaching; (Technology knowledge) is the knowledge of technologies involving the skills of operating and using the old and new of them [12]. Also, they define the concept of (Technological Content Knowledge) as "an understanding of how teaching and learning can change when particular technologies are used in particular ways." [13, p 65]. Thus, Schulman's framework was expanded to (Technological Pedagogical Content Knowledge), which aims to demonstrate the necessary competencies for teachers to integrate technology with education [12]. Koehler and Mishra (2009) have embodied the framework in the "What is TPACK" study. The framework was a schematic illustrating the intersection of the three pieces of knowledge within the framework and the new knowledge resulting from its meeting with seven pieces of knowledge. As a result of the development of educational sciences and technologies, researchers [10,14,15] customized the content in the (TPACK) framework to include only mathematical content. [14] developed the Technological Pedagogical Mathematical Knowledge (TPMK) concept. [15, p 1] used the (Mathematical Technological Knowledge) concept, which they define as a "teacher's knowledge of the technology developed as a result of exploring mathematics with technology". This concept has an issue because some technologies are not just mathematical like an interactive whiteboard or Google apps. Similarly, [16, p 342] used the (Technological Mathematical Knowledge) concept, which they define as "the teacher's knowledge of technological tools that can be used to represent mathematical knowledge". However, [3, p 5] defines the broader concept of ICT-content knowledge as "knowing how to use ICT to represent, communicate, solve and explore mathematical contents, ideas, or problems without consideration of teaching approaches". Taking advantage of these definitions, this paper defines (Technological Mathematical Knowledge) as knowledge of educational technologies hardware- and software along with how to use them to represent, explain, solve and explore mathematical content, ideas or issues regardless of the educational pedagogy, " how to make a circle within a triangle using GeoGebra" [16, p 2].

Educational Technologies for Mathematics

Interactive Whiteboards:

An interactive whiteboard is a versatile tool that allows teachers to deliver engaging lessons using various applications and educational programs [17]. Studies show that it improves students' math achievement [18]. And it can benefit displaced learners in challenging environments.

Computer Algebra Systems: One of the most prominent software applications is GeoGebra. It can solve quadratic equations by graphing and accurately representing geometric transformations, statistical representation and data analysis, providing an interactive geometric environment for learners and representing shapes with a 3D environment; meanly, learning by GeoGebra improves the geometrical abilities of students [19]. In addition to its positive impact on achievement [20], it is also one of the best technological options that enriches the quality of research and mathematical conception from different perspectives that support feedback. It also provides strategies for teachers to teach according to students' needs and facilitates learning through virtual representations that represent reality and focus on educational benefits [21]. Thus, the use of GeoGebra has a significant impact on mathematical abilities [22]. Another example is Sketchpad, which combines geometry designs with algebra and calculus, curves representing descendants, then algebraic representation such as coordinates or equations and finally, a data table representation [23]. Sketchpad shares the advantage of learning through practice and developing the learner's ability to use these applications with GeoGebra on smartphones [24].

Coding language: Scratch, for example, is a straightforward and exciting initial learning tool for understanding basic programming principles, creating educational and recreational content, building mathematical and scientific projects and simulating and visualizing experiments. Not onlgy does Scratch allow for learning math in an easy, effective and exciting way, but teachers also use it to teach basic mathematical principles of arithmetic and geometry [25]. In short, Scratch is superior to other programming languages by attracting children to learn programming in the future [26].

Smartphone apps: are a form of distance learning and an extension of E-learning. Teachers can provide math content and follow learners anywhere, anytime by designing high-quality digital learning objects in math. Students can also learn mathematical content according to their circumstances and needs [27]. Moreover, the smartphone was the best technology for teachers during the COVID-19 pandemic [28]. It also supports applications such as Kahoot, a free educational program that supports many languages, such as Arabic, based on the play-and-response classroom system. It also helps students learn and self-evaluate, better demonstrate what they have learned, make math more exciting and lively, and increase motivation to learn [29].

