Research Article

Improving Algebraic Thinking and Productive Desire among a Training Program Based on (TPACK) Model in Jordan

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Abstract: The study aimed to investigate the effectiveness of a training program based on (TPACK-Technological Pedagogical and Content Knowledge) model in improved algebraic thinking and productive disposition among female Primary school teachers. the guide for the training program and study tools was prepared, ensured their validity and stability, an available sample was selected from the schools of Jerash Kasbah of the Directorate of Education of Jerash Governorate, consisted of (36) mathematics teachers, divided into two groups: one experimental consisted of (18) teachers trained according to (TPACK) model, and the other was a control teacher consisted of (18) teachers who did not undergo training. Results showed statistically significant differences on the algebraic thinking test between the members of the control and experimental groups, and in favor of the experimental group that was trained according to the model, also showed that training according to (TPACK) model improved the level of performance of the experimental group mathematics teachers on the productive disposition scale, and raised their performance to an expert level. one of which is need to change the pattern of training programs directed to teachers within specific mathematics content, and apply integrative teaching models that enhance content, pedagogy and enhanced technology.

Keywords: (TPACK) Training Program; algebraic thinking; productive disposition, primary school mathematics teacher

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1. Introduction

Mathematics represents an integral part of modern education, and the basis of logical, critical, analytical and problem-solving skills through the application of instructional design with specific content, appropriate strategies and supporting technology, according to a context that improves understanding and generates the desire to learn its topics, Smith and Ragan (2005), Strømskag (2017) have discussed the content of mathematical design by identifying performance outcomes with indicators Sub-acquisition of concepts and skills, and the impact of a combination of strategies and assistive techniques and positive trends in order to achieve the desired performance and enhance its acquisition, this is evidenced by a series of processes managed by the teacher and applied by the learner aimed at empowering him conceptually and procedurally, and the choice of instructional design is required a level of experience that can be summarized in three questions: "What is our destination?", "How do we reach it?" and "How do we know that we have reached it?" by providing a cognitive structure that links the learner's previous knowledge with new knowledge, and transfers the teacher's experience to the learner to the intended educational character.

One of the most important mathematical cognitive structures, Cai (2004) described algebraic thinking that connects relationships and symbols and their application in activities that support generalization and abstraction by presenting big ideas within the areas of: variables, relative thinking, relationships and patterns, equivalence of expressions, equation solving, and algebraic modeling.

Booker (2009) emphasized the application of multiple representations in problems of number, geometry and measurement and the introduction of formal generalization accompanied by the need for brief verbal descriptions of the relationships that are revealed, and the establishment of a foundation to use symbols that express generalizations independently of the activities for which they were created. However, the relationship between algebraic thinking and mathematical thinking and supporting learner knowledge is evident as described by Magiera et al. (2013) through teacher's organization of multiple representations, and the attempt to design techniques and tasks that support thinking; to reach the description of relationships and discover patterns, and the learner reaches the stage of developing his algebraic thinking through the knowledge of linking algebraic formulas to different situations and contexts. Liadiani et al. (2020) discussed the interaction of the educational situation and digital tools to engage the learner in the activities that promote this thinking, and how to use the tool with the importance of maintaining a mathematical understanding for concepts and actions of the designed tool. Othman (2020) confirmed the weak application of algebraic thinking due to the weakness of traditional teaching strategies, the lack of curriculum resources that support this thinking, the weak approach to learning and teaching in the classroom, the lack of understanding of structural framework for teaching process, the lack of learners' understanding of the characteristics of algebraic arithmetic operations, the use of rules in solving problems, and the lack of questions that employ the areas of this thinking well within the classroom.

Given the importance of algebraic thinking for both teacher and student and the support it provides to thinking skills, Magiera et al. (2017) discussed algebraic thinking as one of the basics of learning and teaching in mathematics classes (K-8) and supported thinking ability of mathematics teachers through the design of teacher training programs, which address issues related to algebra education with a focus on their ability to justify algebraic rules and procedures, and focus on the habits of mind of algebraic thinking, such as: Abstraction and mathematical operations to establish a comprehensive understanding of algebraic thinking skills. Therefore, the teacher must engage in algebraic thinking, and be able to involve learners in thinking and understand it, to gain important insights on how to improve algebraic ideas, pay attention to learners' thinking situations, and determine what learners already know and what they do not know, and this thinking requires focusing on key areas according to Sibgatullin et al. (2021), as follows: Generalization and formulation of arithmetic operations, Operations on equations, Language and algebraic representation, Relationships and Functions, and Analysis of mathematical structures. Algebraic thinking in this presentation is a cultural product that represents the set of knowledge embedded in patterns, relationships, embodied algebraic structures and their study, numerical systems, and algebraic modeling, and considering the content of mathematics that its realistic and the presentation of mathematical logic in a stimulating manner plays an auxiliary role in predicting the behavioral processes that the teacher generates during the education process, and the emergence of trends, their formation, stability and improvement, which drives efforts to provide training opportunities for teachers to increase the productive desire as one of the components of The athletic prowess sought by reform movements since the (21st) century.

