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The effect of a training program based on TIMSS to developing the levels of habits of mind and mathematical reasoning skills among pre-service mathematics teachers

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Abstract

This study aimed to investigate the effect of a training program based on the trends in international mathematics and science study (TIMSS) on developing the habits of mind and mathematical reasoning skills among pre-service math teachers in Oman. The study sample consisted of 24 female pre-service math teachers divided into two equal groups: experimental and control. The study data was collected by sued the mathematical reasoning test and questionnaire that measured the level of habits of mind after appropriate validity and reliability. The study results showed statistically significant differences between the two study groups in favor of the experimental group in the mathematical reasoning test and the habits of mind scale .The study recommended that the need for pre-service math teachers to use programs based on international studies such as TIMSS, PISA, PIRLS, and TAILS; this was done to prove their effectiveness in developing the levels of habits of mind and mathematical reasoning skills by subjecting them to training programs, courses, and workshops with the aim of training teachers to implement the training programs effectively.

Keywords: TIMSS, mathematical reasoning, habits of mind, pre-service mathematics teachers

INTRODUCTION

The teacher is the essential component in the learning process (Coenders & Terlouw, 2015) and is the means to achieving desired goals and objectives. The educator is the backbone of the educational process and the main factor in achieving the and purposes linked to the curriculum and students. The teacher is the actual translator of the curriculum in the classroom, whose role determines the outcomes of the educational process (Jarrah et al., 2020).

As a translator of the math curriculum, the responsibility rests with the teacher in driving the achievement of all educational outcomes, including linking these sciences to the learner's reality and environment. The main goal is no longer thinking but rather the quality of thinking and the development and improvement of the mental habits of the learner (Hetland et al., 2015). In this way, the student can keep pace with the rapid changes happening in the world (Wardat et al., 2021).

One of the roles of the teacher in the educational field is to develop students who will emerge as contributing members of a generation capable of dealing with the challenges of the time (Iivari & Ventä, 2020). This can be achieved by equipping students with multiple and diverse mental habits that will help discover sound solutions using skills and the ability to think, analyze, and use prior knowledge to deal with exciting problems and find appropriate solutions (Wardat et al., 2022; Zaytoun, 2004).

Given the responsibility that falls on the teacher to provide students with the ability to think (Hardin et al., 2015), it has become necessary to adequately prepare the teacher with mental habits that go beyond just possessing information and skills but knowing how to

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Contribution to the literature

- This study contributed to the provision of an integrated training program that would develop the skills of teachers and expand their knowledge base about international tests. In turn, the training would help teachers to improve their teaching of mathematics, which would reflect positively on student performance in the classroom. The theoretical importance of the study is the real field data it provides, which, in turn, warrants the importance of training programs and the impact it may have in raising the level of mathematics teachers' skills.
- This study is one of the few studies in which a training program based on the international study TIMSS was developed to serve pre-service mathematics teachers for the fourth and eighth grades in Oman. The importance of this study stems from need for training towards TIMSS success. Fourth and eighth grade mathematics teachers in particular need to understand the nature of these tests, their importance, the foundations on which they are based, and the topics they cover.
- The practical importance of the study is the benefit it provides to all parties of the educational process.

apply and employ it in different life situations (Costa & Kallick, 2000).

Mathematics is one of the critical, prestigious sciences that contributes to understanding reality (King et al., 2021), dealing with different life situations and contexts, and overcoming problems. The NCTM standards emphasized the need to improve the habits of mind, develop mathematical reasoning skills in various forms among students, and provide math for students as a tool for thinking. And that can only be done through a well-qualified teacher w with higher-order thinking skills that can be transferred to the students and thereby develop (NCTM, 2000). Related to this, Vollrath (2016) pointed out the need for teachers to acquire habits of mind through training using activities and ideas based on the philosophy adopted by habits of mind so that teachers can then integrate these habits into the curricula and classroom situations and further develop them among students (McCarthy, 2020).

Costa and Kallick (2000) indicate that the habits of the mind are the strategic behavior of the individual, and they act intelligently when facing a problem or a controversial situation or when the answer or solution is not available in his knowledge structure. He has insight and perseverance, and he has the skills necessary to face real-life situations, which is a reference to flexibility in thinking, unlike what is known by traditional education systems that focus on knowledge and information narration. Qatami and Amour (2005) lean towards an assumption that the habits of the mind are skills that can be trained, practiced, and developed so that they adapt into a routine for the subject. This habit makes the individual focus their intelligence on a specific direction and exploits all their potential and abilities to reach a solution (Stoica & Wardat, 2021). There are many educational and research points of view in classifying habits of mind, many educators have identified various mental habits according to the diversity of their theoretical orientations, but in this study, the researchers see organizing the habits of mind, as follows:

1. **Thinking flexibility:** Changing and modifying ideas and opinions in light of new data and evidence.
2. **Metacognition:** Thinking about thinking so that the individual becomes more aware of his actions and their impact on himself and others.
3. **Questioning & posing problems:** The ability to find and solve problems and ask questions that would fill the gaps between what the individual knows and what he does not know.

