Hindawi
Education Research International
Volume 2023, Article ID 4475027, 8 pages
https://doi.org/10.1155/2023/4475027

Research Article

New Teachers' Awareness of Mathematical Misconceptions in Elementary Students and Their Solution Provision Capabilities

Mansooreh Moosapoor

Department of Mathematics Education, Farhangian University, P.O. Box 14665-889, Tehran, Iran

Correspondence should be addressed to Mansooreh Moosapoor; m.mosapour@cfu.ac.ir

Received 31 March 2023; Revised 8 July 2023; Accepted 13 July 2023; Published 27 July 2023

Academic Editor: Goutam Saha

Copyright © 2023 Mansooreh Moosapoor. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Misconceptions are among the barriers that prevent students from mastering mathematics. Since teachers are essential in student education, their awareness of misconceptions helps students to learn effectively. Therefore, it is crucial to know whether teachers, especially new teachers, are capable of identifying and resolving misconceptions. The purpose of this study is to determine the degree of mathematical misconceptions awareness among the new teachers of elementary schools in Iran and their ability to provide solutions. The sample consisted of 225 new teachers who graduated from Farhangian University and worked in Gilan province, Iran. We used a multiple-choice questionnaire, followed by a semistructured oral interview, to gather data. Findings revealed that the degree of mathematical misconceptions awareness in 78.2% of new teachers is at "good" and "very good" levels. On the other hand, 72.9% of teachers have a "weak" to "medium" solution provision capability when faced with misconceptions. Also, there is no discernible difference between gender and mathematical misconceptions awareness. The study showed a significant association between new teachers' knowledge of mathematical misconceptions and their ability to address them. By highlighting the abilities and limitations of teachers in spotting and correcting students' misconceptions, the study's findings serve as a basis for reform in teaching and learning mathematics.

1. Introduction

One of the subjects taught at every level of education is mathematics. Students are introduced to mathematics from an early age [1, p. 1]. According to teachers, academics, and researchers, there are severe issues in mathematics education [2, p. 1]. Despite the efforts of education officials, Iranian elementary students perform poorly in mathematics on TIMSS tests [3, 4].

In the learning process, students tend to misunderstand concepts. These misunderstandings are called misconceptions [5]. Studies show that the elementary school students face misconceptions about scientific topics [6]. Misconceptions are among the most important barriers to learning mathematics [7, p. 21]. Some of the leading factors of misconceptions are poor instruction, improper reasoning, and poor memory [8]. In addition, misconceptions may happen due to the failure to connect old and new concepts [9, p. 3]. In a study titled "Identifying the Common Misconceptions of Fourth-grade Elementary Students in the Content Area of Geometry and Measuring and Comparing Their Performance with the Average Performance at the International Level," Bakhshalizadeh and Boroujerdian [10] investigated the performance of Iranian fourth-grade students in geometry and measuring sections of TIMSS math tests in 2003, 2011, and 2015. As a result, they proved that Iranian fourth-grade students struggle with the conceptual and procedural misconceptions.

According to Duran [11], elementary students learn many fundamental concepts in preparation for later mathematical concepts, so elementary students must be investigated more in the research on misconceptions. Thus, it is important to know students' prior knowledge and develop new strategies accordingly [7, p. 21].

Identifying misconceptions is a fundamental step in solving them; however, identification is not very effective without having solutions to solve the misconceptions. According to many scholars, such as Zuya and Kwalat [12], Sanagi [13], and Mishra [14], teachers and their professional capabilities play an essential role in the learning process. Al-Khateeb [15] suggested that besides investigating students' misconceptions,

we must investigate teachers' awareness of misconceptions and study the effectiveness of their teaching.

An adequate education will not be achieved unless the teachers are aware of the misconceptions and equipped with solutions to resolve the misconceptions. In fact, after measuring teachers' familiarity with misconceptions, we should check their capability to provide solutions and resolve misconceptions. This will help policymakers and key stakeholders in educational provision to fix weak performance and deficiency in these fields. Also, the results of such research familiarize teachers with their strengths and weaknesses, allowing them to improve their weaknesses, which ultimately leading to better education for the students. University education provides knowledge and theoretical skills in the field of mathematics education to student teachers of elementary school. The question is whether the knowledge and skills taught to student teachers are sufficient enough to identify and resolve mathematic misconceptions when they start working in schools.

The core purpose of this research is to study the teacher training curriculum, the level of familiarity with mathematic misconceptions, and the capability of providing solutions to these misconceptions.

