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The Effects of Flipped Classroom Strategy Based on "Addie Model" for Algebraic Skill Development

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The study aimed to investigate the effect of the flipped classroom strategy based on ADDIE Model on Prince Faisal College students' development of algebraic thinking skills. To achieve the goal of the study, the researchers developed a measure of development of algebraic thinking skills. The study used the quasi-experimental approach with a pre-post design, and the study was applied to (53) students, who were divided into two groups: an experimental group of (27) students, and a control group of (26) students. The results showed there is an effect of the strategy on the dimensional measurement of the test of developing all algebraic thinking skill. Flipped Classroom helped develop algebraic thinking skills. The study recommended using the stages of ADDIE model in applying the flipped classroom strategy, and flipped classroom based on ADDIE model enhances student learning, because the strategy integrates student learning at home and in the classroom.

Keywords: flipped classroom, instruction, Addie model, algebraic thinking skills, mathematics education

INTRODUCTION

Educational institutions hastened to develop their educational systems to keep pacing with the rapid change in the field of educational technology, and the attendant repercussions on the educational and learning process, which made those interested in the educational process in constant need to search for new educational methods that suits the features of development and help achieve learning goals (Amasha, 2011). Technological developments in the twenty-first century have made it easier for teachers to provide multimedia to students through online services such as YouTube and Teacher Tube, which have enabled students to access useful online educational resources (Olakanmi, 2017).

This change impose teachers to move to modern tendency in teaching that center on the student and make him an active learner. It became necessary for the teacher to use new learning strategies; to help him shift the student from the state of negative learning in the usual method of education to the state of positive learning (Al-Bakour, 2016).

Given the importance of the use of technology in mathematics` education, the National Council of Teachers of Mathematics (NCTM) has developed standards and principles to school mathematics, which include the principle of technology; Technology is of fundamental importance in teaching and learning mathematics, as it affects the mathematics being learned and supports students' learning, as technology provides visual images of mathematical ideas, facilitates the process of organizing and

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analyzing data, and supports students' exploration in mathematical fields such as: geometry, statistics, and numbers, problem Solving, and Algebra (NCTM, 2000).

The flipped classroom strategy is one of the flexible, student-centered learning environments that has become popular in education due to the Appearance of easy-to-use and effective technologies (Steen - Utheim & Foldnes, 2018), Graham, Woodfield, and Harrison, (2013) see that the flipped classroom strategy is a type of blended learning, in which a blended teaching strategy (usual method and educational technology) is provided to students; Flipped classroom learning is based the online audio and video lectures delivered to students at home, then classroom will be for discussion sessions.

The flipped classroom is a type of blended learning, where the role of the home and the classroom is reversed, where the home becomes a self-learning environment, in which students learn the educational content that they obtain through the teacher using of various educational aids, and try to answer the tasks and exercises related to educational content. The class has become a collective learning environment, and it is dedicated to ensuring that students understand the educational content through tasks and activities within the classroom and under the supervision of the teacher (Marlowe, 2012).

The Flipped classroom is based on its theoretical basis on the Constructivism theory in learning, which emphasizes student-centered learning, where constructivism means that the student builds his learning by his personal ability to deal with events around him based on his previous experiences (Zeitoun & Zeitoun, 2003).

Considering, the constructivist theory is based on four main principles, which were relied upon in this study: First, building knowledge. Students learn in their own way based on their previous knowledge and experience; Therefore, the study asked the students to recall their prior knowledge. Second, learning is an active process. Students need to do something to learn because learning is not a passive activity, and simplified lessons provide an "activity" where students participate in group work and discussion during the lesson, so Therefore, the study requires students to take an active role in answering assignments and watching educational videos at home. Third, learning is a social activity. Students learn through their interaction with other students. This study requires students to interact with each other in class and clarify their understanding Finally, there is a motivation to learn. Where students only learn if they are motivated. Lessons are implemented to motivate students to learn due to their ability to create an enjoyable learning environment.

To implement the flipped classroom effectively, it is necessary to focus on the availability of four basic pillars, according to the study of Nagel (2013), which is derived from the term FLIP: (1) Availability of a flexible learning environment Flexible Environment: The flipped classroom provides a dynamic environment that allows the student to learn freely in Any place and time. (2) A shift in learning culture: the Flipped class helps to shift from teacher-centered learning to student-centered learning, (3) careful thinking in the division and analysis of content International Content: the teacher selects the content he wants to teach directly, knowing what topics and lessons are allowed to be discovered on their own outside of learning groups. (4) Professional Educators: The flipped classroom requires the presence of a qualified teacher, and this allows students to guide, answer their questions, as well as collaborate with other teachers to produce high quality educational materials.