According to Lim and Selden (2009), some proposals help students develop desirable habits of mind. These include involving students in finding solutions to problems, allowing them to express their thoughts publicly and clearly, considering thinking an integral part of the learning experience and education process, and starting to use strategies and setting classroom rules that promote desirable mental habits. These factors all affect students' beliefs, values, practices, and habits, which are necessary for improving students' achievement, especially high-achieving students. However, these practices are not explicitly addressed in schools (Abdallah & Wardat, 2021).

Among the skills that must be emphasized to develop students, and teachers, including pre-service teachers, is mathematical reasoning skills. This is one of the most important mathematical skills a mathematics teacher needs to possess, master, and pass on to his students (Tashtoush et al., 2022). Using mathematical reasoning skills enables students to solve out-of-the-ordinary situations related to sports and life situations in general. This, in turn, requires advanced knowledge and skills rather than knowledge and skills when dealing with more mundane, problems, and issues (Wardat et al., 2022).

Al-Sankari (2003) refers to the advantages of inferential thinking when the transition is made from the known to the unknown. Inferential thinking is a mental process stemming from a premise where logic is required, and a solution is needed. In this way, the student accesses information, solutions, and discoveries.

The researchers believe that this study should be limited to the following three skills of mathematical reasoning: **generalization**, **interpretation**, and **solving problems**.

Steen (1999) holds the view that math teachers can foster different types of thinking and problem-solving skills. One such example is logical-mathematical reasoning. The challenge is that the math curriculum would need to undergo significant major reform, thus implying a complete math review of the way that math is being presented to students. This will never succeed because few teachers are ready for this mental shift in mathematics. As indicated by the trends of international mathematics and science study (TIMSS), math teachers focus on teaching their students how to do math rather than understanding what they do.

One of the essentials to math teachers' most important responsibilities is recommendations on students thinking habits. This is necessary for innovation and reform in math curricula and teaching. It was focusing on thinking skills and considering them as a goal has become and essential to enhance teachers' understanding of modern assessment methods and how to prepare and develop tests. In this context, it is necessary to refer to international tests in light of these habits and higher intellectual skills, including the TIMSS tests (Hamad et al., 2022).

Garden et al. (2006) define TIMSS as a global study that aims to focus on educational policies and systems, study the effectiveness of applied curricula and methods of teaching and their practical application, and assess achievement and provide information to improve the learning and teaching of math and science. This study is conducted under the supervision of the international association for the evaluation of educational achievement, which is held every four years (Garden et al., 2006).

Based on the preceding, Mullis et al. (2005) consider that TIMSS seeks to achieve a number of goals, and the desired benefit of these goals is that it will spread to other countries. These goals are, as follows:

1. We are obtaining comprehensive and internationally comparable data on concepts, processes, and trends of fourth and eighth-grade students in science and mathematics.
2. Assessing international progress in students' learning of mathematics and science in grades four and eight.
3. Identifying aspects of growth and development in knowledge and skills in the mathematical and scientific fields for fourth and eighth-grade students.
4. Monitoring the relative effectiveness of teaching and learning in the fourth grade compared to the eighth by evaluating and reevaluating--grade students in the eighth grade and understanding the contexts in which students learn best.

On the one hand, TIMSS provides an integrated data base necessary to support the development process. On the other hand, it aims to improve policies to assess and direct new educational strategies. In light of the preceding, producing qualified teachers, providing ongoing training, and developing mathematical skills, habits of mind, and sound reasoning skills is of paramount importance. This is necessary to improve the quality of education and raise the math achievement level of all participating countries. Because modern educational systems have begun to move towards a broader and more permanent basic learning system, researchers have started to pay attention to educational strategies to place learners in rich and thought-provoking environments, which is the philosophy adopted by habits of mind (Qatami & Amour, 2005).