Bakhshalizadeh [16, p. 74] divides the misconceptions of Iranian elementary school students in TIMSS tests into 11 categories: misconceptions of natural numbers, of operations with natural numbers, of fractions, of operations with fractions, of decimal numbers, of operations with decimal numbers, of algebra, of measurement, of geometry, of working with data, and of operations on data.

Since elementary mathematics forms the scope of this research, natural numbers and operations, fractions and operations, measurement, and geometry were studied in accordance with the new elementary school teachers' awareness of the misconceptions in above mentioned categories. Also, the new teachers' capability to provide solutions in facing misconceptions and the effect of teachers' gender was investigated in this context.

2. Review of the Related Literature

2.1. Theoretical Background. Many scholars have conducted research to identify mathematical misconceptions [16–19]. The analysis of these studies helps us identify the problems of facing misconceptions and mistakes [20, p. 112].

Numbers are significant and challenging for math teachers, researchers, and educationists [21, p. 206]. Sometimes the pupil misunderstands the place value of the numbers. i.e., the student is unaware that a digit's value is determined by its position in the representation of a natural number [16, 22]. Other concepts that students seem to struggle with are subtractions [23, p. 1] and zero in arithmetic operations [22, 24]. Arithmetic goes beyond dealing with numbers. It includes spatial understanding, pattern, measurement, abstract thinking, and reasoning [14, p. 936]. So it is vital to consider misconceptions in other areas too.

Fractions are an important reoccurring concept both in elementary-level mathematics and everyday life [25, 26]. Some pupils have trouble distinguishing a unit fraction because they regard it as a comparison of "part with part" rather than "part of the total" [16–18]. Sometimes, pupils experience misconceptions in executing fractional operations. For instance, to get the sum of fractions, students mistakenly extrapolate the concept of adding integers to the sum of fractions and add the denominators and numerators together [1, 18, 20, 27]. Similarly, there is a misconception regarding subtracting fractions [1, 8, 28]. When multiplying two fractions with identical denominators, students who struggle to grasp the notion of multiplication or generalize the idea of addition to multiplication might write one of the denominators and multiply the numerators together [23, 24, 29].

For measuring length, an item is divided into pieces and counted [30, p. 188]. Sometimes, pupils do not understand the origin concept and while using a ruler, simply focus only on the endpoint of the object [22, 31].

Geometry is a fundamental branch of mathematics [12, p. 100]. The study of geometry is a crucial component of studying mathematics because it gives pupils the skills to examine, comprehend, and utilize their surroundings and other areas of mathematics. Therefore, pupils must have a solid knowledge of basic geometrical ideas and associated abilities [32, p. 721]. Another area of confusion is the identification of parallel lines, which leads to misconceptions [2, 12, 22]. The incorrect identification of symmetrical lines, length, perimeter, and volume are other misconceptions found in the TIMSS test [4, p. 70, 31, 33, 34].

Teachers play a crucial part in the process of education. They have an essential and influential role in forming students' misconceptions [13, p. 104]. Due to the significance of elementary periods, teachers must continually refine their instructional techniques and knowledge [17, p. 16]. An et al. [35] established a reciprocal link between a teacher's pedagogical knowledge and the lessons she/he provides, as well as the teachings and students' thought processes. Teachers' professional abilities directly impact students' learning and the misconceptions [17, p. 16].

In his study, Kargari Sisi [36] studied why male fourth-graders in elementary schools misunderstood some of the arithmetic problems on the 2015 TIMSS test. After comparing the levels of misconceptions between the experimental and control groups, it was shown that using effective teaching methods for mathematics lessened misconceptions. Kusmaryono et al. [17] studied 30 elementary teachers in the first through sixth grades with 4–20 years of experience. The findings showed that teachers' misconceptions in teaching mathematics include preconception, undergeneralization, overgeneralization, modeling error, and prototyping error.

Having a deep understanding of mathematical knowledge is necessary but not sufficient to teach mathematics. Thus, today's teachers are experiencing major changes in how they teach [14, p. 936]. It is required to have enough knowledge in mathematics education, and teachers need to pass specialized courses to be successful in education [3]. To better understand teachers' pedagogical content knowledge (PCK), it is necessary to study the impact of teachers' backgrounds, such as teaching experience [37]. Therefore, we need researches examining the specialized knowledge of mathematics and the teacher's

capability to teach. As a result, we can identify the possible shortcomings and take actions to fix them.

2.2. The Current Study. Although much research has been done on teachers' understanding of mathematical misconceptions, very little research has been done on the level of familiarity of new elementary school teachers with mathematical misconceptions and specifically comparing male and female new teachers together.