Online Tools: The field of education has been revolutionized by two powerful types of tools. The first type is the learning management system, such as MOODLE, an open-source program utilized in over 235 countries to support the E-learning process. Particularly effective in math education, MOODLE encourages learners to engage in cognitive thinking skills and fosters the generation of new ideas [30]. The second type is online learning resources, including Massive Open Online Courses (MOOCs), which cater to both teachers and students. These resources that are available through platforms like Coursera, Alison, Udemy and others, offer high-quality content in various specialties such as mathematics, computer science and languages. MOOCs have proven to be an invaluable resource, helping teachers enhance their professional knowledge and enabling students to access a wide range of courses, including specific mathematics courses [31], through platforms like Coursera, EdX and others. These platforms provide videos that can effectively supplement classroom learning, allowing teachers to explain complex concepts more easily.

Methods

Participants

The online survey was shared in a Facebook group for Syrian math teachers. The researcher used the approval of the Ethics Committee of the Ministry of Education. Data was collected during the second

Table 1. Participants Demographic Background

Demographic Variables	Frequency	Percentage
Gender		
Female	117	53.4
Male	102	46.6
Training courses		
Technology Integration Courses	88	40.1
MOOCs	35	15.9
No Courses	96	44.0
Academic Qualification		
Master	51	23.2
Bachelor	153	69.8
Diploma	15	7.0
Years of experience		
1-7 years	62	28.31
8-14 years	84	38.39
15 years and more	73	33.3
Internet Access		
ADSL Network	90	41.09
3G/4G Network	129	58.91

Tools

The study used a questionnaire based on [3]. The validity of the study tool was confirmed by an independent T-test and the reliability was assessed with a Cronbach-Alpha coefficient value of 0.859. Its items were classified into two parts; the first included demographic information, including gender, academic qualification, years of experience, established courses and Internet access. The second part: aimed at Technological Mathematical Knowledge, consists of (3) items intended for knowledge of educational devices, (4) items aimed at general understanding of software, (4) items aimed at knowledge of computer mathematical software, (4) items aimed at knowledge of Smartphone tools, two items aimed at knowledge of online tools, (7) items aimed at mathematical technology content knowledge at levels:(strongly disagree, disagree, neutral, agree, strongly agree).

Data Analysis

In this study, the researcher used SPSS for statistical analysis, including coding responses into a five-point scale, calculating averages and standard deviations, conducting T-tests for validity, gender, and internet access, applying Cronbach's alpha for reliability, using ANOVA for comparing mean responses in the case of (Academic qualification, courses, and Years of experience), and performing Fisher's LSD test. All hypotheses were tested at a significance level of α=0.05.

RESULTS

Technological Mathematical Knowledge (TMK) of Syrian Math Teachers

Table (2) shows that the mean score of teachers› knowledge of hardware was (3.37), which is higher than the average. In addition, their mobile knowledge was higher than their computer and interactive whiteboard knowledge, and the mean score of teachers› knowledge of general software was (3.14), and the table shows that knowledge of Microsoft applications was the highest with average (3.92), the average knowledge of mathematical software was (2.53), which is below the average, dynamic applications such as GeoGebra appear as the highest mean (2.84), the mean score of mobile tools was (3.47), which is higher than the average, and social media apps show the highest mean score (3.84), the mean score of online tools was (2.70), but the mean score of using mathematical technology was (2.30), which is below the average, and the highest field of use was in geometry with an average of 2.41.

