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PAPER

The Effectiveness of Multimedia and Virtual Environments in Light of the Conflict Strategy to Reduce Misconceptions in Mathematics among First-Year University Students

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ABSTRACT

The roots of misconceptions in mathematics among first-year students at Hashemite University can be traced back to a flaw in the foundation of their previous mathematics knowledge acquired over the course of their academic years. This flaw presents a significant challenge for them during their studies. This study aimed to determine the effectiveness of multimedia and virtual environments in reducing misconceptions in mathematics among first-year students at Hashemite University, based on the conflict strategy. The study sample consisted of a random cluster sample of 109 male and female students from Hashemite University. The researcher observed the students and recorded their test scores. The researcher conducted face-to-face interviews to collect data for the study and performed statistical analysis using the t-test. The results showed that the percentage of misconceptions in mathematics among first-year students at the Hashemite University for types 1, 2, 3, 4, and 5, respectively, amounted to 23%, 8%, 13.8%, 14.7%, and 0%. And 13.8%. The study examined the effectiveness of multimedia and virtual environments in reducing misconceptions in mathematics among first-year students at Hashemite University, based on the conflict strategy.

KEYWORDS

multimedia, virtual environments, mathematics, misconceptions

1 INTRODUCTION

The results of the studies indicate that there are general misconceptions among students [1–3]. Mathematical concepts are a significant and integral part of the foundation of mathematical knowledge, which includes facts, concepts, theories, and systems of thinking. Previous studies have indicated that misconceptions

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in mathematics manifest as both procedural errors and conceptual errors [4–5]. Conceptual misconceptions in mathematics refer to errors in understanding fundamental concepts while solving mathematical problems. There are many factors that contribute to students' conceptual misconceptions in mathematics, with the most significant being their previous experiences and the way the concept was introduced by teachers in previous grades [15]. The cognitive conflict strategy was employed to mitigate misconceptions by utilizing explanation and discussion providing models and examples within the conceptual framework to facilitate conceptual change [9]. The findings of [10] indicated that students struggled to connect new concepts with prior knowledge, and it was demonstrated that the cognitive conflict strategy could serve as a means for teachers to assist students in linking new concepts with previous ones through the resolution of homework assignments. [12] suggests that the cognitive conflict strategy is an alternative method for reducing misconceptions. This strategy involves creating contextual learning models during problem solving and is found to be more effective when used in conjunction with multimedia and virtual environments.

According to [9], contextual learning models are associated with the learning environment and the utilization of multimedia and virtual environments. This is because they provide students with the opportunity to learn without the limitations of a specific place or time. Through the Internet, which provides students with communication skills among themselves, they are trained to solve problems according to the real societal environment. The problem addressed in this research is the effectiveness of using multimedia and virtual environments, specifically the conflict strategy, to reduce misconceptions among first-year students in the Mathematics Principles course at Hashemite University. These misconceptions manifest as procedural and conceptual misunderstandings during the study of algebraic operations (such as addition, subtraction, multiplication, and division), linear and quadratic equations, exponents logarithms, and the fundamentals of calculus. These misconceptions have a direct negative impact on students' academic achievement in mathematics [10]. The central question of this study is: How effective is the application of multimedia and virtual environments using the conflict strategy, in reducing misconceptions among first-year university students? Study hypothesis: There is no statistically significant difference ($\alpha = 0.05$) in reducing conceptual errors attributed to the application of multimedia and virtual environments when using the conflict strategy. The study is significant because it focuses on reducing misconceptions among first-year university students in the principles of mathematics course. It aims to achieve this by utilizing multimedia and virtual environments, employing the cognitive conflict strategy. The study aimed to determine the effect of applying multimedia and virtual environments, based on the conflict strategy, in reducing misconceptions among first-year university students.