Also, according to the author's knowledge, there has been no research on the ability of new elementary school teachers to provide solutions and resolve mathematical misconceptions. In addition, the relationship between teachers' knowledge and their ability to provide solutions is addressed in this research. The present article is an attempt to solve this research gap.

The results of this research will help educationists and teacher training administrators to present the best educational planning necessary in the field of mathematics education for student teachers and new teachers, which in turn will lead to better performance in teaching mathematics to the elementary students and result in better learning of mathematics.

This study will address the following questions:

(1) To what extent the new teachers of elementary schools are aware of the misconceptions revealed by the previous studies and the TIMSS tests?
(2) What level of expertise do new elementary school teachers have in addressing learners' mathematical misconceptions?
(3) Is there a significant relationship between new elementary school teachers' ability to provide clarification in the face of misconceptions and their familiarity with such misconceptions?

3. Materials and Methods

3.1. Research Approach. This study is considered applied research since its goals can be met by enhancing the mathematics teaching in elementary schools. Additionally, it uses a descriptive strategy for data collecting because it explains the current circumstance and keeps the present in mind.

3.2. Participants. In the field of teacher training, Farhangian University is one of the most important universities in Iran. It holds the most graduated teachers in the field of elementary education. The statistical population studied in this research included 547 male and female elementary school student teachers of Farhangian University who are currently working as teachers in Gilan province. These new teachers had between 2 and 4 years of teaching experience. We determined the sample size using Cochran's formula of 225 people, because female and male teachers were present in the statistical population. We chose a stratified random sampling method, proportional to the volume, to select the statistical sample. As a result, according to the number of female and male teachers in the statistical population, we determined that the sample included 89 men and 136 women. Then, new teachers were randomly selected from the men and women. In this way, we prepared a list of male and female teachers working in nine cities of Gilan province. And according to the number of teachers working in each city, we randomly selected some new teachers from the lists.

Table 1: Misconceptions awareness rating.

Score	0–8	9–12	13–16	17–20
Misconceptions awareness	Weak	Intermediate	Good	Very good

3.3. Instruments for Data Collection. Due to the lack of standardized instruments, we designed a researcher-made questionnaire of TIMSS test questions. We considered the following four misconception hot spots because the concepts related to natural numbers and operations, fractions and operations, measurement, and geometry are present in almost all elementary-grade mathematics. Then, we used the TIMSS tests and some questions designed in consultation with expert professors to prepare a 20-question test related to mathematical misconceptions in the areas mentioned above.

To determine the validity of the test, the study used five professors of mathematics and four experienced mathematics teachers and determined the content validity index (CVI) and content validity ratio (CVR) of the questions. All the questions were entirely related to the selected objectives and were necessary due to the value of 100% obtained for CVI and the value of 1 obtained for CVR. It should be noted that the professors gave constructive comments to modify the options and the transparency of some questions. In the pretest stage, we gave the questionnaire to 40 teachers, and to measure their ability to provide solutions, and interviewed them verbally. According to the answers and opinions of the examinees and the analysis of the obtained data, we confirmed this questionnaire for the main implementation.

The questionnaire contained five questions about misconceptions in natural numbers and operations and five about misconceptions in fractions and operations. Also, there were five questions about misconceptions in measurement and five about misconceptions in geometry. After filling out the questionnaire, we utilized a semistructured interview to gather the necessary data for this study.

3.4. Data Collection and Analysis. We scored the completed surveys so that new teachers received one point for each item they answered correctly and zero points for unanswered questions. We categorized their level of knowledge regarding the misconceptions in Table 1 by the points gained from the test.

Additionally, Table 2 categorization gauges the teachers' degree of expertise in each of the subject areas.

We performed an oral interview with all 225 new teachers following their responses to the questionnaire. To address the misconceptions, we asked four questions, each focusing on one of the four categories.

We coded the interview answers in such a way that if the teacher said, "I do not have a solution," or if she/he simply replied, "I will explain more," the answer received the code,

Table 2: Misconceptions awareness rating in each subject area.

Score in the selected subject area	0–2	3	4	5
Misconception awareness in the subject area	Weak	Intermediate	Good	Very good

Table 3: Solution provision rate.

Interview scores	1 or less good solutions	2 good solutions	3 good solutions	4 good solutions
Solution provision capability, when facing misconceptions	Weak	Intermediate	Good	Very good

"There is no solution." If the teacher made a general reference to the subject, such as, "I'd use handmade," or "I'd use poetry," but did not explain his/her answer, she/he would receive the code, "There is a weak solution." If the teacher could fully explain the proposed methods and provide an effective solution to resolve the misconception, his/her answer would receive the code, "There is a good solution."