Table 2. Mean scores of participants' responses to items of TMK

Teachers' Knowledge of Educational Technologies	Mean	Standard Deviation
Knowledge of hardware		
Interactive Whiteboard	3.24	1.17
Smartphone	3.55	1.13
Computer/Laptop	3.34	1.29
Mean	3.37	
Knowledge of General Software		
Microsoft software (e.g., MS PowerPoint and Word)	3.92	1.12
Document Preparation System (e.g., LaTeX)	2.66	1.19
Google apps (e.g., Google Classroom and Forms)	3.12	1.06
Animation apps (e.g., Flash)	2.87	1.18
Mean	3.14	
Knowledge of Computer Mathematical software		
Computer Algebra Program (e.g., Mathematica)	2.79	1.18
Dynamic Mathematics Software (e.g., GeoGebra)	2.84	1.22
Dynamic Geometric Software (e.g., Cabri 3D and Sketchpad)	2.36	1.04
Coding Language (e.g., Scratch)	2.16	0.87
Mean	2.53	
Knowledge of Smartphone Apps		
Social Media Groups (e.g., WhatsApp and Facebook)	3.84	1.15
Smartphone Mathematics Software (e.g., GeoGebra and Sketchpad)	3.37	1.19
Smartphone Learning Tools (e.g., Kahoot, Monster Math)	3.26	1.08
Self-learning programs (e.g., Photomath, MalMath)	3.45	1.19
Mean	3.47	
Knowledge of Online Tools		
Learning Management System (e.g., Moodle)	2.53	1.08
Online Learning Resources (e.g., Coursera)	2.88	1.23
Mean	2.70	
Knowledge of Mathematical Technology in Teaching		
I know how to use MT in algebra (e.g., to solve equations with graphs, and explain imaginary numbers)	2.31	0.93
I know how to use MT in geometric (e.g., to Draw 3D figures, and transformations)	2.41	1.02
I know how to use MT in calculus	2.34	1.14
I know how to use MT in Statistics and Prospects	2.23	0.87
I know how to use MT in trigonometry	2.21	0.94
I know how to use MT to simulate concepts and theories	2.35	1.08
I know how to use MT to Create creative stories, games and animations	2.28	0.88
Mean	2.30	

The Effects of Demographic Variables on Technological Mathematical Knowledge

Gender differences in teachers' (TMK)

Table 3 shows the results of an independent sample t-test comparing the means of teachers' technological mathematical knowledge based on gender. The table shows that the mean score for male teachers is 3.13 and the mean score for female teachers is 2.75, the t-value is 3.922. A higher t-value indicates a larger difference between the means, the significance level of less than 0.05 is typically considered statistically significant. In this case, the significance level is 0.000, which is less than 0.05. Based on the t-test results, we can reject the null hypothesis that there is no difference between the means of technological mathematical knowledge scores for male and female teachers. So, there is a statistically significant difference between the means, with male teachers scoring higher on average than female teachers.

Table 3. Shows the results of the T-test based on the gender

Gender	Mean	Standard Deviation	T-value	Sig
Male	3.1389	0.81008	3.922	0.000
Female	2.7508	0.63260		

Academic qualification differences in teachers› (TMK)

The results of the one-way ANOVA analysis in Table 4 indicate a statistically significant difference (p < 0.05) in technological Mathematical Knowledge scores between teachers with different academic qualifications. This means that we can reject the null hypothesis that there is no difference in scores between the groups. Further analysis using the LSD test in Table 5 helps pinpoint which specific groups differ from each other. The LSD test reveals significant differences in technological proficiency scores between the following groups:

- Diploma and bachelor's degree holders (average difference: -0.25268 & Sig = 0.193)
- Diploma and master's degree holders (average difference: -0.5207 & Sig = 0.015)
- Master's and bachelor's degree holders (average difference: 0.2680 & Sig = 0.028)

The researcher concludes that there are statistically significant differences in teachers› (TMK) based on academic qualification in favor of the master's degree group. At the same time, there were no differences between the bachelor and diploma groups.

Training courses differences in teachers› (TMK)

The results of the one-way ANOVA analysis in Table 6 indicate a statistically significant difference (p < 0.05) in Technological Mathematical Knowledge scores between teachers with different training courses. This means that the null hypothesis can be rejected. The LSD test in Table 7 reveals significant differences in technological proficiency scores between the following groups:

- No Courses and Technology Integration Courses (average difference: -0.09665& Sig = 0.370)
- No Courses and MOOCs (average difference: -0.50209& Sig =0.001)
- Technology Integration Courses and MOOCs (average difference: -0.40554& Sig = 0.006)

The researcher concludes that there are statistically significant differences in teachers› (TMK) based on Training courses in favor of the MOOCs group. At the same time, there were no differences between the No Courses and Technology Integration Courses groups.

Years of experience differences in teachers› (TMK)

The results of the one-way ANOVA analysis in Table 8 indicate a statistically significant difference (p < 0.05) in Technological Mathematical Knowledge scores between teachers with different Years of experience. This means that the null hypothesis can be rejected.

The LSD test in Table 9 reveals significant differences in technological proficiency scores between the following groups:

- 7-1 years and 14-8 years (average difference: 0.48341& Sig = 0.007)
- 7-1 years and 15 years and more (average difference: 0.39751& Sig = 0.002)
- 14-8 years and 15 years and more (average difference: -0.68713& Sig = 0.280)

The researcher concludes that there are statistically significant differences in teachers› (TMK) based on Years of experience in favor of the 7-1 years group. At the same time, there were no differences between the 14-8 years and 15 years and more groups.