2 RELATED WORK

2.1 Misconceptions in mathematics

A concept is the mental abstraction of the common properties of a set of experiences or objects [6–10]. From this, we can say that the concept is the distinctive feature or characteristic present in all examples that refer to that concept [11]. For example, the defining characteristic of a triangle is that it is a closed shape composed of three straight segments that meet at their end points. However, there are various types of triangles, such as right-angled triangles and isosceles triangles. Despite their differences, all triangles share the common feature of having three sides and three angles, and the sum of their angles is 180 degrees. The set of features defined by the concept is called the reference set [15]. Among the most significant sources of conceptual errors among students are traditional teaching methods that fail to identify errors in comprehension and correct them, as well as traditional evaluation methods that assign grades to students without assessing their understanding or identifying their weakness. Conceptual errors [16] can be attributed to both individual misunderstandings and the influence of societal culture. Within society and the family, certain misinterpretations and concepts are transmitted, which can contribute to the development of conceptual errors in children [17]. Some teachers who do not continuously develop their knowledge and receive appropriate training may have a misunderstanding of certain concepts. This is often due to their lack of training or unfamiliarity with the latest scientific developments related to the subjects they teach. Consequently, these gaps in knowledge will inevitably impact their students and contribute to the students' conceptual errors [18].

There are many methods that can help identity conceptual errors among students, and one of these methods is pre-tests. By answering exam questions, students' errors are discovered before they begin the learning process [19]. Or through concept maps, which involve providing students with a set of concepts and asking them to create a conceptual network to clarify the relationships that link the concepts to each other. This allows educators to determine whether students have any conceptual errors [20]. Seminars play a crucial role in identifying conceptual errors. Class discussions provide students with the opportunity to express their ideas about a concept and evaluate the validity of the ideas that have been proposed. Through these discussions, students can analyze and build upon the concepts presented to them. In addition, students are assigned the task of identifying the concepts they are familiar with. Indeed, they interpret these concepts based on their prior knowledge [21]. Misconceptions in mathematics can be classified into two categories: basic conceptual errors and procedural errors [13]. Procedural errors are errors that occur during arithmetic operations (addition, subtraction, and multiplication). These errors typically involve mistakes in the properties of commutation, distribution, or transitivity, particularly when parentheses are involved and the order of operations is considered. Students' procedural errors can be addressed by re-examining mathematical problems and their results. Procedural errors can also be addressed using appropriate techniques and teaching methods, such as guided discovery, in addition to utilizing effective learning methods like multimedia and virtual environments [24].

The fundamental conceptual errors are related to the student's inability to understand the concept itself. These errors include not understanding the symbols, not knowing the neutral element in the addition and multiplication processes, lacking knowledge of the concept of the greatest common multiple, and not being familiar with the discriminant in the quadratic equation [25]. The misunderstood mathematical concepts are determined for each member of the diagnostic sample by calculating the percentage of error for each concept included in the principles of mathematics course. These concepts are then diagnosed based on the criterion of 34% or more, which means that the percentage of students who answer the paragraph related to the topic is more than 34% of the total number of students [29].

2.2 Cognitive conflict strategies

Piaget's theory of cognitive conflict emphasizes that knowledge development occurs through the process of achieving balance. According to Piaget, imbalance is the main catalyst for knowledge development, and he encourages students to experiment in order to achieve a new balance by assimilating knowledge [28]. The cognitive conflict strategy is implemented through steps in which the student is asked about a specific concept, and their answer is then received and interpreted individually [29]. In this activity, the student is given the opportunity to express their ideas about a concept in class, receive input from classmates, explore learners' perspectives on the concept, and discover alternative ways of understanding [30]. To determine the level of learners' understanding or perception of meaning, the cognitive conflict strategy is implemented by engaging students in solving mathematical problems and defining concepts based on their initial responses. Next, students explore ideas to solve problems [31]. The cognitive conflict increases with the questions and the differences in answers until the student realizes that current ideas need to change. At this stage, we observe that the student transforms their existing ideas into new concepts. They then proceed to explain the observed facts and solve problems using their newfound ideas. The student then generalizes the solution by having students apply newly learned concepts to solve unfamiliar problems. Misconceptions are resistant in the sense that they are not easy to fix, as they can resurface any time. Therefore, it requires an appropriate strategy specifically designed to reduce students' misunderstandings [32]. Applying cognitive conflict strategies requires a relatively longer time, especially to correct the misconceptions that students suffer from. Therefore, we need appropriate resources and support to effectively address this issue [19].