Table 3 categorizes the teachers' capability to provide new responses in accordance with the interview questions.

We employed descriptive and inferential statistics to represent the research results. We used SPSS version 22 software for data analysis, and Spearman and Cramer's V statistical tests to check the relations between variables.

3.5. Ethical Observes. For ethical considerations, first, we explained the purpose and the method of the research to each of the participants. After the participants gave their informed and free consent, we presented them with the questionnaire to complete. After completing the questionnaire, we conducted a semistructured interview. If the participants consented, the interview was recorded by the researcher; otherwise, the researcher noted down the answers to the interview questions. Also, we did not collect names or identifiers.

4. Results

Table 4 and Figure 1 display the responses provided by the new teachers to the questionnaire.

The data in Table 4 indicates that 78.2% of respondents had "very good," or "good" levels of awareness regarding misconceptions, and only 4.9% had "weak" level.

Table 5 also displays the degree of misconceptions awareness in each subject area.

The findings in Table 5 show that the highest level of "very good," with 52%, is in geometry, and the lowest level of "very good," with 12%, is in measurement. Also, the highest level of "weak," with 18.7%, is in the fractions and operations.

The findings in Table 6 reveal that 38 respondents (16.9%) were able to provide solutions to misconceptions at a "good" level, and 23 respondents (10.2%) were able to do so at a "very good" level. In total, 101 of them, or 44.9%, had a "weak" ability to provide solutions, whereas 63 (28%) had an "intermediate" level. The data of Table 6 is also shown in the pie chart in Figure 2.

Table 7 represents the solution provision capability in four categories.

Table 4: Misconceptions awareness distribution frequency.

Misconceptions awareness	Frequency	Percentage (%)
Weak	11	4.9
Intermediate	38	16.9
Good	106	47.1
Very good	70	31.1
Total	225	100

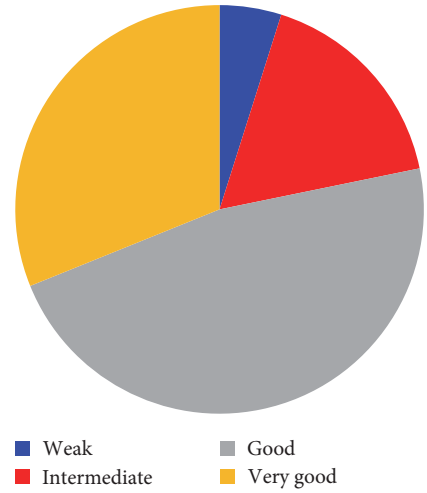


Figure 1: Misconceptions awareness, pie chart.

The data in Table 7 shows that the best performance in misconceptions solution provision, with 57.3%, is related to geometry, and the weakest performance, with 34.7%, is associated with measurement.

Table 8 displays the distribution frequency of misconceptions awareness by gender.

We used Cramer's V test in Table 8 to assess the association between two gender variables (nominal: female or male) and misconceptions awareness (ordered: "weak" to "very good"). We determined that there is no significant difference in misconceptions awareness between genders in line with the acquired values of $p = 0.911$ and $V = 0.049$, of note here is that the value of p (0.911) in the output table was larger than 0.05.

Table 9 represents the distribution frequency of gender-based solution provision capability.

Table 5: Distribution frequency of misconceptions awareness degree in each subject area.

Subject area Misconceptions awareness	Natural numbers and operations Frequency	Fractions and operations Frequency	Measurement Frequency	Geometry Frequency
Weak	23 (10.2%)	42 (18.7%)	39 (17.3%)	16 (7.1%)
Intermediate	57 (25.3%)	59 (26.2%)	79 (35.1%)	33 (14.7%)
Good	110 (48.9%)	79 (35.1%)	80 (35.6%)	59 (26.2%)
Very good	35 (15.6%)	45 (20%)	27 (12%)	117 (52%)
Total	225 (100%)	225 (100%)	225 (100%)	225 (100%)

Table 6: Distribution frequency of solution provision capability.

Ability to offer solutions	Frequency	Percentage (%)
Weak	101	44.9
Intermediate	63	28
Good	38	16.9
Very good	23	10.2
Total	225	100

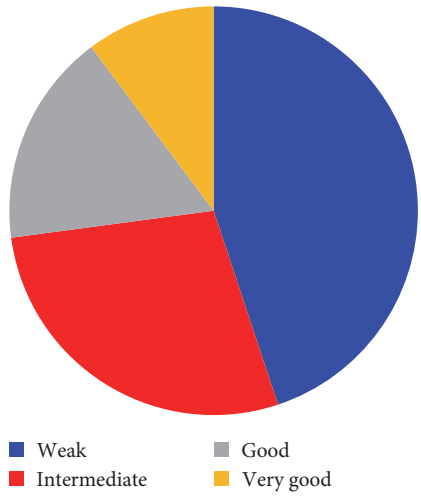


Figure 2: Solution provision capability, pie chart.