The role of the teacher in the flipped classroom differs from his role in the usual classroom, and this is evident by several roles as indicated by Bclasssn (2016) which are: facilitating the learning process by following up on the learning of his students instead of his role as a transmitter of knowledge, and dealing With students in flexible groups instead of dealing with students as a whole class, and training students to write their notes, and write down their questions while watching the content, and the teacher's role becomes to prepare the educational material from one of the sources, either in the form

of an educational video or a presentation, in sufficient time before the class, Taking into account the sequence of the material to suit the students, building multiple educational activities suitable for students, and achieving the objectives of the lesson, in addition to providing immediate feedback to students after viewing the material, either through discussion in one of the social media channels, answering students questions in the classroom about the educational video, and provide the necessary support to students who need help.

Donmez and Turan (2017) explained that the most effective educational design models for implementing the flipped classroom strategy is the ADDIE model. because it is one of the most general and comprehensive models of educational design through its five stages. The model also provides a procedural framework that ensures that the outputs are effective in achieving desired goals through procedural steps and ease of implementation, in addition to the possibility of modifying the model, and adapting it to the nature of the flipped classroom strategy. The name "ADDIE" consists of the initial letters of the steps it includes: Analysis, Design, Design, Development, Implementation, and Evaluation.

Bates (2019) explained the ADDIE for five steps below:

1- Analysis: It is the basis for all the following stages in the design of education, it consists: determined the educational problem, educational content, and educational objectives, in addition to determining the students' prior knowledge and skills. This stage is accomplished by answering the following questions: Who are the target group and their characteristics? What are the students' previous experiences? What are the sources and references? What are the content objectives? How will the outputs be evaluated? What are the special needs of students, and how are they determined? What is the timetable for completing the lesson?

2- Design: This stage determined the initial plans for the development of the teaching process, and the proposed procedures for implementing the learning and teaching processes. Objectives, assessment tools, exercises, content, and media selection are aligned during a design. Stage includes as follows: analysing the content, justifying its selection, defining procedural goals (performance goals) based on lesson objectives, learning outcomes in measurable terms, determining the appropriate assessment for each goal, defining teaching strategies based on educational goals.

3- Development: Translating what was done in the design phase of plans and scenarios into real educational materials by developing a several of educational techniques used in it. It includes as follows: designing educational content in the form of educational videos, educational software, or other educational materials, defining the way educational content is presented to students, uploading educational content on the website or educational platform, or sending it via e-mail, or any means of communication with students, in addition to developing worksheets, exercises, and activities that students will use in the classroom and at home.

4- Implementation: It is the stage in which actual education is implemented and applied using the flipped classroom strategy. Stage includes as follows: ensuring the availability of educational materials and tools to implement teaching strategies, creating all appropriate conditions for the use of teaching strategies, placing educational content in a realistic context to start the student learning process, and determining the mechanism for implementing educational content inside and outside the classroom.

5- Evaluation: The effectiveness and efficiency of the flipped classroom strategy in teaching is measured, and evaluation is a process that takes place after the stages of the model process.

Some studies have pointed to the role of using the flipped class in teaching algebra and mathematics in general, and teaching in particular. The results of Sheikh (2018) study showed that the Flipped class helps raise the level of academic achievement, and the results of the study of Al-Otaibi and Iraqi

(2019) indicated the flipped classroom reveals the algebraic thinking skills of students, and Wiginton's study (2013) showed that the flipped classroom strategy enhances self-learning. Finally, the AlZebidi's study (2021) also indicated that there is a positive effect of the flipped classroom strategy in teaching the algebra course on students' achievement.

Algebra is one of the important fields of mathematics, and it is an extension of the field of numbers and operations, and aims to build symbolic expression skills, describe relationships, study patterns, and infer generalizations, through the processes of: coding, description, representation, generalization, summarization, analysis, and modelling, with the use of knowledge in Domains of algebra to solve mathematical problems related to the formation of relationships, equations and functions (Al-ghtani & Abdulhamiad, 2010).

The principles and standards of the National Council of Teachers of Mathematics (NCTM, 2000) called for the necessity of including algebraic ideas in the curricula from the first to the twelfth grade, and that algebra should be learned as a set of concepts and techniques related to the representation of quantitative relations, and as a method of mathematical thinking.

Considering, algebraic thinking has been of interest to many mathematicians and educational institutions, Kriegler (2008) mentioned in his research paper - What do we mean by algebraic thinking? - algebraic thinking according to the opinions of some experts the development of mathematical thinking within an algebraic mental framework by building a meaning for symbols and algebraic operations in the arithmetic.

Algebraic thinking defined by Will (2010,665) as "one of the patterns of mathematical thinking, related to mental operations carried out by the student to comprehend and describe mathematical patterns and relationships, and deduce a new mathematical relationship about numbers, operations and geometric shapes. Algebraic thinking is linked to the development of a set of skills among Students include as follows: inference about mathematical patterns in (graphs, geometric shapes, numbers and arithmetic operations), deducing and employing mathematical generalizations, developing mental performance in relation to operations on algebraic expressions, and using mathematical representations in describing mathematical relationships.

Soares, Balnton, and kaput (2006) presented a concept that includes algebraic thinking skills, namely: (1) The skill of discovering algebraic relationships and symbols, using of symbols in expressing algebraic quantities, variables and relationships, and distinguishing differences from relationships, functions, and equations. (2) The skill of discovering patterns and algebraic generalizations, and this is done by describing the rule of the pattern, forming the pattern, or using the pattern in the interpretation of relationships, and solving verbal problems. (3) The skill of using algebraic representations and symbols, and using modelling to generalize patterns, and expressing them across situations inside and outside mathematics.

