
| RESEARCH ARTICLE

The effectiveness of self-regulated learning strategies on the square equations problem-solving among ninth-grade students and arousing their motivation for learning.

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| ABSTRACT

The research question intended was to examine the effectiveness of employment some of the self-regulated learning strategies in solving quadratic equations among ninth grade students and increasing their motivation to learn, the research study employed a semi-experimental curriculum, and the students in the research were (60) students in the ninth-grade basic students in mathematics in one of the schools of the Directorate of Education of the Northwest Badia District and they were distributed randomly in two equal groups (one experimental and another group that was not experimental). was taught in accordance with the teaching model based on self-regulated learning, the other was a female officer who was taught in the conventional manner, and there were actually thirty female students in each group. The researcher used two tools in this study, one in the form of a test that measures the solution of quadratic equations and the other in the form of a questionnaire to measure motivation; after confirming their veracity and consistency, the study's results showed that there were statistically significant differences at the level ($\alpha=0.05$) between the average scores in the experimental group and the control group. The study recommended using the model based on structured learning in the teaching of mathematics; the ninth-grade quadratic equation solving module is self-taught. The results also demonstrated statistically significant differences between the average scores of the experimental group and the control group in the measure of motivation.

| KEYWORDS

Self- Regulated Learning, Solving Quadratic Equations, Motivation for Learning, Basic Ninth Graders.

| ARTICLE INFORMATION

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1. Introduction

The student is the central axis of the educational process. Therefore, instructional strategies, methods, and patterns vary to achieve effective learning that develops and improves students' performance. Teachers must provide and create effective educational environments and situations that enable students to interact with them, motivate them to learn, and enhance their motivation.

Al-Ansari (2018) stated that the current situation of mathematics curricula and teaching methods suffers from teachers' failure to use instructional strategies that help identify students' abilities and meet their needs. When teachers use modern instructional approaches, students generate new and integrated ideas, which contribute to achieving the desired learning goals.

Algebra is one of the branches of mathematics. It includes algebraic expressions, symbols, operations, and the solving of linear and quadratic equations. Quadratic equations and their solutions are considered among the main activities in the basic-stage mathematics curriculum. They are a crucial component of fundamental algebraic skills and are crucial to mathematics education because they give pupils several chances to easily exercise computational abilities.

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Additionally, mastering them is essential for the advancement of other mathematical subjects (Al-Nizwani, 2021).

In order to make the teaching and learning process meaningful, the National Council of Teachers of Mathematics (NCTM, 2000) stressed the significance of employing contemporary methods in mathematics instruction. A significant portion of the subject standards in the Principles and Standards for School Mathematics published by the National Council of Teachers of Mathematics include algebra and algebraic expressions, including the solution of algebraic equations.

Al-Atoum et al. (2007) argued that motivation refers to the occurrence of overt or covert behavior, as well as persistence and perseverance. It also denotes the duration for which the behavior continues to occur. Moreover, motivation plays an effective role in explaining the forces that influence behavior, as it determines both the initiation and the termination of behavior. Motivation has great importance in learning, as it affects both learning and performance and provides the drive that leads to improvement in learning processes, attention, and perception; therefore, it is considered a fundamental factor in achievement and learning (Al-Zayyat, 2010).

The researcher believes that solving equations, especially quadratic equations, is one of the difficulties students face in learning mathematics. There are several methods for solving quadratic equations, the most important of which are the general formula, factoring, completing the square, the square-foot method, and graphing.

1.1 Self-Regulated Learning (SRL)

Self-regulated learning is a type of learning that helps students organize instructional material in a way that makes learning meaningful. Through this type of learning, learners acquire the ability to connect prior knowledge and experiences with current information and to employ appropriate methods and strategies to achieve their goals. This aligns with the principles advocated by modern education. Self-regulated learning occurs when students are motivated to engage gradually in learning activities within educational environments that support self-regulation (Abdel-Hamid, 2011).

Self-regulated learning is crucial for increasing productivity and learning effectiveness through goal-setting and accomplishment. It reduces the effort expended in learning and contributes to strengthening self-confidence through achieving educational goals. It also increases intrinsic motivation for learning, thereby enhancing the ability for lifelong learning (Hassan, 2012; Al-Hasanat, 2017).

1.2 Strategies of Self-Regulated Learning

Brak, Paton, and Lan (2010) indicated that there are several self-regulated learning strategies, the most important of which are:

- First Strategy: Self-Evaluation

This refers to statements made by students through which they evaluate the quality of their performance and the extent of their progress in completing a task, as well as the available time and the deadline for completing activities related to these goals.

- Second Strategy: Organization and Transformation

This enables students to reorganize and improve learning materials.

-Third Strategy: Goal Setting and Planning

This would entail establishing educational objectives, allocating time, and setting deadlines on how to finish tasks.

-Fourth Strategy: Information Seeking

This is the tendency of the students to get the supplementary information that is not provided in the social sources when the students encounter a school task.

-Fifth Strategy: Record Keeping

This involves utterances of attempts to document, organize, or capture events or results.