We employed Cramer's V test in Table 9 to assess the connection between two gender variables (nominal: female or male) and the problem-solving aptitude degree (ordered: weak to very good). Given the obtained values of $p = 0.139$ and $V = 0.156$ and the fact that the value of p (0.139) in the output table was greater than 0.05, the conclusion is that there is no discernible difference between male and female teachers in terms of their ability to offer clarifications and solutions when faced with misconceptions.

With 99% confidence (with an error level of 0.01), we conclude that there is a link between the two variables of misconceptions awareness and solution provision capability. This is because the value of $p = 0.001$ in Table 10 is less than 0.05. The modest intensity of this link may be seen by Spearman's method correlation value of 0.365. Therefore, it may be inferred that as awareness of misconceptions grows, so does the ability to provide solutions (Table 10).

Some of the solutions presented in the interview are as follows:

New Teacher 1: "I teach the comparison of fractions by taking apples, cookies, or cakes to the class and dividing them into equal parts."

New Teacher 2: "I explain the concept of fractions with a story. I liken the fraction to a double-decker bus, where the numerator is the passenger sitting on the upper deck, and the denominator is the passenger sitting on the lower deck."

New Teacher 3: "To clear up misconceptions, I will explain several times."

New Teacher 4: "With poetry, I express the characteristics of geometric shapes so that they can remember them better."

New Teacher 5: "I give more examples."

New Teacher 6: "To learn the perimeter and area, I ask them to make a model of their own house and calculate its areas, or calculate the area and perimeter of objects such as carpets and tables."

New Teacher 7: "To clear the misconceptions in parallel lines, I put three students in one row, and two students parallel to the first row and ask them to walk together in a parade. I point it out to them whether they met each other or not. Then I explain that for the lines to be parallel, the size of the drawn lines is not important, but what is important is that if we extend them, they do not intersect each other."

5. Discussion

According to the data, teachers also struggle to spot misconceptions in several areas, such as measuring and fractions. From this perspective, the findings of this study are in line with Kusmaryono et al. [17]. They found that elementary school teachers encounter misconceptions such as preconception, undergeneralization, and overgeneralization errors in teaching mathematics. Additionally, new teachers performed best in spotting geometric misconceptions, and the outcomes were consistent with Bakhshalizadeh's [16] study.

Compared with Zuya and Kwalat [12], the results indicated that new teachers lack the necessary expertise to resolve the misconceptions. Their research showed that since teachers could not suggest effective ways to solve the

Table 7: Distribution frequency of solution provision capability in each subject area.

Subject area Ability to offer solutions	Natural numbers and operations Frequency	Fractions and operations Frequency	Measurement Frequency	Geometry Frequency
There is no solution	41 (18.2%)	79 (35.1%)	70 (31.1%)	37 (16.4%)
There is a weak solution	70 (31.1%)	58 (25.8%)	77 (34.2%)	59 (26.2%)
There is a good solution	114 (50.7%)	88 (39.1%)	78 (34.7%)	129 (57.3%)
Total	225 (100%)	225	225 (100%)	225 (100%)

Table 8: Distribution frequency of gender-based misconceptions awareness degree.

Misconceptions awareness	Weak	Intermediate	Good	Very good
Male	4	17	41	27
Female	7	21	65	43
Total	11	38	106	70

Table 9: Distribution frequency of gender-based solution provision capability.

The ability to offer solutions	Weak	Intermediate	Good	Very good
Male	48	18	15	8
Female	54	44	23	15
Total	102	62	38	23

Table 10: The connection between misconceptions comprehension and solution provision capability.

			Misconceptions awareness degree	Solution provision capability
Kendall's tau-b	Awareness of misconceptions	The correlation coefficient	1.000	0.365**
		p	0	0.001
		N	225	225
	Ability to provide solutions	The correlation coefficient	0.365**	1.000
		p	0.001	0
		N	225	225

**Correlation is significant at the 0.01 level (two-tailed).

students' misconceptions, they were also unable to help students resolve their misconceptions about some geometrical topics. As Abdul Ghani and Maat [20] believe, it is the teachers' responsibility to select the appropriate teaching style to overcome misconceptions and make sure that the students do not repeat the mistakes. Also, this research can be regarded as in line with Kazemi and Bayat [9]. They considered integrating technology as part of teachers' PCK. Their results indicated a significant relationship between using technology in the classroom and mathematical problem-solving performance.