In addition to the above, and the lack of studies - according to the researcher's knowledge - that used the ADDIE model in applying the flipped classroom strategy, in addition to the few studies that aimed to determine students' ability to acquire algebraic thinking skills using the flipped classroom strategy. This study investigates with the aim of knowing the effect of the flipped classroom strategy based on the ADDIE model on the ability to acquire algebraic thinking skills among Prince Faisal College students.

Statement of the Problem

Through his work (author 2) as a Mathematics teacher at Prince Faisal College, the researchers noticed that there is a clear weakness in the students' understanding of mathematical skills, and algebraic skills, and that this weakness is reflected in their achievement in the mathematical course. It also

affects the results of the comprehensive exam for middle college students in Jordan, and by reviewing the previous literature, the researchers noticed a weakness among students in general in the subject of algebra (concepts, thinking skills) such as the studies of Aydin and Aygun`s study (2021),), Satoshi`s study (2014), Agoestanto et al., study (2019), and Blanton, Stephens, Knuth, Gardiner, and Lsler`s study (2015).

Given that technology is considered one of the principles of mathematics education defined by the National Council of Teachers Mathematics, in addition, according to Kim, Park, and Joo (2014), technology is a basic resource that helps students learn and give meaning to mathematical ideas, Communication and mathematical thinking, developing mathematical proficiency, however. what was recommended by the study of Al-Otaibi and Iraqi (2019), and the Sheikh's study (2018) about the importance of the flipped classroom strategy in learning mathematics, developing academic achievement and mathematical thinking. This study is to identify the effectiveness of the flipped classroom strategy based on the ADDIE model in knowing students' ability to acquire algebraic thinking.

Research Question

The study attempted to answer the following question: What is the effect of the flipped classroom strategy based on the ADDIE model on Prince Faisal College students' acquisition of algebraic thinking skills?

Research Hypothesis

Based on the study questions, the following hypothesis was derived: There is no statistically significant differences between the mean scores of the students of the experimental and control groups.

Significance of the Study

The study presents an educational and learning strategy using the flipped classroom based on the ADDIE model in which technology and educational techniques are used in an effective manner on ADDIE model.

The study helps in overcoming the weaknesses and shortcomings suffered by students in general, and Prince Faisal College students in particular, and help to know students' ability to acquire algebraic thinking, through the use of a new teaching methods, and highlighting the use of Technology-based teaching strategies. The study also helps mathematics teachers to use the flipped classroom strategy to allocate class time in activities and class interaction. The results of the study also indicate that Mathematics teachers benefit from the Flipped Classroom strategy based on the ADDIE model in various fields of mathematical content. The study helps educational workers to activate and support the use of the flipped classroom based on the ADDIE model in the teaching-learning process.

Procedural Concepts

The Flipped Classroom Strategy Based on the ADDIE model:

It is defined procedural as an educational and learning strategy, where the educational material and home exercises for the functions unit are presented in the Mathematical course for students to Prince Faisal College, by watching educational videos prepared in advance by the teacher at home, and writing down their notes and questions about the lesson, while in the classroom Activities and worksheets are practiced, and students' observations and questions from the teacher are answered. The Flipped Class Strategy is implemented according to the stages of ADDIE model: analysis, design, development, implementation, and evaluation.

Algebraic thinking skills:

The researchers adopted the definition of Soares and others (Soares et al., 2006) for algebraic thinking, which includes the skills: Discovering algebraic relationships and symbols, discovering algebraic patterns and generalizations, using algebraic symbols, and procedurally defined as: the student's abilities, knowledge, and mathematical experiences to acquire algebraic thinking skills. And conducting mathematical operations that include mathematical justification, mathematical inference and mathematical representation (NCTM, 2000), and it is measured by the degree that the student obtains on the scale prepared by the researchers for this goal.

Study Delimitation:

The study is delimitated to Prince Faisal College students who are studying the unit of functions included in the "Mathematical Concepts" course approved by Al-Balqa Applied University for engineering classes in the second academic year 2021/2022 (The time period extending from 9/1/2022 to 10/2/2022). limitations is included the Algebraic thinking skills, the tools prepared by the researchers to answer the study questions, and its psychometric properties acceptable for scientific research purposes.

Review of literature

Reviewing the previous literature found that few studies have verified the effect of the inverted class based on a ADDIE model. Among these studies is the study of Al-Otaibi and Iraqi (2019), that revealed the levels of algebraic thinking using the flipped classroom strategy among secondary school students, and the researchers divided the class to experimental group (29) female students studied by he flipped class, and the control group of (27) female students studied the same unit in the usual way. A test was also prepared to measure algebraic thinking skills, and the researchers used the Edmodo educational platform. The results revealed that there were statistically significant differences between the means of the experimental and control groups in the skill of discovering algebraic functions and relationships in favor of the experimental. And there were no statistically significant differences between experimental and control groups` mean in exploring patterns and algebraic generalizations, the use of representation and algebraic symbols, and the skills of algebraic thinking.