Kilpatrick et al. (2001) defined the productive desire by inclined to see meaning in mathematics, and to realize that it is useful and worthwhile, and to believe that constant effort in learning mathematics as an effective learner of mathematics, and if the teacher wants to improve conceptual understanding, procedural fluency, strategic competence and adaptive thinking abilities, he must believe that mathematics can be learned and used with effort, and improving productive desire requires frequent opportunities to understand mathematics when done within an environment to solve the problem. Schoenfeld (2010) cited "productive desire" as one of the threads of mathematical prowess described to see mathematics as useful and worthwhile, along with a belief in diligence and learner effectiveness, and that the idea of "beliefs and attitudes" are important aspects of mathematical prowess while learning mathematics. Al-Qarni (2019) pointed out that the productive desire requires effort, whether from the teacher or the student, to acquire mathematical knowledge, and also pushes the teacher to have a tendency or a productive tendency to behavioral patterns and teaching practices that lead the educational process to more innovation and creativity. Sutrisno (2020) described the productive desire as one of the components of the emotional field and can be interpreted as self-confidence, and a positive attitude towards values in mathematics, and the teacher must make decisions related to creating educational situations that generate self-confidence and positive tendencies and show behavior consciously, and motivation to learn mathematics, the productive desire accompanies the teacher's attitudes and desires through his teaching practices, and Al-Khidr (2020) mentioned the areas that develop productive desire, including: Reinforcement that mathematics is meaningful, Explain mathematics using modern learning methods and techniques and electronic programs, Consider previous interests and experiences when explaining content, and Linking mathematics and other sciences. Österling (2021) pointed that the productive desire includes the presence of an "informed teacher" to obtain knowledge of content, cognitive and emotional theories, and knowledge of learners as well as the ability to practice thinking skills, but the emphasis came on the idea that productive desire includes the ability to implement this knowledge in the educational situation, and understand it.

In the context of teacher experience, Shulman (1986) put the foundations of teacher knowledge by formulating questions in the field of teacher knowledge: "What is relevant content and pedagogical knowledge? And what forms of knowledge are represented in the minds of teachers? What are the promising ways to promote the acquisition and development of this knowledge?" The quality of teacher performance is the focus of educational policy analysis, as it represents a qualified teacher who provides with his expertise opportunities for creativity, communication, critical thinking, problem solving, finding creative solutions, working collaboratively, and demonstrating the ability to innovate, by paying attention to organizing the teacher's knowledge and its actual areas of application in the classroom. Mishra and Koehler (2009) added a third knowledge to content knowledge, and pedagogy called technology knowledge, produced a framework called (TPACK) for Technological Pedagogical and Content Knowledge, as illustrated in Figure 1.

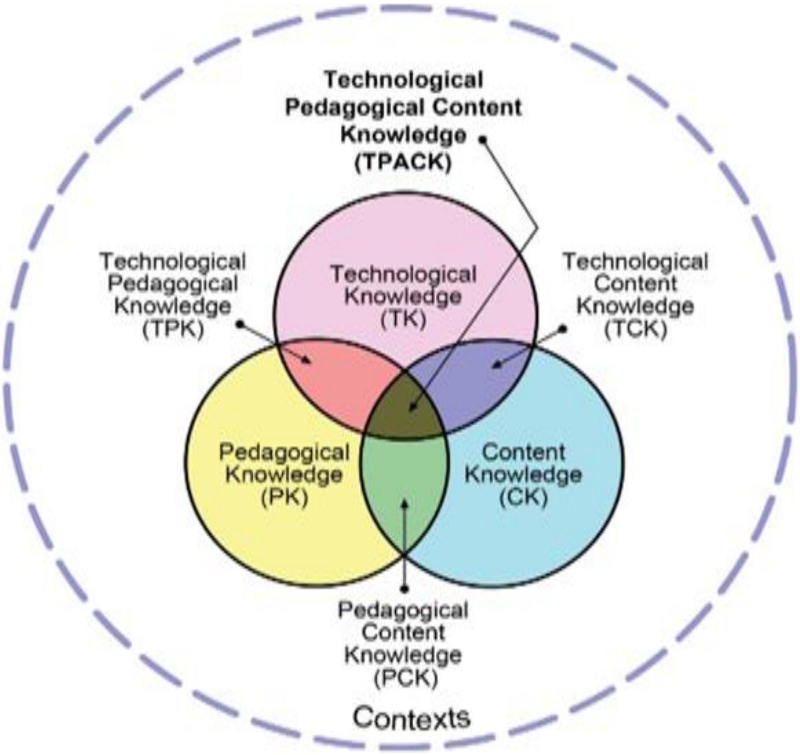

Figure 1. (TPACK) model.

Source: http://(TPACK).org

Grandgenett (2008) discussed the characteristics of the teacher accompanying (TPACK) model through teachers' openness to experimenting with technological tools, applying new lessons using technology, diversifying performance tasks, applying clear strategies, what learners need to know and how they are taught, and helping learners understand the importance of technology and used it to manage and evaluate classrooms and learn about technological developments. Koehler et al. (2012) linked (TPACK) model to a managed domain to influence practice and actual observation of performance and requires an understanding of the multiple interactions of knowledge, and the challenge comes from the rate of technological change of technology-focused technical tools which need constant updating, Pierce and Stacey (2014) proposed the classification of pedagogical opportunities that support mathematics content through technological applications capable of performing algorithmic operations, performing mathematical actions, and organizing classification including The teacher reports a scheme to give a visual indication of potential teaching practices, pay attention to teaching possibilities, remind teachers of available options, and identify teachers' professional development needs.

Stapf and Martin (2019) emphasized that teacher education programs have a responsibility to deliver the application of technological integration through the use of (TPACK) so that model combinations are better intertwined to improve self-efficacy and how the model is applied in contextual knowledge development. From the above, it is clear that the conceptual framework of the model provides an organizational view of the nature of the relationship between the teacher, the learner, and knowledge; the meaning appears when the symbols and concepts are clearly differentiated, so that trends are generated in the learner through questions related to the cognitive structure. The current study is concerned with the application of the model within a training program directed to mathematics teachers, and to know the impact of the program in improving algebraic thinking, and productive desire, so that knowledge of mathematical and technological pedagogical content is interactively integrated with a variety of performance tasks that help improve algebraic thinking, and simulating educational contexts within a specific technology in order to improve productive desire. After reviewed the research literature related to the model in databases and refereed periodicals, and through the researcher's access to studies that dealt with the model, it is possible to present previous studies that applied the model in teacher training, and the interaction of the model with many variables, as they were all selected within mathematics, and their chronology is all from the latest to the oldest.