Through electronic multimedia services, the cognitive conflict strategy is implemented. Students are provided with activities to solve challenging math problems. This strategy aims to assess students' initial responses and perceptions, with an emphasis on problem-solving through e-learning platforms and the Microsoft Teams application [19].

By utilizing various methods such as asking questions, providing worksheets, engaging in direct discussions through multimedia, and utilizing the virtual environment on the e-learning platform, teachers can effectively generate cognitive conflict among students [33–38].

During this stage, we notice that people undergo changes and develop their opinions to generate new concepts. Through continuous discussion and questioning, facts are better expressed. Each student solves problems using new ideas, and then we collect and classify the solutions. We then generalize these solutions by applying new concepts to solve mathematical problems [39–44].

3 METHODOLOGY

The study sample consisted of a random cluster sample of 109 male and female students enrolled in the Principles of Mathematics course at Hashemite University during the academic year 2022–2023. The mathematical concepts covered in the Principles of Mathematics course were identified through content analysis. The process involved the following steps: identifying the scientific subject and referring to Table 1.

Table 1. The scientific subject in the principles of mathematics course

Topics	Section
Graphs of linear equations	1
Algebraic solution of simultaneous linear equations	2
Algebra	3
Transposition of formulae	4
Quadratic functions	5

The unit of algebraic analysis is defined as the fundamental unit of analysis because it is directly related to the concept being studied. Qualitative analysis of concepts is conducted by examining and marking the concept once. Even though it was repeated multiple times, the initial form of the list consisted of eight concepts. A list of eight mathematical concepts was presented to a panel of judges, and the criterion for accepting a concept was that 80% or more of the judges' opinions agreed on it. As a result, three concepts were excluded, namely group, element, and Venn diagram. The arbitrators agreed on this because some of them are included in other, more comprehensive concepts. More generally, and because there was no definition or explanation for some of the others, it was agreed upon that five concepts needed clarification. The types of misconceptions in mathematics among first-year university students at Hashemite University were limited to five categories: (1) misconceptions in basic concepts; (2) misconceptions in concept referencing; (3) arithmetic misconceptions; (4) procedural misconceptions; and (5) misconceptions in concept symbols (see Table 2).

Table 2. Mathematical misconceptions

Concept	Type of Misconceptions	Misconceptions
Linear equations	1	Misunderstanding the order of equation
Simultaneous linear equations	2	Misconceptions of variables coefficients
Rank of algebra	3	Mathematical misconceptions in finding a rank
Switching independent and dependent variables	4	Procedural misconceptions in the way to find the independent and dependent variables
Quadratic functions	5	Misconceptions in the symbol of the concept when finding the discriminant through the coefficients of variables

To diagnose misunderstood concepts, the researcher conducted a conceptual diagnostic test. After agreeing upon five mathematical concepts identified by experts and agreed upon by 80% or more, a conceptual diagnostic test was prepared to identify misconceptions. The test consisted of multiple-choice questions with four alternatives. It is also one of the tests that minimizes the chances of a minimum. The initial test consists of 15 items, where each set of three consecutive items measures one specific concept based on Bloom's first cognitive levels. The areas of translation, interpretation, and completion are used to measure understanding in succession. Then the three items that assess a different understanding are repeated in the same order. After presenting its paragraphs to a group of experts, the text was amended several times based on their important comments. The agreement rate of the experts reached 80%, and the text was finalized [30].

For the purpose of the conceptual test, the apparent validity was confirmed. This involves gaining insight into the content of each paragraph of the test and assessing its relevance to the subject matter in question (experts or specialists). The degree of apparent validity of the test can be assessed by examining the agreement between the estimates of the arbitrators. Mathematical concepts agreed upon by experts and mathematics writers for the second intermediate grade were then examined. They were asked to express their opinions on the suitability of the items in measuring the content of the academic subject for mathematical concepts, specifically in the areas of translation, interpretation, and completion. Taking their feedback with 80% or more agreement, thus achieving face validity. As for content validity, tests are considered valid in terms of content if they accurately reflect the material covered in the academic subject [6].