The previous study focused a secondary school student. So, this study came to apply the flipped classroom strategy based on the ADDIE model in knowing the ability of Prince Faisal college students to acquire algebraic thinking skills.

Study Design

The study adopted the quasi-experimental approach with two groups (experimental and control), and applying a pre- and post-test to answer the study questions:

G1: O1 X O1

G2: O1 ———O1

G1: the experimental group

G2: the control group

x: Processing (using ADDIE-based Flipped Classroom)

O1: A measure of the ability to acquire the skills of pre and post algebraic thinking.

Participants

Prince faisl College was chosen as an available sample for the study, for the following reasons: The researcher works at the College, and the capabilities required by the Flipped Class Strategy based on the ADDIE model provide tools and teaching aids, and the number of classes at College has ten classes, where an experimental group was selected using the random cluster method taught using the flipped classroom strategy based on the ADDIE model, numbering 27 students, and a control group taught by the usual method, numbering 26 students.

Research Instrumentation

A measure of the ability to acquire algebraic thinking skills.

The researchers prepared a measure for the ability to acquire algebraic thinking skills in mathematics in general, and the researchers rely on previous literature to build the scale, such as the study of Al-Otaibi and Iraqi (2019), and the study of Al-Balawi (2018). A measure questions were of the type of open questions. The scale of the ability to acquire algebraic thinking skills was divided into three skills, according to Soares and others (2006) classification of algebraic thinking skills, which are the discovery skill Relationships and algebraic symbols, the skill of discovering patterns and algebraic generalizations, and the skill of using algebraic symbols. Each skill was assigned five questions.

To ensure the validity of the scale, it was presented to a group of arbitrators with expertise and competence from members of the teaching staff in mathematics` curricula and methods of teaching working at Jordanian universities, and Mathematics teachers. Arbitrators' comments Re-drafting some questions, modifying some questions of the scale, standardizing the number of questions for each skill, and taking into account all the referees' comments.

The scale of the ability to acquire algebraic thinking skills in its final form consists of (15) open-ended questions, and the scale has been corrected by giving two marks for each correct answer and correct justification, one degree for the correct answer and wrong justification, and a zero degree for a wrong answer and a wrong justification, and thus the total score of the scale reached (30) marks, and questions that do not have an answer and justification were treated as wrong and have a score of zero.

During the application of the scale to the exploratory sample of (24) students, the time taken to answer the scale questions was monitored, and the time taken was (50) minutes in addition to (10) minutes for arranging the students, distributing the scale papers and giving the scale instructions, and thus the duration of the scale was (60) min.

To calculate the coefficients of difficulty and discrimination on a sample other than the study sample consisting of (24) students, Table (1) shows the coefficients of difficulty and discrimination coefficients for each paragraph of the scale.

Table 1
Difficulty and discrimination coefficients for the items of the ability scale to acquire algebraic thinking skills

Paragraph number	Difficulty coefficient	Discrimination coefficient
1	0.56	0.53
2	0.52	0.41
3	0.54	0.57
4	0.42	0.49
5	0.54	0.46
6	0.48	0.39
7	0.52	0.65
8	0.52	0.60
9	0.50	0.57
10	0.54	0.44
11	0.46	0.54
12	0.63	0.61
13	0.44	0.53
14	0.50	0.44
15	0.56	0.69

Table (1) revealed the coefficients of the paragraphs' difficulty ranged between (0.42-0.63), and the coefficients of discrimination ranged between (0.39-0.69). And based on what Odeh (2010) indicated to the acceptable extent of the difficulty of the paragraph and discrimination, and accordingly, none of the paragraphs were deleted based on the coefficient of difficulty or the coefficient of discrimination.

To ensure the validity of the scale, the validity coefficient was calculated using the internal consistency method according to Cronbach's alpha equation, which amounted to (0.81) for the scale. And Table (2) shows the internal consistency coefficient for skills and the total score, and these values were considered appropriating for the purposes of this study.

Table 2
Cronbach's alpha internal consistency coefficient and the total score for the items of the ability to acquire algebraic thinking skills scale

skills	internal consistency
Discovering relationships and algebraic symbols	0.62
Discovering algebraic patterns and generalizations	0.65
Using algebraic symbols	0.73
algebraic thinking scale	0.81

To ensure the stability of the correction, the study used the stability of the correction across people, where the researchers and another Mathematics teacher corrected some of the answers, and determined the congruence in the correction of the correctors, and reached an agreement through the correction.

To verify the equivalence of the groups, the arithmetic means and standard deviations of skills and the total score of Prince Faisal College students' scores on the scale of the ability to acquire pre algebraic thinking skills were extracted according to the group variable (experimental, control), and to indicate the statistical differences between the arithmetic means, the "t" test was used, and the table (3) Explains this.