McKitrick-Rojas (2022) aimed to clarify the basic characteristics of planning and implementing lessons for secondary mathematics teachers according to (TPACK) model within the content of algebra and the application of (DESMOS Calculator) in linear equations and functions, the case study design was adopted, and the study sample consisted of (5) middle and high school teachers in the United States of America, a questionnaire was applied to the pre-(TPACK) survey, where the study continued to be applied For six months, the results showed a statistical difference of factors affecting the teacher's self-efficacy in the application of technology within the field of language and algebraic representation in favor of the model.

The study of Filho and Gitirana (2022) provided the knowledge that arises from collaborative attitudes and the integration of technology to teach associations according to (TPACK) model, the study adopted the experimental approach, the program included five stages from theoretical discussion to automated planning within the associations using digital resources in a sample of (21) pre-service teachers in Brazil, and the data was collected through electronic models, text messages, interviews, and video recordings, the results showed that the collaborative interaction provided Teachers have different aspects of teaching practices and provided a futuristic perspective in improving training models in favor of the model.

Kartal and Cinar (2022) proposed a training program according to (TPACK) for primary school mathematics teachers, the study adopted the longitudinal design of a multi-stage case study that extended for three semesters, and the study sample consisted of (6) mathematics teachers in Turkey, the field of patterns and operations was applied to equations within the content of polygons and the application of (GeoGebra) software, and the results showed that self-efficacy increased as a result of training opportunities, especially with regard to the application of technology, and its interaction with the content of mathematics, and pedagogy Helped improve participants' attitudes towards the conceptual framework of the nature of mathematics in favor of the model.

Rakes et al. (2022) also examined the use of the (TPACK) model by secondary mathematics teachers in the conceptual understanding of mathematics from university teacher preparation programs, and the mixture design was followed for one group before - after, and the study sample included (17) teachers in the United States of America, and teaching practices were monitored to measure the effectiveness of teaching mathematics within the content of numbers, geometry, and algebra, and (34) video examined the performance of the study sample during teaching, and the results indicated the ability of teachers to The use of technology to improve the application of mathematical thinking fields in favor of dimensional application.

López et al. (2021) dealt with the topic of teaching quadratic coupling to mathematics teachers in Costa Rica according to (TPACK) model, and the study followed the qualitative approach with a sample of (27) teachers, and they were registered in courses related to the three basic areas of the model, a questionnaire consisting of (17) different mathematical questions and tasks was applied about quadratic coupling with the application of (GeoGebra) and the design of an element associated with quadratic conjugation, and the results showed that the participants possess special basic knowledge on the subject of quadratic coupling according to the model, and identifying conceptual and procedural errors associated with the concept of conjugation through appropriate modeling and solving non-routine problems that develop algebraic thinking skills in favor of the model.

Saritepeci (2021) discussed one of the main obstacles associated with the integration of technology in education by studying the relationship between classroom management in technology-rich courses and computational thinking according to (TPACK), the descriptive approach was adopted through relational examination The application of data collection tools, and the study sample consisted of (125) secondary school teachers in Turkey, the computational thinking scale includes (29) items in five sub-dimensions: Creativity, algorithmic thinking, collaboration, critical thinking, and problem solving, and the results showed that the relationship of performance within the dimensions of computational thinking came in favor of the model.

Hill and Uribe-Florez's study (2020) expanded the detection of (TPACK) for middle and high school mathematics teachers from grades (6-12) in the United States of America with a sample of (31) teachers, the design adopted the mixture, and the data was collected using a survey consisting of (22) closed questions to measure (TPACK) for teachers and (7) open questions for technology integration in the content of algebra and geometry, and digital resources (Desmos, GeoGebra and Geometer's Sketchpad) were used as tools for graphing and modeling mathematics, and the results showed that Teachers were more confident in their pedagogical knowledge and less confident in their technological knowledge, and teachers reported obstacles to applying technology including access, resources, and time, the model also helped them improve their experiences.

Sabri's study (2019) revealed the impact of a training program based on (TPACK) used infographic technology to develop cognitive achievement among middle school mathematics teachers in Saudi Arabia, and visual generative thinking skills, the study sample consisted of (21) teachers and (92) students, the study followed the semi-experimental approach in three groups, and the program was divided into two stages that included training teachers, and following up on the performance of students after training, and the program included the content of the engineering unit, spatial reasoning, and the study tools included the cognitive achievement test, the scale of infographic making skill, and the test of visual generative thinking skills: reasoning, prediction, fluency, and flexibility, the results showed the impact of the model in improving the performance of the third group in testing thinking skills for the benefit of the program.

Erduran and Ince (2018) discussed the difficulties that secondary school teachers face when integrating technology into their classrooms, and understanding the causes of these difficulties within the work of (TPACK), the study adopted a case study design, the study sample included (5) mathematics teachers in Turkey, and the tools included lecture plans, classroom monitoring, semi-structured interviews with a focused group interview, the results showed that some teachers suffered with acquaintances (PK, PCK and TPCK) and the difficulties they face in integrating technology were clarified, including: Teaching without planning, working to integrate different types of knowledge, lack of basic knowledge, errors in technological knowledge, lack of field support.

Kim (2018) discussed the relationships between the beliefs of secondary mathematics teachers, knowledge of teaching mathematics to a sample of (4) secondary mathematics teachers in the United States of America, their beliefs about the nature of mathematics, and the use of technology in teaching within (TPACK), the study followed the methodology of studying multiple cases within the content of geometry, probability, and series in dynamic engineering environments (DGEs-Geometer's Sketchpad), the results showed that teachers with constructivist-oriented beliefs in the field of the framework Conceptual to the nature of mathematics, using of technology showed higher levels in favor of the model.