Of note here is that worse performance in solution provision, in comparison with other areas, was in fractions and operations. In this regard, the research may be connected with Aksoy and Yazlik [29] and Rosli et al. [38], who believe that fractions are difficult for teachers and students. Moreover, studies by Saili et al. [39], Ojose [8], Trivena et al. [1] also point to this matter.

The findings show that regarding new teachers, there is no significant association between gender, misconceptions awareness degree, and solution provision capabilities. Therefore, male and female new teachers are equally capable of pinpointing misconceptions and offering solutions. These results are similar to the study of Caplan and Caplan [40] and Halpern et al. [41]. Also, the findings are in line with the results obtained by Tavanaii Shahroudi and Mahram [42]. They found that there is no significant difference between gender and teaching abilities. On the other hand, a research by Copur-Gencturk et al. [43], claims that according to teachers, gender difference is crucial in teaching mathematics.

The findings indicate a link between misconceptions awareness and solution provision capability. Similarly, it was found by Mishra [14] that some teachers are not aware of arithmetic misconceptions in students. Also, they are not sure whether they are teaching some contents of arithmetics

correctly or not. This dilemma decreases the teacher's self-confidence and the effectiveness of teaching. Of note here are the findings of An et al. [35], who claimed that the knowledge of mathematics teachers deeply impacts their teaching methods. The results also align with Manasia et al. [44] since their findings show that new teachers who are more aware of misconceptions are more likely to be able to address them. Also, Kargari Sisi [36] believes that teachers can provide the opportunity to resolve misunderstandings by employing educational activities and appropriate educational situations. Therefore, the more capable the teacher is, she/he can provide better learning opportunities for the students.

6. Conclusion

The first step in solving the students' mathematical misconceptions is to identify and recognize their misconceptions. Therefore, research is vital to measure the ability of teachers to identify students' mathematical misconceptions. This study has made a significant contribution to this objective by identifying the level of expertise new elementary school teachers have in addressing learners' mathematical misconceptions.

The research showed that although most of the new teachers perform "very good" in recognizing mathematical misconceptions, a few possess the capability and knowledge to resolve the misconceptions, and there is no significant difference in performance between male and female teachers. Of note here is that there was better performance in some areas, such as geometry. Therefore, this study expands our knowledge about the awareness of new elementary school teachers in mathematical misconceptions and the effect of their gender in this regard, which can contribute to the future educational planning in Iran's higher education.

The next step after misconception identification is resolution. Therefore, we have to measure the ability of teachers to resolve the misconceptions and identify the effective factors to increase this ability. Because by strengthening these factors, we can have more capable teachers. This research showed a clear correlation between the mathematical misconceptions awareness of the teachers and their ability to provide solutions. This information is significant for the policymakers and educational planners because the findings show that the more we improve the teachers' abilities in mathematics education, the better they perform in classrooms.

In this research, we investigated numbers, fractions, measurement, and geometry. We suggest this research be employed in familiarizing new teachers with misconceptions in volume, decimals, statistics, and probability. In addition, the relation between years of experience and solution provision capability can be a matter of research.

Holding conferences and workshops may be a great way to promote solution provision for mathematical misconceptions and empower new teachers to tackle misconceptions in elementary schools. In last, we suggest revising mathematics textbooks in a way that prevents the creation of mathematical misconceptions and facilitates teaching.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical Approval

This article followed ethical standards for research.

Conflicts of Interest

The author declares that there is no conflict of interest.

Acknowledgments

The author gratefully acknowledges the generous funding provided by Farhangian University, Iran for this study under contract number 50000/1522/120.

References

[1] V. Trivena, A. R. Ningsih, and A. Jupri, "Misconception on addition and subtraction of fraction at primary school students in fifth-grade," *Journal of Physics: Conference Series*, vol. 895, Article ID 012139, 2017.

[2] J. Ryan and J. Williams, *Children's Mathematics 4-15: Learning from Errors and Misconceptions*, Open University Press, 2007.

[3] A. Karimi, S. Bakhshalizadeh, and M. Kabiri, *A Summary Report of the Most Important Results of TIMSS and PIRLS 2011 and Comparing it with the Performance of Iranian Students in Previous Periods*, TIMSS and PIRLS National Studies Center, Iran, Tehran, 2011.

[4] S. Bakhshalizadeh and M. Kashefi, *Publishable Questions of TIMSS 2015*, Madreseh Publications, Tehran, Iran, 2016.