Accordingly, the researchers have prepared a training program TIMSS-based that can contribute to developing the levels of habits of mind and mathematical reasoning skills among pre-service math teachers. It is hoped that the impact will be reflected in all participating students, as evidenced in previous similar studies (Burroughs & Luebeck, 2010; Dede & Karakus, 2014; Rasheed & Tashtoush, 2021; Tashtoush et al., 2020a, 2022), this study will provide an opportunity to verify its effect.

Problem Statement

Those working in the educational field know math increasing importance. Because of the many challenges students face in learning math, leads to other learning problems that negatively affect their overall learning. to teach. It becomes an even greater challenge for teachers under these circumstances. This is evident from observations in the educational field and the results of international studies and previous educational literature that these reasons can be attributed to the weakness of math teachers not possessing adequate mathematical reasoning skills and the lack of training programs and strategies that contribute to raising their level of competence in various areas of cognitive thinking skills and mathematical reasoning. Through the observations of some researchers, as well as practical experience in working with students of varying levels, and through participation in international and local tests, it was observed that math teachers, in general, lack a set of skills, attitudes, and values that constitute good habits of the mind, mathematical reasoning, and thinking skills. The lack of familiarity with these math-related concepts by teachers in general and pre-service math teachers in particular, in addition to weakness in understanding the importance of TIMSS, opens the gateway to a path of the necessary research to address and possibly change and improve the situation.

TIMSS test results generally indicate a low level of student achievement in math and that the Sultanate of Oman is the same as all sharing countries. A training program for pre-service math teachers who teach fourth and eighth-grade students was drafted to investigate the effect of this training program TIMSS-based to developing the levels of habits of mind and math reasoning skills among pre-service math teachers. More specifically, the problem of the study was represented in the following two questions:

1. What is the effect of the training program TIMSS-based to developing the *levels of habits of mind* for pre-service math teachers?
2. What is the effect of the training program TIMSS-based to developing the *mathematical reasoning skills* of pre-service math teachers?

Study Significance

The importance of this study stems from a need for training toward TIMSS success. Fourth and eighth-grade math teachers, in particular, need to understand the nature of these tests, their importance, the foundations on which they are based, and the topics they cover. This study is also one of the few studies in which a training program TIMSS-based was developed to serve pre-service math teachers for the fourth and eighth grades in Oman. For pre-service teachers, the current study contributed to the provision of an integrated training program that would develop the skills of teachers and expand their knowledge base about international tests. In turn, the training would help teachers improve their math teaching, which would reflect positively on student performance in the classroom.

Objective of the Study

This study aims to detect the impact of a training program TIMSS-based to develop the levels of habits of mind and sub-skills (thinking flexibility, metacognition, and questioning & posing problems) among pre-service math teachers. In addition, it provides recommendations and proposals that could play an important critical essential role in developing mathematical reasoning skills and advancing the levels of mind habits of pre-service math teachers in particular and mathematics teachers in general for various academic levels.

Procedural Definitions

1. **Training program TIMSS-based:** A set of processes, activities, and procedures designed in the light of the TIMSS international study that will be provided to pre-service math teachers who teach fourth and eighth-grade students.
2. **Habits of mind:** A set of mental skills that pre-service teachers should possess and practice in the classroom and develop among students can be strengthened among pre-service teachers through training courses and programs.
3. **Flexible thinking:** The individual's ability to look at the subject from different angles and e aspects to generate alternatives and solutions to situations, problems, and issues facing him.
4. **Questioning & posing problems:** The individual's ability to ask questions and formulate the problem accurately so that the information collected helps fill the gaps in the knowledge building.
5. **Metacognition:** The individual becomes more aware of his actions and the impact of those actions on him, others, and the surrounding environment, and that the individual forms internal questions through which he searches for information and meaning.
6. **Mathematical reasoning:** A process through which the learner can organize ideas to reach generalizations, access errors, discover and modify them, give convincing justifications, and be creative in solving ordinary problems.
7. **Generalization:** Reevaluate the results in more general and applicable terms.
8. **Interpretation:** Combining a set of mathematical procedures to determine the results and linking these results to reach more general results and linking concepts and interpreting them based on previous experiences necessary to learn them.
9. **Problem solving:** Solving mathematical problems or unfamiliar life situations in various ways and using multiple strategies.

LITERATURE REVIEW

By reviewing previous studies, it was found that many studies dealt with the importance of training programs for develop thinking skills for teachers and students. Many studies have dealt with the habits of mind by building training programs based on the habits of mind or knowing the effects of training programs on developing habits of mind among students or teachers. There are no studies dealing with the design of training programs regarding TIMSS. The lack of studies in this area warranted a study on pre-service teachers. Based on what was established, it was concluded that a necessary study needed to be conducted among pre-service math teachers; this is the most important of this study.