Table 3
Arithmetic means, standard deviations, and t-test according to the group variable on skills and the total score for the experimental and control group scores on the scale of the ability to acquire algebraic thinking skills

skills	Group	Number	Mean	Standard deviation	Value of "t"	Degrees of freedom	Statistical significance
Discovering relationships and algebraic symbols	Experimental	27	5.04	1.53	.09	51	.93
	Controlled	26	5.00	1.36			
Discovering algebraic patterns and generalizations	Experimental	27	4.52	1.55	.66	51	.51
	Controlled	26	4.23	1.63			
Using algebraic symbols	Experimental	27	3.96	1.61	-.09	51	.93
	Controlled	26	4.00	1.55			
algebraic thinking scale	Experimental	27	13.52	3.76	.32	51	.75
	Controlled	26	13.23	2.61			

Table (3) shows that there are no statistically significant differences ($\alpha = 0.05$) attributable to the group in all skills and in the total degree of the ability to acquire tribal algebraic thinking skills, and this result indicates the equivalence of the groups.

Interviews

Interviews were conducted with some students after the completion of the correction process to ascertain the way to answer the study question. The interview questions were as follows: Tell us, how did you answer this question? Why did you choose this method? Justify using this method? Is there another correct way to get to the correct answer?

Study procedures

The study included the following procedures:

- A review of the previous literature related to the subject of the study, the Flipped Classroom Strategy and ADDIE model, and Algebraic thinking skills.

- Obtaining an assignment facilitation letter from Yarmouk University addressed to Prince Faisal College, and the college's approval to implement the study.

- Choosing the study groups from Prince faisl College students as an available sample for the study, where one of the groups was chosen by the random cluster method to be a control group taught in the usual way, numbering 26 students, and an experimental group taught using the flipped class strategy based on the educational design ADDIE, numbering 27 students.

- Preparing the educational material according to the Flipped Classroom strategy based on the ADDIE model, and verifying the suitability of the strategy by presenting it to a group of arbitrators and Mathematics supervisors.

- Preparing the initial and final test of the study tool, according to the study question and its variable.

- Finding the validity of the study tools by presenting them to a group of arbitrators from Jordanian universities, and Mathematics teachers to verify the apparent validity of the study tools, and write the final test of the study tools. And to ensure the stability of the tools from Codrichardson coefficient and Cronbach's alpha coefficient.

- Applying the study tool to an exploratory sample of 24 students from Prince Faisal College and outside the study sample, to verify the validity and reliability coefficients, discrimination coefficients and difficulties for the study tools, and to ensure the appropriateness of the proposed time for each tool.

- Applying the study tool before and after the study members.

- The flipped classroom based on the ADDIE explanatory design was applied to the experimental group members and the usual teaching method to the control group members.

- Conducting interviews with some students, to ascertain how to answer the question.

- Analysing data statistically, drawing conclusions, and discussing them.

Statistical processing

The Statistical Package for Social Sciences (SPSS) program was used to statistically process the data in answering the study question:

- Calculating Arithmetic means and standard deviations of the experimental and control group scores on the scale of the ability to acquire algebraic thinking skills for the pre and post measurements according to the teaching strategy

- Using the One way ANCOVA analysis for the post-measurement of the scores of the experimental and control group on the scale of the ability to acquire algebraic thinking skills according to the teaching strategy after neutralizing the effect of their pre-measurement

- *Analysis of the one-to-one variance associated with multiple analysis of the effect of the teaching strategy on the scale of the ability to acquire algebraic thinking skills*

- Using the Associated one-way variance analysis (ANCOVA) for the effect of the teaching strategy on the post-measurement of each of the algebraic thinking skills after neutralizing the effect of their pre-measurement

FINDINGS

The results of the study question that states "What is the effects of the flipped classroom strategy based on the ADDIE model on the ability to acquire algebraic thinking skills among Prince Faisal College students?

In order to answer the study question, the arithmetic means and standard deviations of the scores of the experimental and control group were calculated on the scale of the ability to acquire algebraic thinking skills in the pre and post measurements according to the teaching strategy, as shown in Table (4).

Table 4
Arithmetic means and standard deviations of the experimental and control group scores on the scale of algebraic thinking measurements according to the teaching strategy

		Pre-Test		Post Test			
group	number	Arithmetic mean (*)	Standard deviation	Arithmetic mean (*)	Standard deviation	Mean dimensional arithmetic adjusted (*)	Standard error
Experimental	27	13.52	3.76	24.33	1.30	24.33	.27
Controlled	26	13.23	2.61	17.92	1.44	17.93	.27

Total score (30).

It is evident from Table (4) that there are apparent differences between the arithmetic means of the scores of the experimental and control group on the scale of the ability to acquire algebraic thinking skills in the pre and post measurements according to the teaching strategy, and the modified arithmetic means and standard errors were extracted According to the teaching strategy, the results in Table (4) indicate that the differences were in favour of the experimental group who were exposed to the teaching strategy (the flipped classroom based on the ADDIE model) compared to the control group.