Adulyasas (2016) dealt with determining the impact of lesson design for secondary school teachers within (TPACK) model, the qualitative approach was used, with a sample consisted of (5) teachers in Thailand, the tools included the use of the Generalized System of Preferences for five lesson plans in the subject of "relations", three groups of students were taught by three different teachers, an interview was applied to teachers, the results showed the effectiveness of enhancing the level of geometric thinking of students and the level of teachers' performance in favor of applying the model, The study also sought to identify an additional set of skills needed by mathematics teachers within the application of technology in their classrooms within the application of the model, the study followed the methodology of quantitative survey in Cameroon with a sample of (400) teachers, selected using stratified random sampling technology from (10) schools, and the results indicated that teachers have better mastery of content knowledge (CK), pedagogy knowledge (PK), knowledge of content pedagogy (PCK), knowledge of technological content (TCK), and showed Weaknesses in three other combinations, most notably: technological knowledge (TK), knowledge of pedagogical technology (TPK), and (TPACK).

The study of Bos and Lee (2014) dealt with the integration of teachers technology-based education, concepts of numbers, geometry, statistics, and probability in the US state of Texas, the semi-experimental design of (TPACK) survey, and a qualitative scale (TPACK- Levels Rubric) were used to evaluate the use of technology within teachers' lesson plans, the study sample consisted of (45) teachers, the results showed improved application of supporting technology such as: GeoGebra, Graphing calculator support mathematical thinking, producing a positive attitude as a result of applying a problem-solving environment in favor of the model.

Also, Lyublinskaya and Tournaki (2012) provided a developmental program for mathematics teachers in the United States of America, and the program consisted of the teacher's design of curricula that included the technique (TI-Nspire) within the content of algebra, the study underwent a longitudinal design to monitor the change in teachers' behaviors, the change in teacher responsibilities, and technical difficulties, the levels of (TPACK) of the teacher were measured through an evaluation model was used to evaluate written records, the results indicated that The program contributed to improving the reality of teaching in the field of language and algebraic representation in favor of the model.

Riales (2011) applied a study to examine the knowledge of (TPACK) for a sample of (6) mathematics teachers in the United States of America while they were participated in the preparation of a technology-based lesson using the model (Niess et al., 2009), the examination of the model used (TI-Navigator), the study adopted a multi-layered case study approach, the results indicated that the technology-based lesson design provided opportunities to practice the model's application development procedures, the participants showed practices indicating an increase in the levels of development of the model, and greater positive changes in favor of the application of Prototype.

it is cleared that there are studies that dealt with algebra as educational content within the model and dealt with improving thinking by applying (TPACK) model among teachers in the context of training programs, while studies dealt with mathematical prowess, or one of its fields as a variable, or investigated the relationship of applying the model with other variables for teachers. The diversity in objectives, procedures, and results of these studies on the application of the model in training programs directed to teachers were demonstrated, as studies were similar in the application of the model within the content of algebra McKitrick-Rojas (2022), López et al.(2021), Lyublinskaya and Tournaki (2012) and Riales (2011) and the results of the studies showed an effect of applied the model for the content of algebra as in a study Riales (2011), and studies were similar in the application of the model within one of the areas of mathematical prowess, or an indicator of productive desire as in a study Kartal and Cinar (2022) and Kim (2018).

This study was distinguished from other studies as one of the first studies that linked the improvement of algebraic thinking, and the productive desire of mathematics teachers in the primary stage to apply a training program directed to teachers within the integration between knowledge of content, pedagogy and technology, and this study was also distinguished for its application of the general model of instructional design (ADDIE; Analysis, Design, Development, Implementation, Evaluation), which included (analysis, design, development, implementation, and evaluation) and the model of Niess et al.(2009) as in Riales (2011), which included (discrimination, acceptance, adaptation, exploration, progress) in formulating integration between the knowledge of the model, and the overall previous studies affected the researchers in accessed the theoretical literature and helped to prepare the study tools, and know the aspects that were discussed with the application of (TPACK) In previous studies with algebraic thinking and productive desire to uniquely this study with its new variables.

Study Questions

Are there statistically significant differences between the average scores of Elementary mathematics teachers in the algebraic thinking test as a whole, and each of its fields between the control and experimental study groups due to the application of the training program according to (TPACK) model?

Are there statistically significant differences between the average scores of Elementary mathematics teachers in the productive desire scale as a whole, and each of its fields between the control and experimental study groups due to the application of the training program according to (TPACK) model?

Hypotheses of the study that emerged from its questions:

There were no statistically significant differences at the level of significance (ἀ≤0.05) between the average scores of Elementary mathematics teachers in algebraic thinking test as a whole, and each of its fields between the control and experimental study groups attributed to the application of the training program according to (TPACK) model.

There were no statistically significant differences at the level of significance (ἀ≤0.05) between the average scores of Elementary mathematics teachers in the scale of productive desire as a whole, and each of its fields between the control and experimental study groups attributed to the application of the training program according to (TPACK) model.

2. Materials and Methods

2.1 Methodology

The study used the semi-experimental approach with a pre-post design for two groups, one experimental and the other control, in order to investigate the effectiveness of the training program based on (TPACK) model in improving algebraic thinking and productive desire of primary mathematics teachers, the application of the test and the scale was before and after.

2.2 Participants

The study population consisted of (165) mathematics teachers in Jerash Governorate, and an available sample of (36) mathematics teachers was selected from the basic stage teachers studying grades from the fifth basic to the eighth grade based on the placement and assistance of mathematics supervisors of the Guidance and Supervision Department / Directorate of Education - Jerash Governorate for the second semester of the academic year 2022/2023, and obtaining the teacher's approval to participate in the application of the training program, and a sample was divided The study to an experimental group of (18) mathematics teachers subject to the training program by obtaining the teacher's approval, and a control group of (18) mathematics teachers who are not subject to training.