Burroughs and Luebeck (2010) conducted a study that presented qualitative evidence to answer the questions, "What are the outcomes of engaging pre-service and in-service teachers in a collaborative lesson study experience" and "How can the outcomes of this experience inform future ways to include pre-service teachers in lesson study?" The results conclude that enhancing design thinking can improve metacognition

and promote design thinking that promotes a good interaction between the pre-service teacher and the student. It can inspire pupils to think like instructors and allow them to be critical thinkers in the context of math education. Although the results were positive, there were still a few issues like poor use and application of technology, especially in algebra, and both categories of teachers not being in sync with predictability and past experiences of the students and thus unable to apply it in conception of the subject.

An outlook was done in order to determine the effects of teacher training programs on pre-service math teachers' beliefs about math that included a study sample of 173 pre-service math teachers from a Turkish education faculty in the Central Anatolia Region. The overall results leaned towards, a more depressed population of pre-service teachers who did not experience difference, whether with the regular training or the tactical mathematical approach. Although it is vital to point out that despite this, the senior class showcased a more established belief in mathematics than previously (Dede & Karakus, 2014).

Agyei and Voogt (2014) conducted a study about pre-service math teachers' learning and teaching of activity-based lessons supported with spreadsheets; pre-service math teachers worked in teams to develop their knowledge and skills in designing activity-based lessons supported by spreadsheets. The pre-service teachers developed and demonstrated their knowledge and skill adequately during the design and enactment of their lessons. The results showed that the activity-based lessons supported by spreadsheets served a functional pedagogical approach, impacted student learning outcomes, and could improve teaching and learning math in secondary education. The results concluded that metacognition combined with habitual development is one of the best approaches to improving a mathematical issue.

A study that investigated the mathematical content knowledge (MCK) of two primary pre-service teachers during their practicum experiences in the first, second, and fourth years of a four-year Bachelor of education program was conducted to see the effects of the TIMSS training program. The findings show when and under what circumstances pre-service teachers formed various categories of MCK during practicum. A program structure that provided breadth and depth of experiences, continuous engagement for learning MCK, and quality of pre-service teachers' learning experiences were all factors that helped pre-service teachers develop their MCK. The mathematical reasoning through the training was greatly enhanced, although in a more tactical and rational approach (Livy et al., 2016).

Ibrahim et al. (2020) employed a qualitative research design; 30 pre-service mathematics teachers were questioned about their math learning needs in a qualitative study approach. The study's findings revealed that the training's learning experiences were appropriate. Still, there was a gap between the training curriculum and the school math subject matter that pre-service teachers were trained to teach. Pre-service math instructors have described the program's lecturers as unsupportive, which has prevented them from engaging in active learning. This recommends that the program incorporate a school mathematics curriculum for pre-service math teachers to get the subject matter expertise they have been educated to teach. The program's lecturers should adjust their attitudes and behaviors that could harm the learning of pre-service math instructors. Clearly it is evident that the training needs a great adjustment, especially in habits of mind for effective and efficient adoption.

METHODOLOGY

The current study adopted the quasi-experimental approach, where the researchers constructed a training program TIMSS-based that would include activities, skills, and math tasks that would simulate TIMSS-type tests. The training program used would be aimed at training pre-service math teachers.

Population and Sample

The study population consisted of fourth and eighth-grade pre-service female math teachers in public schools in Oman at the North Al Batinah Governorate during the second semester of the academic year 2021/2022. The study sample was selected by the cluster method from the higher diploma program at Sohar University. Nine schools for females were selected. Those schools were visited, and the pre-service female math teachers' desire to participate in this study was confirmed. The sample size was 24 pre-service female math teachers, and they were randomly divided into two equal groups: experimental and control.

Training Program TIMSS-Based

After reviewing previous theoretical and educational literature and previous studies (Ibrahim et al., 2020; Livy et al., 2016; Makamure & Jita, 2019; Tashtoush, 2020b; Tinh et al., 2021) and the mechanism for building training programs, a design was made in light of this. The training program TIMSS-based had the following three main components:

1. **Preparation of the training program:** The training program was prepared and released in its final form after verifying its validity and reliability. At this stage, a set of elements were identified through which the program was built, which are, as follows:
    a. Defining the main objective of the program and the sub-objectives, which is to deepen the understanding of the pre-service teacher's

parameters of the TIMSS international study, its directions, the vision for this study, the nature of the tests, and the topics covered.

b. We are identifying learning resources such as books, references, studies related to international exams, electronic resources, and others.

c. It was determining the knowledge content or the training package that includes math concepts, topics, activities, booklets, samples from previous international tests, books from the curricula that are taught to students, and samples of previous tests.

d. Determining teaching methods and teaching tools such as the lecture method, discussion with pre-service math teachers, learning through play by posing life problems and trying to find solutions to them, presentations, and brainstorming sessions.