To find out whether these apparent differences are statistically significant, one-way ANCOVA was used to measure the post-measurement of the ability to acquire algebraic thinking skills as a whole according to the teaching strategy after neutralizing the effect of their pre-measurement, and the following is a presentation of these results as shown in Table (5).

Table 5
One-way ANCOVA analysis for the post-measurement of the scores of the experimental and control group on the scale of the ability to acquire algebraic thinking skills according to the teaching strategy after neutralizing the effect of their pre-measurement

Source of variance	sum of squares	degrees of freedom	mean sum of squares	value F	level of significance	eta square η2
Pre Test	.144	1	.144	.08	.79	
strategy	542.36	1	542.36	283.36	.00	.85
error	95.70	50	1.91			
total	640.11	52				

It is evident from Table (5) that there are statistically significant differences at the level of significance (α=0.05) in the scores of the experimental and control groups, Faisal, on the scale of the ability to acquire algebraic thinking skills according to the teaching strategy. The value of (P) reached (283.36) with a statistical significance of (0.00), which is a statistically significant value, which means that there is an effect of the teaching strategy and to determine in favour of whom the differences are attributed.

As shown in Table (5), the effect of the teaching strategy was large; The value of the Eta square (η2) explained (85%) of the explained (predicted) variance in the dependent variable, which is the teaching strategy.

The arithmetic means and standard deviations of the two pre and post measures of algebraic thinking skills were calculated according to the teaching strategy, as shown in Table (6).

Table 6
Arithmetic means and standard deviations of the tribal and remote measures of the ability to acquire algebraic thinking skills according to the teaching strategy

skills	Group	Number	Pre Test		Post Test			
			Mean	Standard deviation	Mean	Standard deviation	Mean dimensional arithmetic adjusted (*)	Standard error
Discovering relationships and algebraic symbols	Experimental	27	5.04	1.53	8.07	1.14	8.07	.20
	Controlled	26	5.00	1.36	5.81	.85	5.82	.20
Discovering algebraic patterns and generalizations	Experimental	27	4.52	1.55	7.78	.97	7.77	.17
	Controlled	26	4.23	1.63	6.04	.87	6.057	.18
Using algebraic symbols	Experimental	27	3.96	1.61	8.48	.99	8.467	.17
	Controlled	26	4.00	1.55	6.08	.98	6.10	.18

Total score (30)

It is noted from Table (6) that there are apparent differences between the arithmetic means in the pre and post measurements of algebraic thinking skills resulting from the difference in the teaching strategy. The significant differences between the arithmetic means adjusted for the post-measurement in all algebraic thinking skills were in favor of the experimental group members who were exposed to the teaching strategy (the flipped class based on the ADDIE model) compared to the control group, noting that the effect sizes of the skills ranged between (49.6% - 65.7%). In order to verify the significance of the apparent differences, one way MANCOVA was applied. This is as shown in Table (7).

Table 7
Analysis of the one-to-one variance associated with multiple analysis of the effect of the teaching strategy on the scale of the ability to acquire algebraic thinking skills

Impact	Type of test multiple	Multiple test value	F total	Degree of freedom of the hypothesis	Degree of freedom of error	Indication level	Effect size η2
Strategy	Hotelling's Trace	6.21	95.20	3.00	46	.00	.86

Table (7) shows that there is a statistically significant effect of the teaching strategy at the significance level (α = 0.05) on the post-measurement of the scale of the ability to acquire the skills of algebraic thinking combined, where Hotelling's value reached (6.21) and statistical significance amounted to (0.00), and to determine which skill Of the skills, the effect of the teaching strategy was the associated one-way analysis of variance (ANCOVA) for each skill separately, according to the teaching strategy after neutralizing the effect of their pre-measurement, as shown in Table (8).

Table 8
Associated one-way variance analysis (ANCOVA) for the effect of the teaching strategy on the post-measurement of each of the algebraic thinking skills after neutralizing the effect of their pre-measurement

skills		Source of variance	Sum of squares	Degree of freedom	Mean sum of squares	Significance level	Effect size η2
Discovering relationships and algebraic symbols (accompanying)		.08	1	.08	.08	.79	
Discovering algebraic patterns and generalizations(accompanying)		.77	1	.77	.95	.33	
Using algebraic symbols (accompanying)		3.03	1	3.03	3.80	.06	
Group	Discovering relationships and algebraic symbols (Post)	66.14	1	66.14	61.66	.000	.56
	Discovering algebraic patterns and generalizations(Post)	38.48	1	38.48	47.28	.000	.50
	Using algebraic symbols (Post)	73.33	1	73.33	91.95	.00	.66
error	Discovering relationships and algebraic symbols (Post)	51.49	48	1.07			
	Discovering algebraic patterns and generalizations(Post)	39.07	48	.81			
	Using algebraic symbols (Post)	38.28	48	.80			
corrected total	Discovering relationships and algebraic symbols (Post)	119.93	52				
	Discovering algebraic patterns and generalizations(Post)	83.70	52				
	Using algebraic symbols (Post)	125.17	52				

Table (8) shows that there are statistically significant differences at the significance level (α = 0.05) according to the effect of the teaching strategy in all skills.