[5] B. Meseci, S. Tekin, and S. Karamustafaoglu, "Misconceptions about the particulate nature of matter detection," *Dicle University Journal of Social Sciences Institute*, vol. 5, no. 9, pp. 8–40, 2013.

[6] M. Allen, *Misconceptions in Primary Science*, Open University Press, Berkshire, England, 3rd edition, 2010.

[7] Y. Ay, *Education Research Highlights in Mathematics, Science and Technology 2017*, ISRES Publishing, 2017.

[8] B. Ojose, "Students' misconceptions in mathematics: analysis of remedies and what research says," *Ohio Journal of School Mathematics*, vol. 72, pp. 30–35, 2015.

[9] F. Kazemi and S. Bayat, "The effect of integrating technology in teaching as part of teachers' PCK on students' attitude, misconceptions, and mathematical problem solving performance," *International Journal of Education and Information Technologies*, vol. 6, no. 1, pp. 1–8, 2012.

[10] S. Bakhshalizadeh and M. Boroujerdian, "Identifying the common misconceptions of fourth-grade elementary students in the content area of geometry and measuring and comparing their performance with the average performance at the international level," *Quarterly Journal OFEducational Innovations*, vol. 16, no. 64, pp. 101–126, 2018.

[11] M. Duran, "Opinions of primary 7th-grade students about visual mathematics literacy," *Mehmet Akif Ersoy University Journal of Educational Sciences Institute*, vol. 2, no. 2, pp. 38–51, 2013.