2. **Implementation of the training program:** The program was implemented,. The pre-service math teachers agreed on the appropriate schedule to implement the program as well as, pre-service math teachers agreed on the appropriate schedule to implement the program. The pre-service math teachers agreed on the appropriate schedule, and a mutually agreed period required to implement the program.

3. **Assessing the performance of the pre-service teachers:** The achievement of the educational program objectives that were previously identified was evaluated by providing immediate feedback during the pre-service training of the teachers and successively after the implementation of each activity and a final evaluation of what was presented in the session. At the end of the program, a final evaluation was made, and at the end of the program, the post-application of the study tools used was done. Given the nature of TIMSS, as represented in the set of goals that were previously mentioned, two criteria were used to achieve the TIMSS training objectives:

a. The content standard defines the knowledge that fourth and eighth graders should possess to describe topics and concepts in the mathematics curriculum. This standard includes numbers, operations, algebra, geometry, data, and probability.

b. The standard of operations describes how to use and apply knowledge and deal with content to apply these skills that allow for the acquisition of, access to, and use and application of real-life situations. This standard includes knowledge, application, and inference.

Based on these criteria, the training program was built to achieve the desired goals, and the pre-service teachers were trained towards TIMSS. The topics that were trained on were identified and selected according to the international tests included in the curriculum for the 4th and 8th grades, which are, as follows:

1. **Numbers and operations:** The topic of total numbers was addressed, which included understanding whole numbers, four arithmetic operations, percentages, and decimals, and solving problems using whole numbers.

2. **Algebra:** Algebraic expressions and operations dealing with solving problems and finding the value of the algebraic expression by giving a value to the variables and simplifying algebraic expressions that contain addition and multiplication were discussed.

3. **Geometry:** Locating a point and solving problems on points in the Cartesian plane.

4. **Statistics and probability:** The comparison of comprehensive data features of mean, median, mode, range, and the shape of distributions in general, calculating the arithmetic mean, median, mode, range, interpretation of results, and problem-solving was determined.

The validity of the training program TIMSS- based was also verified by presenting it to a group of arbitrators specialized in math curricula, teaching methods, and measurement and evaluation. Educational supervisors were consulted to express their observations about the training program's quality and content and measuring the objectives set and within the set time period. Based on these observations and suggestions, the program was produced in its final form.

Instruments

The habits of mind scale

By reviewing the theoretical and research literature, as well as looking at some scales of habits of mind in math (Assadi & Hibi, 2020; Berisha & Vula, 2021; Fannakhosrow et al., 2022; Tinh et al., 2021;), a standing scale was prepared at the form of a questionnaire according to the 5-choice Likert scale, that consisted of 30 items that included three sub-scales (thinking flexibly, metacognition, and questioning & posing problems), with a maximum score of 150 and a minimum score of 30.

To determine the levels of the habits of mind, the researchers purposefully categorized them according to **Table 1** by rotating out the division of the scale's degree range over the number of its five levels (did not practice habits of mind, rarely practices habits of mind, practices some habits of mind, practices habits of mind, practices habits of mind significantly), according to the following two equations:

Table 1. Classification of the levels of habits of mind

Level	Classification	Description
0	Did not practice the habits of mind	If the teacher got a score between 30 and 53
1	Rarely practices the habits of mind	If the teacher gets a score between 54 and 77
2	Practices some habits of mind	If the teacher gets a score between 78 and 101
3	Practices habits of mind	If the teacher gets a score between 102 and 125
4	Practices habits of mind a lot	If the teacher gets a score between 126 and 150

$$\text{Scale degree range}=150-30+1=121 \quad (1)$$

$$\text{Class length for each level}=121\div5=24.2\approx24 \quad (2)$$

To verify the validity of the scale, it was presented to expert arbitrators of university professors specialized in educational psychology, measurement, and evaluation, math curricula and teaching, as well as a group of educational supervisors belonging to the fields of study. Based on the arbitrators' opinions, the amendments were made until the scale took its final form.