DISCUSSION

We discuss the results of the study, as it was relied on previous literature and previous studies related to the subject of the study in discussing the results of the study. The results showed that there were differences in the total degree of the scale of acquisition of algebraic thinking skills in favour of the experimental group, and this result is attributed to the fact that the strategy worked to recall previous knowledge and use it in new learning situations, and this was reflected in a positive impact on mathematical thinking skills in general, and algebraic thinking skills.

The differences are also attributed to the fact that the flipped classroom strategy based on the ADDIE model included mathematical activities and tasks for the students of the experimental group that enabled them to deal with algebraic relationships and functions, the use of algebraic symbols, and dealing with patterns and algebraic generalizations in the mathematical content, which led to the development of students' algebraic thinking skills, and these activities and tasks Mathematics was not enough for the control group, which is taught in the usual way.

The Flipped Class Strategy based on the ADDIE model helped enrich the students' mathematical knowledge of concepts, generalizations, skills and algorithms, through group learning and increased interaction and discussion between the students themselves, and between the students and the teacher, which helped them enhance their algebraic thinking skills.

This result differed from the study of Al-Otaibi and Iraqi (2019), which showed no differences in the total score of algebraic thinking skills according to the Flipped Class Strategy based on the ADDIE model . The researchers attributed this to the fact that the activities and tasks included in the strategy did not enhance the algebraic thinking skills.

The results showed that there were differences in the algebraic thinking skills according to the teaching strategy in favour of the experimental group (taught using the Flipped Class Strategy based on the ADDIE model); In the skill of discovering patterns and algebraic generalizations, the differences were in favour of the experimental group.

The skill of discovering patterns and algebraic generalizations includes describing the pattern rule, writing algebraic generalizations, or using the pattern in interpreting relationships, solving verbal problems, and it requires mental skills related to meditation and advanced mathematical thinking such as generalization and abstraction. Algebraic patterns and generalizations. Students' prior knowledge played a positive role in developing this skill and reaching generalizations. Students also benefited from the laws of exponential and logarithmic functions in enhancing this skill.

Figure (1) shows the answer of one of the students of the experimental group to one of the questions related to using the skill of pattern discovery and algebraic generalizations.

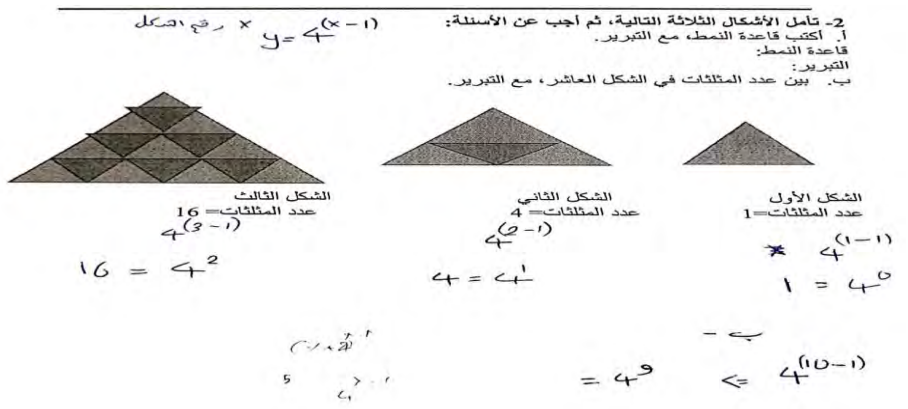

Figure 1
The answer of one of the students of the experimental group to one of the questions about the skill of discovering patterns and algebraic generalizations

An interview was conducted with the student who answered this answer, and after asking the interview questions to him, the student said:

"I used algebra in solving the question, and I had a good practice in dealing with patterns, expressing them in an algebraic form, and I noticed an algebraic relationship between the three forms, and after trying several algebraic formulas, I reached the pattern rule, and I prefer using algebra to express patterns, I think there are other ways to solve But I haven't tried it".

This result differed with the study of Al-Otaibi and Iraqi (2019), which showed that there were no differences in the skill of discovering patterns and algebraic generalizations according to the Flipped Class Strategy based on the ADDIE educational design. It can be presented in the tasks and activities of the Flipped Classroom Strategy based on ADDIE in the secondary stage. The researchers also attributed this to the fact that the students' previous experiences negatively affected the development of this skill.

The results showed that there were differences in the skill of discovering algebraic relationships and symbols according to the teaching strategy in favor of the experimental group. The Flipped Classroom Strategy Based on ADDIE model Various mathematical contexts of educational videos, additional links, practice questions, worksheets, and assessments enable students to see relationships and algebraic symbols, and express algebraic expressions, and this enhances their understanding and stimulates their motivation to learn, and the use of group learning Class discussions led students to build their new knowledge, and this skill became more used and practiced.

Figure (2) shows the answer of one of the students, the experimental group, to one of the questions related to the use of the skill of discovering relationships and algebraic symbols.