[12] H. E. Zuya and S. K. Kwalat, "Teacher's knowledge of students about geometry," *International Journal of Learning, Teaching and Educational Research*, vol. 13, no. 3, pp. 100–114, 2015.
[13] T. Sanagi, "Teachers' misunderstanding the concept of inclusive education," *Contemporary Issues in Education Research*, vol. 9, no. 3, pp. 103–114, 2016.
[14] L. Mishra, "Conception and misconception in teaching arithmetic at primary level," *Journal of Critical Reviews*, vol. 7, no. 5, pp. 936–939, 2020.
[15] M. A. Al-Khateeb, "The extent of mathematics teacher's awareness of their students' misconceptions in learning geometrical concepts in the intermediate education stage," *European Scientific Journal*, vol. 12, no. 31, pp. 357–372, 2016.
[16] S. Bakhshalizādeh, *Identifying the Common Misconceptions of Fourth-Grade Elementary Students in the Content Area of Mathematics (Research Project)*, Education Research Institute of Iran, 2012.
[17] I. Kusmaryono, M. A. Basir, and B. A. Saputro, "Ontological misconception in mathematics teaching in elementary schools," *Infinity Journal*, vol. 9, no. 1, pp. 15–30, 2020.
[18] R. G. Mohyuddin and U. Khalil, "Misconceptions of students in learning mathematics at primary level," *Bulletin of Education and Research*, vol. 38, no. 1, pp. 133–162, 2016.
[19] F. Aliustaoğlua, A. Tunab, and A. Ç. Biber, "Misconceptions of sixth grade secondary school students on fractions," *International Electronic Journal of Elementary Education*, vol. 10, no. 5, pp. 591–599, 2018.
[20] S. N. A. Ghani and S. M. Maat, "Misconception of fraction among middle grade year four pupils at primary school," *Research on Education and Psychology (REP)*, vol. 2, no. 1, pp. 111–125, 2018.
[21] M. Chrysostomou, D. Pitta-Pantazi, C. Tsingi, E. Cleanthous, and C. Christou, "Examining number sense and algebraic reasoning through cognitive styles," *Educational Studies in Mathematics*, vol. 83, pp. 205–223, 2013.
[22] A. Hansen, D. Drews, J. Dudgeon, F. Lawton, and L. Surtees, *Children's Errors in Mathematics*, SAGE Publication, 4th edition, 2017.
[23] A. Sadi, "Misconceptions in numbers," *UGRU Journal*, vol. 5, pp. 1–7, 2007.
[24] M. Doosti and E. Reyhani, "Misconceptions of sixth-grade students in working with fractions," *Growth in Mathematics Education*, vol. 122, pp. 4–11, 2014.
[25] D. W. Braithwaite, J. Tian, and R. S. Siegler, "Do children understand fraction addition?" *Developmental Science*, vol. 21, no. 4, Article ID e12601, 2018.
[26] R. S. Siegler, C. A. Thompson, and M. Schneider, "An integrated theory of whole number and fractions development," *Cognitive Psychology*, vol. 62, no. 4, pp. 273–296, 2011.
[27] D. Wulandari and M. F. Amir, "Analysis of elementary school students' difficulties in fraction addition," *Kreano, Jurnal Matematika Kreatif-Inovatif*, vol. 13, no. 1, pp. 43–54, 2022.
[28] F. Kara and L. Incikabi, "Sixth grade students' skills of using multiple representations in addition and subtraction operations in fractions," *International Electronic Journal of Elementary Education*, vol. 10, no. 4, pp. 463–474, 2018.
[29] N. C. Aksoy and D. O. Yazlik, "Student errors in fractions and possible causes of these errors," *Journal of Education and Training Studies*, vol. 5, no. 11, pp. 219–233, 2017.
[30] J. E. Barrett, D. H. Clements, D. Klanderman, S. J. Pennisi, and M. V. Polaki, "Students' coordination of geometric reasoning and measuring strategies on a fixed perimeter task: developing mathematical understanding of linear measurement," *Journal for Research in Mathematics Education*, vol. 37, no. 3, pp. 187–221, 2006.
[31] G. T. Sisman and M. Aksu, "A study on sixth grade students' misconceptions and errors in spatial measurement: length, area, and volume," *International Journal of Science and Mathematics Education*, vol. 14, pp. 1293–1319, 2016.
[32] A. Özerem, "Misconceptions in geometry and suggested solutions for seventh grade students," *Procedia - Social and Behavioral Sciences*, vol. 55, pp. 720–729, 2012.
[33] H. Idrus, S. S. A. Rahim, and H. Zulnaidi, "Conceptual knowledge in area measurement for primary school students: a systematic review," *STEM Education*, vol. 2, no. 1, pp. 47–58, 2022.
[34] C. Runnalls and D. S. Hong, ""Well, they understand the concept of area": pre-service teachers' responses to student area misconceptions," *Mathematics Education Research Journal*, vol. 32, pp. 629–651, 2020.
[35] S. An, G. Kulm, and Z. Wu, "The pedagogical content knowledge of middle school, mathematics teachers in China and the U.S." *Journal of Mathematics Teacher Education*, vol. 7, pp. 145–172, 2004.
[36] N. Kargari Sisi, "*Recognizing the causes of mathematical misunderstanding of fourth-grade elementary school boys in answering the selected questions of TIMSS 2015 and providing appropriate solutions*," Master's Thesis of Educational Sciences, Refah Faculty, Tehran, Iran, 2015.
[37] N. C. C. Brown and A. Altadmri, "Novice java programming mistakes: large-scale data vs. educator beliefs," *ACM Transactions on Computing Education*, vol. 17, no. 2, pp. 1–21, 2017.
[38] R. Rosli, D. Goldsby, M. M. Capraro, A. J. Onwuegbuzie, R. M. Capraro, and E. G. Y. Gonzalez, "Elementary preservice teachers' knowledge, perceptions and attitudes towards fractions: a mixed-analysis," *Journal on Mathematics Education*, vol. 11, no. 1, pp. 59–76, 2020.
[39] J. Saili, E. B. Samuel, and A. Mukuka, "Effect of visual-based instruction on elementary pre-service teachers' conceptual understanding of fractions," *Journal of Mathematics and Science Teacher*, vol. 3, no. 1, Article ID em030, 2023.
[40] J. B. Caplan and P. J. Caplan, "The perseverative search for sex differences in mathematics ability," in *Gender Differences in Mathematics: An integrative Psychological Approach*, A. M. Gallagher and J. C. Kaufman, Eds., pp. 25–47, Cambridge University Press, 2005.
[41] D. F. Halpern, C. P. Benbow, D. C. Geary, R. C. Gur, J. S. Hyde, and M. A. Gernsbacher, "The science of sex differences in science and mathematics," *Psychological Science in the Public Interest*, vol. 8, no. 1, pp. 1–51, 2007.
[42] E. Tavanaii Shahroudi and B. Mahram, "Investigating the ability level of primary school teachers and its relationship with the components of the organizational culture of schools, the organizational culture of the school," *New Educational Approaches*, vol. 12, no. 2, pp. 23–40, 2010.
[43] Y. Copur-Gencturk, I. Thacker, and D. Quinn, "K-8 teachers' overall and gender-specific beliefs about mathematical aptitude," *International Journal of Science and Mathematics Education*, vol. 19, pp. 1251–1269, 2021.
[44] L. Manasia, M. G. Ianos, and T. D. Chicioreanu, "Pre-service teacher preparedness for fostering education for sustainable development: an empirical analysis of central dimensions of teaching readiness," *Sustainability*, vol. 12, no. 1, Article ID 166, 2020.