Internet access differences in teachers› (TMK)

Table 10 shows the results of an independent samples t-test comparing the means of teachers› technological mathematical knowledge based on Internet access. The mean score for 3G/4G Network is 2.43 the mean score for ADSL Network is 3.85, t-value is 3.734 & (p = 0.05 > 0.000). Based on the t-test results, the null hypothesis can be rejected. So, there is a statistically significant difference between the means in favor of the ADSL Network.

Table 4. Shows the results of one-way ANOVA analysis in terms of academic qualification

Variance	Sum of Squares	Mean Squares	F-value	Sig
Between Groups	4.164	2.082	3.831	0.023
Within Groups	117.386	0.543		
Total	121.550			

Table 5. Shows the results of the (LSD) test based on the academic qualification

academic qualification (I)	academic qualification (J)	Differences between averages (I-J)	Sig
Diploma	Bachelor	-0.25268	0.193
	Master	-0.52070*	0.015
Bachelor	Diploma	0.25268	0.393
	Master	-0.26802*	0.028
Master	Diploma	0.52070*	0.015
	Bachelor	0.26802*	0.028

Table 6. Shows the results of one-way ANOVA analysis in terms of training courses

Variance	Sum of Squares	Mean Squares	F-value	Sig
Between Groups	6.408	3.204	6.011	0.003
Within Groups	115.141	0.533		
Total	121.549			

Table 7. Shows the results of the (LSD) test based on the training course

Course (I)	Course (J)	Differences between averages (I-J)	Sig
No Courses	Technology Integration Courses	-0.09665	0.370
	MOOCs	-0.50209*	0.001
Technology Integration Courses	No Courses	0.09665	0.370
	MOOCs	-0.40554*	0.006
MOOCs	No Courses	0.50219*	0.001
	Technology Integration Courses	0.40554*	0.006

Table 8. Shows the results of one-way ANOVA analysis in terms of years of experience

Variance	Sum of Squares	Mean Squares	F-value	Sig
Between Groups	5.748	2.874	5.361	0.0٠5
Within Groups	115.789	0.536		
Total	121.537			

Table 9. Shows the results of the (LSD) test based on years of experience

Years of experience (I)	Years of experience (J)	Differences between averages (I-J)	Sig
1-7 years	8-14 years	0.48341*	0.007
	15 years and more	0.39751*	0.002
8-14 years	1-7 years	-0.48341*	0.007
	15 years and more	-0.68713	0.280
15 years and more	1-7 years	-0.39751*	0.002
	8-14 years	0.68713	0.280

Table 10. Shows the results of the T-test based on the internet access

Internet Access	Mean	Standard Deviation	T-value	Sig
ADSL Network	3.8512	0.74329	3.734	0.000
3G/4G Network	2.4397	0.68832		

DISCUSSION

The results of the study showed that the general knowledge about devices was slightly above average and that a higher percentage of math teachers used smartphones because they are easy to use and widely available among learners in WhatsApp and Facebook groups as indicated in [9]. This result contradicts [3], where the highest percentage was computers. However, the researcher added an interactive whiteboard instead of the graphing calculator in our study. Our study indicates that Syrian math teachers' general software knowledge ranked slightly above average. The highest percentage was Microsoft applications because they are familiar and easy to use and their training courses are easily accessible (ICDL). In this section, our findings are consistent with the results of [3, 9, 5], and add a section for smartphone applications, consistent with [33] in the excellent degree of using the WhatsApp application. Within the knowledge of mathematical software, the highest percentage was for GeoGebra. This may be due to its support for the Arabic language and its easy-to-use qualities. Besides, smartphone applications were more elevated than computer applications.