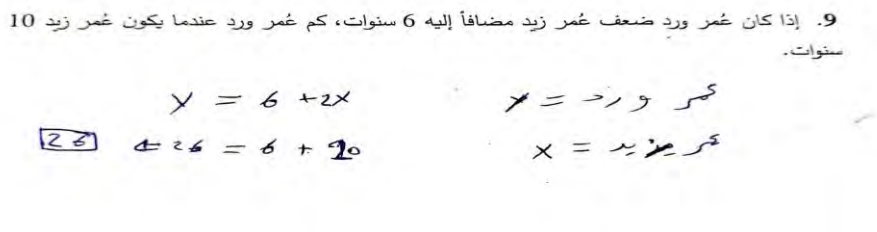

Figure 2
The answer of one of the students of the experimental group to one of the questions about the skill of discovering relationships and algebraic symbols

An interview was conducted with the student who answered this answer, and after asking the interview questions to him, the student said:

"Algebraic symbols were used to solve the question, as it was assumed that Ward`s age y and Zaid`s age x, and because age of Ward is greater, y imposed the subject of the equation, and I tried to formulate the problem with an algebraic equation to discover the relationship between Ward`s age and Zaid`s age, and the ward age`s is double Zaid`s, and with the addition of 6. The equation became y = 2x+6. There are other ways to solve it, for example: taking the double of Zaid`s age of 10 years to become 20 years, and adding 6 years; Ward`s age to be 26 years old".

This result agreed with the study of Al-Otaibi and Iraqi (2019), which showed that there are differences in discovering relationships and algebraic symbols according to the flipped classroom strategy based on the ADDIE educational design, and that the presentation of mathematics activities and tasks depending on the techniques used in the flipped classroom strategy, enabled them to see the relationships and algebraic symbols. In a variety of mathematical contexts, which enhanced the deep understanding of this skill among students, the researchers also attributed this result in the fact that learning through groups enhanced opportunities for social negotiation among students, and to reach solutions to the tasks presented to them, which led to the reorganization of their knowledge structures. The skill is more distinct and clearer. The results showed that there were differences in the skill of using algebraic symbols according to the teaching strategy in favour of the experimental group, and this skill requires using algebraic symbols, generalizing patterns, and expressing them through situations inside and outside mathematics. And worksheets and assessments), which helped students to use and deal with algebraic symbols on a continuous basis, which led to the development of students' performance in using algebraic symbols in situations inside and outside mathematics for types of functions.

Figure (3) shows the answer of one of the students, the experimental group, to one of the questions related to the use of the skill of using algebraic symbols.

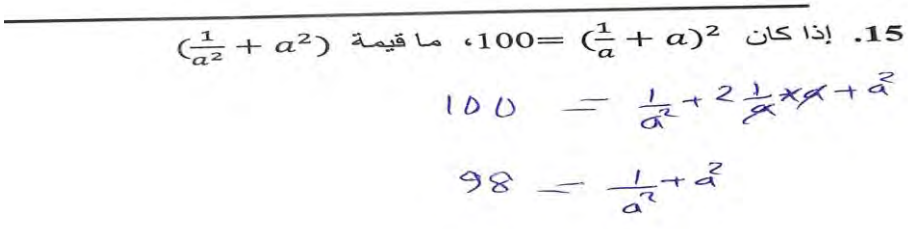

Figure 3
The answer of one of the students of the experimental group to one of the questions about the skill of using algebraic symbols

An interview was conducted with the student who answered this answer, and after asking the interview questions to him, the student said:

" I dealt with algebraic symbols in answering the question, where I extracted the results of decoding parentheses, and performed arithmetic operations such as abbreviation, grouping similar terms, addition and subtraction from both sides of the equation".

This result differed with the study of Al-Otaibi and Iraqi (2019), which showed that there were no differences in the skill of using algebraic symbols according to the Flipped Class Strategy based on the educational design ADDIE, and this may be due to the fact that this skill needs to employ mathematical concepts and generalizations, and formulate previously learned algebraic equations. , despite the availability of multiple sources for learning to use the Flipped Classroom strategy based on the ADDIE model, the researchers also attributed this to the fact that the students' previous experiences were limited to developing this skill.

CONCLUSIONS

Based on the results, the study reached a set of conclusions:

1. The application of the flipped classroom strategy according to the stages of the ADDIE model helps to organize and implement the flipped classroom strategy to achieve its objectives.

2. The positive effect of using the flipped classroom strategy based on the ADDIE model in mathematics learning and teaching in revealing students' ability to possess algebraic thinking skills.

3. The Flipped Classroom Strategy based on ADDIE model enhances student learning, because the strategy integrates student learning at home and in the classroom.

RECOMMENDATIONS

1. Benefiting from the results of the study by mathematics teachers using the flipped classroom strategy based on ADDIE instructional design in learning and teaching mathematics.

2. Conducting studies on the impact of the flipped classroom strategy based on educational design ADDIE on students' acquisition of mathematical concepts in other fields such as geometry, probability, statistics, etc.

3. Studying the impact of the flipped classroom strategy based on ADDIE instructional design in revealing students' ability to possess mathematical thinking skills.

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