2.3 Guide Manual

The educational material was prepared according to the following steps: Designed a unit in algebra within the model to include (3) packages on the topics: algebraic expressions, solving linear equations, relationships and patterns, to produce framing knowledge of algebra content within the knowledge of (TPACK) model and preparing it as a reference for algebra content, and identified supporting technology For the training program through the application of presentations within *www.emaze.com* and the adoption of knowledge supporting the content of algebra within *www.wordwall.com* and *www.Liveworksheet.com*, the activities of the Algebra Module, and the Training Program Section are designed for five sessions of three hours each within the conceptual framework of the model. The "trainee's booklet" was made to explain the general and special objectives of the training program, the indications of the validity of the educational material were verified by presented it in its initial form to experienced arbitrators, and the competence to verify the results, and ensure their compatibility with the model, and the content of algebra and the indications of its stability were verified by presented the initial image to arbitrators with experience and competence and verified the results and their compatibility with the model. The algebra unit applied in the training program was prepared, as it combined educational experiences with technological capabilities, and the mechanism for building the applied algebra unit based on the model was determined based on the range and sequence matrix for grades from the fifth basic to the eighth grade issued by the National Center for Curriculum Development (2021) and the tasks were presented used a variety of educational media of paper and electronic presentations and worksheets, and the algebraic content was accompanied by technological design.

2.4 Algebraic Thinking Test

The algebraic thinking test was prepared to include (5) areas: generalization and formulation of arithmetic operations, operations on equations, analysis of mathematical structures, relationships and functions, algebraic language and representation, within (4) objective questions for each field with justification for the answers, so that the total questions are (20) questions for the test as a whole, and both groups are subject to it before and after. The test was applied to an exploratory sample from the study population and from outside in order to determine the appropriate time for the test, where the average time was (60) minutes, and the stability coefficient was calculated for each area of algebraic thinking using the Cronbach alpha equation and ranged within the category (0.83 – 0.86) and calculated the correlation coefficients of the areas of algebraic thinking with the total score of the test and ranged within the category (0.32 – 0.56) The correlation coefficients of each question with its domain were in the category (0.32 -0.77), the difficulty coefficients were within the category (0.45 – 0.70), while the discrimination coefficients ranged within the category (0.43 – 0.98). A correction rubric has been prepared for the test through which the areas of algebraic thinking are measured, thus the total score for the test is (40).

2.5 Productive Desire scale

In defined the areas of productive desire, it was ensured that the paragraphs that were selected and arranged to suit the terms and objectives of the study, and their appropriateness The level of the selected sample, the scale was presented to arbitrators with experience and competence and taking their opinions in order to ensure its stability and make the necessary adjustment according to their opinions on the linguistic formulation of the paragraphs and their clarity to the level of the study sample, and the scale adopted a level of performance (very high, high, medium, low) and Adopting the accompanying quantitative scale (4, 3, 2, 1) respectively. the correlation coefficients of paragraphs on the scale as a whole within the category (0.59 – 0.89) and according to the stability coefficient according to the Cronbach alpha equation, the stability and correlation coefficients were found, for the areas of desire produced as shown in Table 1.

Table 1. Areas of productive desire scale, correlation, and stability coefficients

Areas of Productive Desire Scale	No. of paragraphs	Correlation Coe.	Stability Coe
Reinforcement that mathematics is meaningful.	4	0.81	0.76
Explain mathematics using modern learning methods and techniques and electronic programs.	6	0.74	0.86
Consider previous interests and experiences when explaining content.	4	0.72	0.89
Linking mathematics and other sciences.	5	0.83	0.91

For the scale as a whole within the category (0.85-0.89). The productive desire scale included four general areas, each of which has paragraphs as sub-indicators, and to facilitate dealing with the responses of the parameters on the scale as a whole, performance was rated based on the adoption of the highest mark (76) and the lowest mark (19) for the scale and the level of performance: Need to train, intermediate, advanced and expert training to facilitate the handling of teacher responses on the areas of the desire scale produced within the performance level as in Table 2.

Table 2. Distribution of productive desire scale categories

Level	Need to train	Medium	Advanced	Expert
Total score of scale	19 -33	34 – 48	49 – 63	64 – 76
Scale indicator mark	1-1.74	1.75-2.49	2.5-3.24	3.25-4

2.6 Statistical treatment

Answers of the study questions Quantitative and qualitative analyses were used according to the study questions: to answer the first question, the arithmetic averages and standard deviations of the parameter scores were calculated in the algebraic thinking test in the pre- and post-measurements according to the application of the training program based on (TPACK) model, and to find out whether the apparent differences between the averages in the post-test are statistically significant, the associated single variance analysis (ANCOVA) and multiple variance analysis (one way – MANCOVA), and the second question was answered by calculating the arithmetic averages and standard deviations of the pre- and post-productive desire scale according to the model, and variance analysis (one way- ANOVA) was used for the areas of the productive desire scale for the two study groups in the fields of the productive desire scale, and the use of qualitative analysis to interpret the results of the parameters in the areas of the scale, and the third question was answered by analyzing the answers of the experimental study group in the dimensional measurement of the productive desire scale and classifying them into levels: Need to train, Intermediate, advanced, and expert, to investigate the impact of training according to the model.

3. Results

The results of the first question: "Are there statistically significant differences between the average scores of Elementary mathematics teachers in the post-algebraic thinking test as a whole, and each of its fields is attributed to the training program according to (TPACK) model?" to answer this question, the hypothesis emanated from it was tested, namely: "There are no statistically significant differences (ἀ≤0.05) between the average scores of Elementary mathematics teachers in the post-algebraic thinking test as a whole, and each of its fields is attributed to the training program according to the model;" The averages and standard deviations of the parameter scores were calculated in the algebraic thinking test as a whole in the pre- and post-measurements as shown in Table 3.