To verify the reliability of the scale, it was applied to the exploratory sample, the reliability coefficient was calculated by using the test-retest method, and it was applied twice with a time difference of two weeks between the two applications. Correlation for the scale was 0.931, and for each sub-scales (thinking flexibly, metacognition, and questioning & posing problems) was found 0.914, 0.896, and 0.923, respectively. These values confirms that the scale has reliability indications that allow it to be used in this study (Odeh, 2014).

Mathematical reasoning skills test

Mathematical reasoning skills test was prepared by reviewing the theoretical and research literature (Agyei & Voogt, 2014; Livy et al., 2016; Tashtoush, 2013; Tashtoush et al., 2020a, 2022), where the test consisted of 30 multiple choice items. The test included various mathematical tasks; according to the first 4-levels of Bloom's knowledge (remember, understand, apply, and analyze), the value of the scores on the test ranged from 0 as a minimum to 30 as a maximum.

To verify the validity of the test, it was presented to an experts arbitrators, including university professors specialized in math, math curricula and teaching methods, measurement, and evaluation; they were asked to express their opinions about the test, suitability of tasks to the areas they measured, as well as their scientific and linguistic accuracy. Based on the arbitrators' opinions, and according to their opinions, some items of the test were modified until they morphed into their final form. The difficulty and discrimination coefficients of the test items were also calculated by applying it to the exploratory sample, the coefficients of discrimination range in values between 0.48 and 0.86, and the coefficients of difficulty range in values between 0.58 and 0.82. Therefore, they are appropriate and acceptable for this study (Odeh, 2014).

To verify the reliability of the test, it was applied to the exploratory sample the reliability coefficient was calculated using the test-retest method, and it was applied twice with a time difference of two weeks between the two applications. The values of the Pearson correlation coefficient were calculated between the degrees of the total pre-service teachers in both applications, and it was found 0.862, which confirms to be used for this study (Odeh, 2014).

Procedures

The theoretical and research literature related to the subject of this study was reviewed and used to prepare the study tools and the training program TIMSS-based. The study tools were prepared in their initial form, and judged to ensure their validity and reliability, then reformulated and modified based on the arbitrators' opinions. They, to ensure their validity and reliability, then reformulated and modified based on the arbitrators' opinions, and produced in their final form. The study tools were applied to the exploratory sample that was selected, the validity, reliability, coefficients of difficulty and discrimination were calculated with a time difference of two weeks between the two applications. The 1st author trained the experimental group on the training program TIMSS-based at the accredited training center at Sohar University for four weeks, at a rate of two meetings per week with eight lectures of 75 minutes each, while the control group did not receive any kind of training. Finally, the habits of mind scale and the math reasoning test were analyzed using the SPSS program to answer the study questions, compare them with previous studies' results and provide suggestions and recommendations.

Informed consents were obtained from all participants before they were involved in the study. Applicable ethical procedures, under the guidance and supervision of the first author's institutional ethics committee, were followed.

Data Analysis

For statistical analysis, the data was entered and analyzed using the SPSS, as follows: The test of two independent proportions using the Chi-square test for independence revealed the levels of habits of mind, The means and standard deviations of the pre-service teachers' scores were extracted to reveal the apparent differences of the means, and (MANCOVA) was used to analyze the results of the mathematical reasoning test.

Table 2. Numbers and percentages of teachers according to the levels of habits of mind

Group	Application	Levels of habits of mind										X^2	Sig.
		Level 0		Level 1		Level 2		Level 3		Level 4			
		No	Percent	No	Percent	No	Percent	No	Percent	No	Percent		
Control	Pre	2	16.6	5	41.6	5	41.6	0	0.0	0	0.0	4.11	0.025
	Post	2	16.6	5	41.6	4	33.3	1	8.3	0	0.0		
Experimental	Pre	3	25.0	4	33.3	5	41.6	0	0.0	0	0.0	11.91*	0.005
	Post	0	0.0	1	8.3	4	33.3	5	41.6	2	16.6		

Note. *Significant (α=0.05) & $X^2(1, 4)=9.94$

Table 3. Means and standard deviation for the mathematical reasoning test

Group	Application	Statistic	Mathematical reasoning skills			Test overall
			Generalization	Interpretation	Problem-solving	
Control	Pre-test	Mean	3.66	4.38	3.98	11.93
		Standard deviation	1.08	1.48	1.35	3.12
	Post-test	Mean	3.75	4.88	4.08	12.23
		Standard deviation	1.25	1.75	1.59	3.41
Experimental	Pre-test	Mean	3.89	4.58	4.28	12.07
		Standard deviation	1.15	1.56	1.35	3.12
	Post-test	Mean	7.59	7.86	7.15	19.38
		Standard deviation	3.19	3.11	3.06	5.94

FINDINGS

Results of the First Question

The first question aimed to reveal the habits of mind among the pre-service female teachers before and after training on the TIMSS-based training program for the two study groups. The percentages of pre-service math female teachers were extracted according to the classification of the levels of mind habits in light of the tribal and remote mind habits scale results for the two study groups using the Chi-square test for independent ratios, and **Table 2** shows this.