To achieve this type of validity, the researchers prepared a list of 15 test items. These items were developed to measure the mathematical concepts that were identified in a previous stage. The researchers then presented the test items to a group of experts and specialists [14–18]. To assess the alignment between the test and the article's content, the researcher used the consensus of at least 80% of the experts' opinions as a criterion for establishing the validity of the test paragraph and, consequently, the validity of the content being evaluated. The test instructions were formulated, and the answer instructions were provided. The test instructions included a comprehensive explanation of the test's purpose. The types of questions (paragraphs) and how to answer accurately without leaving any paragraph unanswered. Debugging instructions have been prepared [21–24]. For each item, one point was awarded for a correct answer, and zero points were awarded for an incorrect answer. The paragraphs on the left were considered incorrect answers, and a correct answer form was prepared. The test contains 15 items, so the maximum score a student can achieve is 15 points. An exploratory experiment was conducted. The tests were administered to a sample of 100 male and female students as preparation for their application. To ensure the clarity of the items, it was found that the time taken to answer the test items ranged from 110 to 130 minutes. The test takes approximately 120 minutes to complete [6–8]. The test items were analyzed. Through analytical processes, the following was calculated: [16] The goal of calculating the difficulty of a paragraph is to select paragraphs that are suitable for students in terms of their level of difficulty while also removing paragraphs that are either too easy or too challenging. The difficulty or ease of the task ranges from 20% to 80% [23]. Therefore, the difficulty factor for all test items was determined by applying the difficulty factor formula to the survey sample. It was found that all items had a difficulty level ranging between 22% and 53%, making them all acceptable based on the difficulty conditions. The discriminative power of the item was calculated. As Roussin pointed out, an item is also considered good if it can distinguish between a high-performing student and a low-performing student, in addition to its difficulty factor. Therefore, those who prepare for tests are eager to determine the item's ability to discriminate, as it is considered one of the crucial indicators for describing the item.

4 RESULTS

In this study, the researchers identified five types of misconceptions in mathematics among first-year undergraduate students at the Hashemite University.

These include: (1) misconceptions in the basic concept, (2) misconceptions in the reference to the concept, (3) arithmetic misconceptions, (4) procedural misconceptions, and (5) misconceptions in the concept symbol. Please refer Table 3.

Table 3. Types of misconceptions among students

Question Number	Type of Misconceptions				
	Type 1	Type 2	Type 3	Type 4	Type 5
1	25	4	13	15	14
2	29	8	13	13	14
3	13	8	17	17	14
4	30	9	15	17	13
5	20	7	15	19	19
Total	120	41	73	81	75
Average (%)	23%	8%	13.8%	14.7%	13.8%

The average misconceptions in mathematics among first-year students at Jordanian universities for types 1, 2, 3, 4, and 5 were 23%, 8%, 13.8%, 14.7%, and 13.8% respectively. This indicates that most of the misconceptions in mathematics among first-year students in Jordanian universities are due to misunderstandings (1). And the slightest suspicion. While types 3, 4, and 5 are relatively close together.

The results of testing the effectiveness of multimedia and virtual environments, using the cognitive conflict strategy, in reducing misconceptions in mathematics among first-year students at the Hashemite University can be seen in Table 4.

Table 4. Paired samples statistics

	Mean			N		Std. Deviation Std.		Error Mean
First Test	75.0			109		.59		.35
Second Test	78.0			109		3.8		.36
	Paired Differences			95% Confidence Interval of the Difference				
	Mean	Std. Deviation Std.	Std. Error Mean	Lower	Upper	t	df	Sig. (2 tailed)
First Test – Second Test	–2.8	3.00	.293	3.388	–2.2	–9.5	108	0.00

The average results of testing the effectiveness of multimedia and virtual environments using the cognitive conflict strategy in reducing misconceptions in mathematics among first-year students at Hashemite University before and after implementing multimedia and virtual environments reached 75 and 78, respectively. The significant value is 0.00 ($0.00 < \alpha = 0.05$), indicating that the effectiveness of students in applying multimedia and virtual environments, using the cognitive conflict strategy, to reduce misconceptions in mathematics among first-year students at Hashemite University is better than before.