Table 3. Averages and standard deviations of algebraic thinking test (a whole)

Groups	Number of teachers	Pre-test		Post–test		Average	Standard error
		$\bar{x}$	σ	$\bar{x}$	σ		
Experimental	18	18	23.34	6.20	28.55	6.66	25.95
Control	18	18	20.44	5.96	22.68	6.22	21.56

It is clear from Table 3 that there is an apparent difference between the averages of the scores of mathematics parameters in the test according to the training program, and to find out whether the apparent difference in the total dimensional test is statistically significant, use the associated single variance analysis (one way - ANCOVA) for the dimensional measurement of the test as a whole according to the training program, in Table 4.

Table 4. (ANCOVA) for algebraic thinking test according to training

Variance	Sum of squares	Df	Average of squares	F	Sig.	ή2
Pre-test	0.232	1	0.232	0.005		
Training	1709.79	1	1709.79	39.991	0.0001*	0.62
Error	1410.88	33	42.754			
Total	26592.00	35				

It is clear from Table 4 that there is a statistically significant difference between the average scores of mathematics teachers in the two study groups in the algebraic thinking test, where the value of (F) is equal to (39.991) and the value of (P) is equal to (0.0001) in favor of the experimental group that was trained according to the model and it is clear from Table 4 that the training has an impact on improving the algebraic thinking of primary mathematics teachers, and the value of (ή2) explained (62%) of the explained variance (predicted) in improving algebraic thinking, and attributed the rest to other influences, calculated averages and standard deviations for pre- and post-measurements, adjusted averages, and standard errors for the areas of algebraic thinking to determine in favor of either of the two study groups were the substantial differences, according to the teaching method as in Table 5.

Table 5. Averages and standard deviations of categories of algebraic thinking

Category	Group	Number	Pre-test		Post-test		Average	Standard error
			$\bar{x}$	σ	$\bar{x}$	σ		
Generalization and formulation of arithmetic operations	Experimental	18	4.67	2.11	5.67	2.33	5.17	0.37
	Control	18	3.67	2.13	4.67	1.89		
Operations on equations	Experimental	18	4.89	1.66	5.89	1.56	5.56	0.30
	Control	18	4.22	2.10	5.22	1.90		
Language and algebraic representation	Experimental	18	5.00	1.80	6.11	1.70	5.06	0.35
	Control	18	4.44	1.83	4.00	1.89		
Relationships and functions	Experimental	18	4.56	1.46	5.89	1.56	5.23	0.31
	Control	18	3.89	1.94	4.56	1.86		
Analysis of mathematical structures	Experimental	18	4.22	2.10	4.89	2.02	4.56	0.35
	Control	18	4.22	2.30	4.22	2.10		

Table 5 shows that there are apparent differences between averages in the dimensional measurement of the areas of algebraic thinking, which is the result of the training method, and in order to verify the essence of the apparent dimensional differences, the analysis of multiple single covariance (one way- MANCOVA) was applied as shown in Table 6.

Table 6. (MANCOVA) of training on the categories of algebraic thinking

	Impact	Value	F	Df	Df of error	Error
Training	Hoteling's Trace	1.269	7.360	5.000	29.000	.0001

Table 6 showed that there is a statistically significant effect of training for the dimensional measurement of the areas of algebraic thinking as a whole, where (Hoteling's Trace) reached a value of (1.269), meaning that there is a statistically significant difference for training in the areas of forced thinking as a whole, to determine the areas of algebraic thinking that caused this effect, the analysis of the single variance associated with each area separately was conducted according to the training, as shown in Table 7.

Table 7. (MANCOVA) of training on each category of algebraic thinking

Variance	Categories of algebraic thinking	Sum of squares	Df	Average of sums	F	Sig.	ή2
Pre-test	Generalization and formulation of arithmetic operations	11.803	1	11.803	2.593		
	Operations on equations	1.652	1	1.652	0.508		
	Language and algebraic representation	4.442	1	4.442	1.317		
	Relationships and functions	0.846	1	0.846	0.265		
	Analysis of mathematical structures	0.214	1	0.214	0.046		
Training	Generalization and formulation of arithmetic operations	133.418	1	133.418	29.313	.0001	0.89
	Operations on equations	58.060	1	58.060	17.867	.0001	0.88
	Language and algebraic representation	36.357	1	36.357	10.776	.0001	0.89
	Relationships and functions	55.362	1	55.362	17.337	.0001	0.83
	Analysis of mathematical structures	46.484	1	46.484	10.047	.0001	0.78
Error	Generalization and formulation of arithmetic operations	150.197	33	4.551			
	Operations on equations	107.237	33	3.250			
	Language and algebraic representation	111.336	33	3.374			
	Relationships and functions	105.376	33	3.193			
	Analysis of mathematical structures	152.675	33	4.627			
Total error	Generalization and formulation of arithmetic operations	171.000	35				
	Operations on equations	112.889	35				
	Language and algebraic representation	155.889	35				
	Relationships and functions	122.222	35				
	Analysis of mathematical structures	156.889	35				

Table 7 shows the existence of statistically significant differences for each area of algebraic thinking, and in favor of the experimental group; and from the above, it was found that there is a statistically significant difference for the model in improving algebraic thinking in the test as a whole, and each of its fields, and the value of (ή2) for each area of algebraic thinking came between (0.78 – 0.89), which is statistically significant, thus rejecting the null hypothesis emanating from the first question, which concerns the areas of algebraic thinking.

The results of the second question: "Are there statistically significant differences between the average scores of the basic stage mathematics teachers in the productive desire scale as a whole and each of its fields, attributed to the training program according to (TPACK) model in improving the productive desire of the primary teachers?" to answer this question, the hypothesis emanating from it was tested, which is: "There are no statistically significant differences at the level of significance (ἀ≤0.05) between the average scores of the mathematics parameters in the scale of productive desire as a whole, and each of its fields between the control and experimental study groups is attributed to the application of the training program based on the model." The means and standard deviations of the answers of the mathematics parameters were calculated in the pre- and post-measurements of the productive desire scale as a whole as shown in Table 8.