Table 2 shows clear progress in the levels of the pre-service math female teachers on the scale of the habits of mind of the experimental group and that the levels of the pre-service math female teachers in the experimental group were better than the levels of the pre-service female teachers in the control group, specifically at the third level (practice habits of mind) and the fourth level (practice habits of mind greatly), as the percentage of pre-service teachers in these two levels together in the experimental group reached 58.2%.

In contrast, only one teacher reached the third level in the control group and no teachers from the control group in the fourth level. For the third level (practice habits of mind), the results showed an improvement for teachers compared to the control group, where the percentage of pre-service teachers at this level was 41.6% for the experimental group. Compared to 8.3% for the control group, their percentage before training was 0%.

The results also showed an improvement in the level of habits of mind for the experimental group for the three lowest levels (did not practice habits of mind, rarely practice habits of mind, and practice some habits of mind) through a decrease in their percentage compared to the control group, where the proportions of the teachers reached 0%, 8.3%, and 33.3%, respectively, compared with the percentages of teachers in the control group (16.6%, 41.6%, and 33.3%).

Results of the Second Question

The second question aimed to reveal the impact of the training program on developing the study sample's mathematical reasoning skills before and after its application to the two study groups. **Table 3** shows this.

It is clear from **Table 3** that the levels of the pre-service teachers in the pre-application were somewhat similar for the two study groups, while in the post-application of the mathematical reasoning skills test, it appears that there is a clear improvement in the teachers on the whole test and in each sub-skills (generalization, explanation, and problem-solving) for the experimental group, but the results of the experimental group were much better than the results of the control group that was not exposed to the training program, as it was found that there were apparent differences for the experimental group in the post-application of the mathematical reasoning skills test as a whole and each skill, the mean of the mathematical reasoning skills (generalization, interpretation, and problem-solving) and for the test as a whole for the experimental group was 7.59, 7.86, 7.15, and 19.38, respectively, while it was for the control group 3.75, 4.88, 4.08, and 12.23 on the arrangement.

To find out whether these apparent differences are statistically significant, the accompanying MANCOVA was used, and the effect size was calculated to test the mathematical reasoning skills test as a whole, and for each sub-skills (generalization, interpretation, and

Table 4. Results of MANCOVA and the effect size for the mathematical reasoning test

Source of variance	Skill	SS	df	MS	F	Sig.	η^2	Effect size
Accompanying	Generalization	169.32	1	169.32	10.08	0.000	0.503	
	Interpretation	148.65	1	148.65	9.76	0.005	0.417	
	Solving equations	118.04	1	118.04	10.81	0.005	0.550	
	Overall	406.12	1	406.12	11.77	0.027	0.574	
Dimensional	Generalization	125.32	1	125.32	7.46	0.002*	0.273	Large
	Interpretation	72.95	1	72.95	4.78	0.029*	0.206	Large
	Solving equations	68.71	1	68.71	6.29	0.017*	0.263	Large
	Overall	175.25	1	175.25	5.07	0.000*	0.315	Large
Error	Generalization	352.62	21	16.79				
	Interpretation	319.98	21	15.23				
	Solving equations	229.25	21	10.91				
	Overall	724.55	21	34.50				
Total modifier	Generalization	557.25	23	24.22				
	Interpretation	448.12	23	19.48				
	Solving equations	421.03	23	18.30				
	Overall	1235.22	23	53.70				

Note. *Significance level (α=0.05)

problem solving) in the post-application of the two study groups after neutralizing the effect of their pre-application, **Table 4** shows this. **Table 4** shows that there are statistically significant differences at α=0.05 between the means of the two study groups in the mathematical reasoning skills as a whole and for each sub-skills (generalization, interpretation, and problem-solving) due to the impact of the training program versus the traditional method, all the differences came in favor of the experimental group that was exposed to the training program.

In order to reveal the effectiveness of the training program in developing the mathematical reasoning skills of the pre-service teachers, the effect size was found using the eta-square (η^2), which was found to be greater than 0.14, which means that the effect size is large (Afana, 2000) for the mathematical reasoning skills test and each sub-skills (generalization, interpretation, and problem-solving).