5 DISCUSSION

The results of the test revealed that first-year students at the Hashemite University had misconceptions in mathematics while learning through the application of multimedia and virtual environments, using the conflict strategy. Among the issues discussed to help students solve algebraic problems and discover misconceptions, the teacher asked the students to solve a question that had been discussed using the cognitive conflict strategy. The teacher also explained how the student responded. The example asks you to choose an equation that simplifies the solution and provide a reason for your response. The example was (7x + 8), and the options given to simplify the solution are 15x, 7x + 8, and 15. Some students chose 15x as the correct answer because they mistakenly believed that 7x + 8 = 15x. Students then consider 7x + 8 and 15 to be incorrect. Students confuse that 7x + 8 is the same equation. This is not a simplification of the solution, and 15 has nothing to do with x; therefore, 10x represents a simplification of the solution. This suggests that students still have misconceptions and misunderstand the concept, as they grouped together inequivalent concepts (variables). This is an excerpt from a conversation between the teacher and students discussing how to solve the problem.

Teacher: *"Provide the reason for your answer."*
Student: *The result is 15. With the symbol 'x' it becomes 15x.*
Teacher: *"Are you sure?"*
Student: *"Yes."*
Teacher: *Is it correct to add 7x to 8?*
Student: *Yes. 15x."*
Teacher: *"How about 5x + 10y? What is the simplified solution?"*
Student: *"It's 15xy."*
Teacher: *"I think x is an apple and y is a banana." Is it permissible to combine apples and bananas?*
Student: *(stands and thinks)*
Teacher: *What is the answer?*
Student: *"And 5 bananas and 10 apples."*
Teacher: *Is the answer 15 bananas and an apple?*
Student: *"No."*
Teacher: *"How can we add 5x + 10y?"*
Student: *"No." "5x +10y"*
Teacher: *"What about 7x + 8?"*
Student: *"7x + 8"*

The students then edited their answers in their groups on the Microsoft Team platform, and the teacher asked the groups to submit their answers, and the teacher gave all groups the opportunity to comment and share. At this stage, it is expected that conflict will arise in the minds of the students, which encourages them to check their understanding of the concept by collecting similar variables. The teacher instructs the students to ask interrogative questions, specifically starting with "why" and "how," in order to correct their misconceptions. Please refer Table 5.

Table 5. The cognitive conflict questions on algebraic addition and subtraction

Chose the Simple Form of (7x + 8), Given Opinion	
a. 15x	
correct	Reason
incorrect	
b. 7x + 8	
correct	Reason
incorrect	
c. 15	
correct	Reason
incorrect	

6 LIMITATIONS AND FUTURE RESEARCH

The time required to utilize multimedia and virtual environments, specifically through the cognitive conflict strategy, to reduce misconceptions in mathematics among first-year university students is a crucial factor. This is particularly important during official lectures conducted via electronic platforms, as the time available for these lectures is limited. This limitation is addressed through the teacher's work, perseverance, and constant interaction with students in conversations on Microsoft Teams.

7 CONCLUSIONS

The types of misconceptions in mathematics among first-year university students at Hashemite University were limited to five categories: (1) misconceptions in basic concepts, (2) misconceptions in concept referencing, (3) arithmetic misconceptions, (4) misconceptions in mathematics (procedural misconceptions), (5) misconceptions regarding symbols. The percentages of misconceptions in mathematics among first-year students at the Hashemite University for types 1, 2, 3, 4, and 5 were, 23%, 8%, 13.8%, 14.7%, and 13.8%, respectively. This indicates that the majority of misconceptions in mathematics among first-year students at Hashemite University are related to basic concepts (1), while the fewest misconceptions are related to concepts (2). While types 3, 4, and 5 are relatively close together, findings are indicated based on data obtained through research tools such as tests, interview records, and observations. It was found that the application of multimedia and virtual environments, in accordance with a conflict strategy, reduced misconceptions in mathematics among first-year university students at Hashemite University by 85% of the total number of students. The effectiveness of students in applying e-learning, specifically the conflict strategy, to reduce misconceptions in mathematics among first-year students at Hashemite University has improved compared to before. The results of the average effectiveness test demonstrated the effectiveness of applying multimedia and virtual environments, specifically the comparison strategy, to reduce misconceptions in mathematics among first-year students. The cognitive conflict strategy was applied before and after implementing multimedia and virtual environments at Hashemite University, resulting in a 75% and 78% improvement, respectively. The significance value = 0.00 (0.00 < α = 0.05).

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