Table 8. Means and standard deviations of the scale of productive desire as a whole

Categories of productive desire	$\bar{x}$ / σ	**Control**		**Experimental**	
		Pre-test	**Post-test**	**Pre-test**	**Post-test**
Reinforcement that mathematics is meaningful.	$\bar{x}$	9.7	10.2	10.2	12.8
	σ	7.3	7.3	9.3	8.3
Explain mathematics using modern learning methods and techniques and electronic programs.	$\bar{x}$	12.9	14.5	14.4	17.4
	σ	3.5	4.5	2.4	4.5
Consider previous interests and experiences when explaining content.	$\bar{x}$	9.2	10.9	10.2	11.8
	σ	2.3	2.8	3.5	4.04
Linking mathematics and other sciences.	$\bar{x}$	10.9	11.6	12.9	14.9
	σ	2.2	2.7	2.6	4.4
Total scale	$\bar{x}$	42.7	47.2	47.7	56.9
	σ	15.3	17.3	17.8	21.24

Table 8 shows an improvement in the performance of the parameters in the scale of the dimensional productive desire of the experimental group compared to the control group, where the means in the areas of the productive desire scale show an improvement and this indicates the impact of the training program in improving the areas of productive desire of the study sample, and we note that the value of the dimensional measurement of the experimental group amounted to (56.9) and is classified within the level of performance (advanced), compared to the value of the dimensional measurement of the control group of (47.2) and is classified within the level of performance (medium), as stated in the Table 2, this indicates the impact of training program in improving the level of performance of the parameters in the scale, and the difference in the level of performance of the parameters in the dimensional measurement as a whole, to find out whether the difference on the dimensional test is statistically significant, the associated variance analysis (one way- ANOVA) was used for the dimensional measurement of the scale of desire produced as a whole according to the training program in Table 9.

Table 9. (ANOVA) of productive desire as a whole according to training

Variance	**Sum of squares**	**Df**	**Average of sums**	**F**	**Sig.**	**ή2**
Between groups	1965.444	1	1965.444	36.369	0.0001	0.52
Inside groups	1837.444	34	54.042			
Total	3802.889	35				

Table 9 shows a statistically significant difference in the average performance of the parameters on the pre-and post-measurements of the productive desire scale as a whole due to the effect of applying the training program, and the calculated value of (F) was (36.369) statistically significant (P) equal to (0.0001) in favor of the experimental group that was trained according to the model and according to (ή2) by (0.52), which means that the model-based program enhances the productive desire included in the scale by (52%), therefore the hypothesis of the study regarding the level of performance of mathematics teachers is rejected. In the scale as a whole, to examine the performance of the parameters on each scale area according to the analysis of variance (one way- ANOVA) for pre- and post-measurement and (ή2), to investigate the impact of the training program in improving each area of the scale as in Table 10.

Table 10. Analysis of variance for the categories of the productive desire

Category	**Variance**	**Sum of squares**	**Df**	**Means of squares**	**F**	**Sig.**	**ή2**

Reinforcement that mathematics is meaningful	Between groups	213.333	26	8.205	3.956	.018	0.67
	Inside groups	18.667	9	2.074			
	Total	232.000	35	14.239	13.257	.0001	0.52
Explain mathematics using modern learning methods and techniques and electronic programs	Between groups	370.222	26	1.074			
	Inside groups	9.667	9				
	Total	379.889	35				
Consider previous interests and experiences when explaining content	Between groups	267.333	26	10.282	3.910	.019	0.72
	Inside groups	23.667	9	2.630			
	Total	291.000	35				
Linking mathematics and other sciences	Between groups	349.222	26	13.432	6.843	.002	0.69
	Inside groups	17.667	9	1.963			
	Total	366.889	35				

It is noted from Table 10 an improvement in the level of performance of the parameters of the experimental group on the indicator "Reinforcement that mathematics is meaningful", it was found that it is statistically significant, and the calculated value of (F) was (3.956) with statistical significance (P) amounted to (.018) as calculated by (ή2), and it was (0.67), which explains the percentage of (67%) of the performance of the teachers in the field as a result of the training program based on the model and attributed the rest to other factors. This indicates that the training program helped to improve the beliefs of the field, thus there is a difference in the level of performance of mathematics teachers in the field, so the hypothesis of the study related to the field of "reinforcing that mathematics is meaningful" is rejected.

The second area "Explanation of mathematics using modern learning methods and techniques and electronic programs" in the application of the scale of desire produced in the pre- and post-measurements, it is noted from Table 10 an improvement in the level of performance of the experimental group parameters in the field, a value of (F) (13.257) was found with statistical significance (P) equal to (0.0001) and therefore the training program has an impact on improving the field through the responses of the parameters, and to ensure the size of the impact, (ή2) was calculated and amounted to (0.52) and explains that (52%) of the responses of the teachers in the field is attributed to the training program based on the model and attributed the rest to other variables, so we reject the hypothesis of the study related to the field.

For the third area "taking into account previous interests and experiences when explaining the content", and through the statistical analysis in Table (10), we notice an improvement in the level of performance of the experimental group parameters in the field for the dimensional measurement compared to the control group, and the value of (F) amounted to (3.910), which is statistically significant (P) amounted to (0.019) in the dimensional measurement of the scale of productive desire, and the size of the effect according to (ή2) for the experimental group is equal to (0.72), which means that the training program has an impact on the field by (72%) and at-tributed the rest to other variables, thus rejects the hypothesis of the study associated with the field.

As for the fourth area: "linking mathematics and other sciences" in the application of the pre- and post-scale to the two study groups, and it is noted from Table 10 an improvement in the level of performance of the experimental group parameters in the indicator dimension com-pared to the control group by finding the values of the arithmetic mean of the two study groups in the pre- and post-measurement, and that the value of (F) has been calculated on the post-measurement of the experimental group with a value of (6.843), which is statistically significant (P) equal to (0.002) and (ή2) reached (0.69), which means that the training program recorded an impact of (69%) in the dimensional measurement of the experimental group, and this explains the role of the training program in improving the field, so the hypothesis of the study associated with the field is rejected.