As for Internet tools, knowledge of learning resources such as Coursera was higher than knowledge of learning management systems. This result contradicts [3] during a pre-COVID-19. This difference indicates that teachers use smartphones directly as an educational tool or a learning resource in times of crisis. The results showed poor use of mathematical technologies; a possible explanation might be that teachers are not well qualified in these technologies and are not sufficiently proficient in English. Another possible explanation is that most educational technological devices are unavailable in schools because the Ministry does not provide schools with such devices, which may be due to their high cost and the difficulty of producing them locally, along with the circumstances of the war. This conclusion supports [5], which linked poor knowledge and use to the unavailability of technologies and devices in schools. On the other hand, [10] ranked the expertise and use of technology by Chinese math teachers as good and the integration of technology with education as excellent, owing to the availability of devices in Chinese schools.

Gender: There were significant differences in teachers' (TMK) based on gender in favor of the male group, and this might be due to female teachers being busy with their household duties, so they do not have time to learn or use modern technological skills, unlike male teachers who have time to learn and use new technologies. This conclusion supports [8], which explains that male students tend to be more technological than female students who want to study languages and social sciences. This result is contrary to [9, 34, 6] where they showed no gender differences.

Academic qualification: There were significant differences in teachers' (TMK) based on academic qualification in favor of the master's degree group; a possible explanation is that master's degree holders have excellent English and research skills. They also have a good relationship with the Internet and all the new technologies in their specialties. As Patalinghug and Arnado [35, p 585] have pointed out *"It would be a good practice for teachers to pursue advanced degrees like master's degrees or even higher degrees"* unlike the teachers who stopped at the bachelor's or diploma, as they do not require development or scientific research. He satisfied himself with his job as a middle or secondary school teacher, which does not require technical skills in our schools, [36] recommended that a bachelor's degree program should be redefined with smart technologies so that students can learn quickly and subjectively. Teachers might also need more time to master new technology. As [37, p 9] has mentioned, *"Teachers may also feel that they do not have the time to learn new technologies because there have been many changes to middle and high school math courses and curriculum over the past several years"*.

Training courses: There were significant differences in teachers' (TMK) based on training courses in favor of the MOOCs group. This result might be due to the fact that mathematical technologies are still new; therefore, they need advanced techniques that are not available in the ministerial integration courses. Logically, this result supports the impact of MOOCs on teachers' professional development and technological skills, as the studies of [38, 39] have indicated. In the USA, researchers have tested MOOCs as a teacher training course that provides content-focused experiences using technology. Expert trainers successfully designed exciting experiences for teachers that positively affected their perspectives, practices and beliefs in math teaching and statistics [39]. MOOCs worldwide allow teachers to forge partnerships and create learning communities that improve their professional knowledge and skills [40].

Years of experience: There were significant differences in teachers' (TMK) based on years of experience in favor of the '1-7 years' group. These teachers started their careers in the harshest circumstances of the war and then the COVID-19 pandemic. So, this shows that they were more resilient to learning modern technologies that helped them overcome these conditions. This result is consistent with [6], which explains that teachers with less educational experience have better training in ICT and use it broadly. However, this result contradicts with [8, 34], where they showed no differences in years of experience.

Internet access: There were significant differences in teachers' technological mathematical knowledge based on Internet access in favor of (ADSL); a possible explanation is that (ADSL) is more stable and cheaper in developing countries like Syria. Therefore, it allows teachers to comfortably explore the Internet, enroll in any course, such as a course on Coursera, and watch a large number of instructional videos on YouTube, unlike the limited access (3G/4G).

CONCLUSION AND RECOMMENDATIONS

The present research aimed to classify the technological mathematical knowledge of Syrian math teachers. The results showed that their classification is below average, with the highest percentage of smartphones and their mathematical applications. In the face of unprecedented challenges such as war and pandemics, teachers must remain committed to developing themselves and their skills. Our research reveals a powerful tool for overcoming these obstacles: a strong relationship with the Internet. By leveraging the vast resources available online, teachers can expand their mathematical and technological knowledge and equip themselves to better serve their students. This is a critical time for educators to embrace the power of technology and chart a path forward to a brighter future. This paper suggests that Ministries of Education develop comprehensive teacher training programs to prepare teachers for crises such as war or pandemics. These programs should focus on developing teachers' skills in modern mathematical software tools, mathematical applications, social media platforms, distance learning platforms, interactive lessons and E-testing. They can be extended to cover other educational subjects and mathematical technologies should be introduced to build the technological mathematical knowledge of graduates. Finally, teachers' access to the Internet must be supported. These measures will ensure quality education during crises.

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