CONCLUSIONS

The low levels on the tribal habits of mind scale for the two study groups may be attributed to the lack of knowledge of the pre-service teachers with the international test standards. As the focus of the teachers was essentially on traditional mental practices and habits, and for the same reason, this may explain the results of the control group teachers in the post-test as well, even though 41.6% of the teachers of this group are within the first level (the habits of mind are rarely practiced). It is noted that this percentage decreased for the female teachers of this group on the post-test within the second level (practice some habits of mind).

It is noted from the previous results an improvement in the levels of mind habits of the pre-service female teachers of the experimental group on the post-test, and this may be due to the reflection of the impact of the training program. The pre-service teachers who underwent the training program and got acquainted with the international test standards were of greater benefit to their students because of the training they had undergone.

Teachers who did not undergo the training program to develop the levels of habits of mind on the NCTM standards and the international test standards that stem from NCTM standards did not perform as well as the group who had undergone training. This result can also be explained by the fact that training through the training program TIMSS-based has contributed to improving and advancing the levels of habits of mind for pre-service teachers. Because of the training in which problem-solving was emphasized, pre-service teachers could find and solve problems, raise questions and new ideas, change ideas and opinions, and modify those considering the latest data and evidence. The levels of habits of mind of the experimental group progressed. The results showed that 58.2% of the teachers reached the level of their mental habits of the third level (practice habits of mind) and the fourth level (practice habits of mind significantly), which constitutes more than half of the teachers. This is consistent with many previous studies that indicated the effectiveness of using training programs in developing the levels of habits of mind (Agyei & Voogt, 2014; Al-Jizani & Warad, 2012; Fannakhosrow et al., 2022; Makamure & Jita, 2019; Tashtoush et al., 2022; Tinh et al., 2021).

The results came with a greater positive effect in favor of the experimental group that was exposed to the training program TIMSS-based as compared to the control group that was not exposed to it. Operations and students' attitudes, assessing the progress achieved internationally in students' learning of math, identifying aspects of growth and development in knowledge and

skills in the mathematical and scientific fields for 4th and 8th-grade students, and self-critiquing by asking questions, all reflected the effective participation of pre-service teachers. By asking questions and exchanging views on how to achieve TIMSS objectives, pre-service teachers were found to be more effective.

In reviewing the results of the study, the conclusion reached was that training programs to prepare and qualify pre-service teachers by enhancing their knowledge of international test standards and objectives is one of the successful teaching strategies in developing mathematical reasoning and sub-skills (generalization, interpretation, and problem-solving). It has become clear that traditional math teaching environments do not give enough attention to activities that are characterized by novelty, modernity, diversity, that is rich in ideas and moving away from stereotypes.

The main conclusion of the current study, thus, taking into consideration the effectiveness of the training program TIMSS-based shown by this study, the recommendation is that math teachers, in general, participate in effective training programs and teaching strategies. This is consistent with the recommendations of many previous studies that indicated the effectiveness of using training programs and teaching strategies in developing mathematical reasoning and its sub-skills, such as the study of Abdallah and Wardat (2021), Assadi and Hibi (2020), Berisha and Vula (2021), Burroughs and Luebeck (2010), Higgins et al. (2016), and Livy et al. (2016); so, it is necessary to note to the planners of the math curriculum the importance of focusing on developing mathematical reasoning and sub-skills among pre-service and in-service math teachers, by subjecting them to training programs, training courses, and workshops to train them on how to use appropriate teaching strategies and programs, especially those based on international studies such as TIMSS or PISA.

In addition, the need to include activities and tasks in the math curriculum that would develop mathematical reasoning and improve the various habits of mind should be considered a major positive factor in achieving math success.

Limitations

1. This study is limited to identifying the effect of a training program TIMSS-based on developing the levels of habits of mind and mathematical reasoning skills among pre-service math teachers.
2. This study reliability psychometric properties of validity and reliability acceptable for was determined by its tools and psychometric properties of validity and reliability that are acceptable for scientific research purposes, which were prepared to achieve the study's objectives.

Recommendations

The researchers recommend conducting similar studies to develop other mathematical reasoning skills not addressed in this study. Conducting more studies that deal with preparing training programs that help pre-service teachers to develop mathematical reasoning and its various skills and to develop the habit of minds–using some models of international tests and TIMSS tests to train teachers and students on international tests to develop the level of the habit of mind and mathematical reasoning skills.

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