4. Discussion

The results of the first question indicated that there are statistically significant differences in the algebraic thinking test between the performance of the experimental and control groups in favor of the experimental group, whether in the test as a whole, or in each area of algebraic thinking, it can be said that the training program has helped the teachers to enhance their knowledge of the model and align the intended learning outcomes, and helped the teachers identify the areas of algebraic thinking and Allocate tasks and skills that support areas of algebraic thinking. The results of the experimental group in the algebraic thinking test proved superior compared to the control group, and it can be said that the training program has helped the teachers to improve performance in the areas of algebraic thinking, where the value of ($\acute{\eta}2$) for each area of algebraic thinking came within the category (0.78 – 0.89), which is statistically significant, and perhaps this is consistent with the study of study of López et al. (2021) in identifying conceptual and procedural errors associated with areas of algebraic thinking through appropriate modeling and non-routine problem solving that develop algebraic thinking skills.

The results provides practical evidence that providing a perception within (TPACK) model in the content of algebra raised the performance of the teachers in the algebraic thinking test, and helped create an effective classroom environment that differs from the traditional classroom environment that the teachers used to prepare inside the classroom, and the interaction between the knowledge of the model helped increase the effectiveness of the teacher, and the results of this study and previous studies are consistent McKitrick-Rojas (2022), Filho and Gitirana (2022) and Riales(2011) that the application of the model helps the teacher to increase their knowledge of the content of mathematics and its teaching methods, as well as to see what is new in the field of supporting technology that helps build meaningful understanding and learning, and create an effective, purposeful training environment that differs from the traditional training environment that teachers are accustomed in linking topics to realistic contexts, improving ways of thinking, the ability to link facts, and organizing steps in a logical sequence of During the recruitment of Keeping pace with the developments of the times, and prepared a teacher capable of succeeding in the age of technology.

The results are consistent with the study of Magiera et al. (2017) on the importance of changing practices in the context of training as part of the learning process, understanding the nature of mathematics, the nature of algebraic thinking, the importance of refining teaching approaches in favor of this thinking and acquiring different strategies that help reach a deep understanding of mathematical concepts, and expose the teacher to more real and virtual contexts that help employ conceptual and procedural knowledge in solving practical problems, especially since algebra is a branch of mathematics that needs more abstraction and generalization. From the researcher's point of view, teachers must be provided with more training opportunities in more areas within the content of algebra, especially since focusing on algebraic thinking requires more formal algebraic methods represented in linking the initial context, providing informal justifications to educational activities that provide more formal learning opportunities, and abstraction free from the real context presented.

The results of the second question support the idea that the training program is effective in improved the areas of productive desire, which adds to the research community results that may be important in focusing on teaching models, which support mathematical prowess, especially with regard to the level of performance of female teachers. Mathematics in the scale as a whole, and perhaps this is consistent with the study of Al-Qarni (2019) in exerting effort, whether from the teacher or the student, in acquiring mathematical knowledge and applying teaching practices that lead the educational process to more innovation and creativity and the study of Stapf and Martin (2019) that teacher education programs have a responsibility to deliver the application of technological integration through the use of the model, so that model structures are better intertwined to improve self-efficacy and how to apply the model in the development of contextual knowledge.

The training program improved the beliefs of the field of "reinforcing that mathematics is meaningful", and provided an opportunity for teachers to evaluate their practices, perhaps consistent with the study of Kartal and Cinar (2022) in that training opportunities, especially with regard to the application of technology, and its interaction with the content of mathematics and its pedagogy, helped improve participants' attitudes towards the conceptual framework of the nature of mathematics, including the study of Bos and Lee (2014) in improving the application of technology and producing a positive attitude as a result of the application of the model. The results are also consistent with Kim's (2017) study in that teachers with constructivist-oriented beliefs in the use of technology showed higher levels in favor of model application. From the point of view of researchers, they believe that the experimental group was higher than the control group in the aforementioned areas in the scale of productive desire as a whole, and is attributed to the application of the training program based on the model, where opportunities were available to help enhance the meaning of mathematics, link mathematics with other sciences, and take into account previous interests and experiences when explaining the content, and the training program according to (TPACK) model provided employment, testing and application of clearly produced desire areas, especially in knowledge of the content of algebra, and the application of content within knowledge.

5. Conclusions

The objective limits were represented in building a proposed training model according to (TPACK) model within algebraic content in accordance with the general framework of mathematics, its standards and performance indicators issued by the Jordanian National Center for Curriculum Development (2021) for primary stage from the fifth basic grade to the eighth grade, and the objective limits in the algebraic thinking test and the limits included Objectivity of the scale of productive desire, and limiting spatial boundaries The selection of the study population of the Directorate of Education for Jerash Governorate, and the human limits were represented in the researchers' selection of an available sample of (36) mathematics teachers from primary stage teachers of the Directorate of Education for the academic year 2022/2023. The direction for further research is:

- diversify the application of (TPACK) model within the content of algebra for mathematics teachers, for different stages, and its reflection on the performance of the teacher and the student.
- diversify the areas of forced thinking within the application of school curricula, and focus on their development for both the teacher and the student.
- apply (TPACK) model in the formulation and design of educational activities that support curriculum and increase the chances of improving performance for both teacher and student.
- link the areas of algebraic thinking and diverse teaching models on the one hand, and the performance of teachers in various topics in mathematics, and their reflection on students and teachers.

Supplementary Materials & Data availability statement: The following supporting information can be downloaded at: within www.emaze.com and the adoption of knowledge supporting the content of algebra within www.wordwall.com and www.Liveworksheet.com.

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