-Sixth Strategy: Environmental Structuring

- This describes efforts to modify the physical environment or psychological context to enhance learning.

-Seventh Strategy: Self-Outcomes

This involves giving oneself rewards or imposing penalties related to success or failure.

-Eighth Strategy: Rehearsing and Memorizing

This refers to efforts to remember information through repetition and practice.

-Ninth Strategy: Seeking Social Assistance

This includes students' efforts to obtain help from peers, teachers, or adults.

-Tenth Strategy: Reviewing

This refers to students' efforts to reread notes, tests, and textbooks when preparing for lessons or exercises.

2.Previous Studies

Several previous studies have been conducted on this topic. Rahal (2024) examined the impact of SRL based training program on solving linear inequalities and attitudes toward mathematics among ninth-grade students. Using a sample of 59 students and a quasi-experimental methodology, the study discovered statistically significant changes that favored the experimental group.

Al-Sharif (2021) investigated how SRL strategies can improve students' reflective thinking and achievement in chemistry and found that self-regulated learning strategies were effective in improving both achievement and reflective thinking.

The researcher benefited from these studies in enriching the theoretical framework, identifying the research problem, and developing the study instruments. This is based on the fact that, according to the little information the researcher has, it is one of those first studies to investigate the effectiveness of self-regulated learning strategies in solving quadratic equations as well as in creating motivation in 9th grade students.

Study Problem

Algebraic skills are considered one of the main branches of mathematics, and solving quadratic equations is one of the most important topics in the curriculum. However, students face difficulties in solving quadratic equations (Al-Nazwana, 2021).

Obeida (2016) reported a deficiency in students' interest in learning equation-solving skills and noted that teachers often use ineffective teaching strategies and instructional aids. These methods fail to stimulate students' motivation and instead lead to boredom and negative attitudes.

Modern developments require educators to adopt strategies that promote meaningful learning. However, many teachers still rely on rote memorization. Self-regulated learning allows students to direct their efforts, control their learning environment, and think critically. Traditional teaching limits students' cognitive development and motivation.

Tarhi (2010) and Abdelhavez et al. (2024) found that students make many errors when solving quadratic equations. Abu Zaid et al. (2023) showed that some teaching strategies fail to stimulate motivation. As such, this study seeks to examine how SRL strategies can help students in solving quadratic equations and increase their motivation.

Study Questions

This study attempts to answer the following questions:

1. Do the mean scores of post-tests solving quadratic equations differ statistically at the $\alpha=0.05$ level between the experimental and control group based on the teaching method used?
2. Do the results of the post-test of learning motivation show statistically significant differences between the mean scores of the experimental and the control groups at $\alpha= 0.05$ due to the teaching method?

3. Objectives of the Study

This study aims to:

- Examine how well ninth-grade students use self-regulated learning techniques to solve quadratic problems.

- Determine whether self-regulated learning techniques can boost ninth-grade students' motivation to learn.

4.Importance of the Study

4.1Theoretical Significance

This study presents the concept of SRL and its strategies and measures to how extent they are effective in helping ninth grade students solve quadratic equations and stimulate their motivation. It also provides teachers with a guide and research instruments.

4.2Practical Significance

The results may benefit teachers, supervisors, and curriculum planners in improving mathematics curricula and teaching methods and in designing the quadratic equations unit according to self-regulated learning strategies.

5. Definitions of Terms

-Effectiveness of Implementation

It is defined as "the extent of the effect produced by the experimental treatment as an independent variable on one of the dependent variables, as reflected in the amount and type of learning achieved through educational situations inside and outside the classroom" (Shehata & Al-Najjar, 2003, p. 230).

Operationally, it is defined as the extent of the effect resulting from the use of some self-regulated learning strategies in teaching the unit on solving quadratic equations among ninth-grade female students in mathematics.

-Self-Regulated Learning Strategies

They involve creating activities that help students create learning objectives and then try to control their motivation, thought processes, and behavior. These components are directed and limited by their objectives as well as the environment's contextual features (Masoudi, 2010, p. 67).

Pint rich and Schunk (2004, p. 37) define them as goal-directed actions and processes carried out by the learner to acquire information and skills. These involve the individual's regulation of knowledge and behaviour through self-regulatory activities that the learner believes will help achieve the intended goals.

Operationally, the researcher defines self-regulated learning strategies as those strategies organized in sequential steps to regulate the learning process to achieve the desired goals. These include the following strategies: information seeking, self-observation, rehearsal, goal setting and planning, self-evaluation, and organization and transformation, which are adapted by the mathematics teacher while teaching the unit on solving quadratic equations in the ninth-grade mathematics textbook.

-Solving Quadratic Equations

Solving a quadratic equation is defined as the process of finding the set of numerical values that the variable takes that satisfy the equation. Operationally, the researcher defines it as the methods used by ninth-grade students to solve a quadratic equation, represented by one of the following methods: the general formula for solving quadratic equations, factoring, completing the square, the square-foot method, and the graphical method. It is determined by the study sample's results on the test designed specifically for this purpose.

- Motivation for Learning

Awais (2009, p. 8) defined learning motivation as "a state that drives the student and stimulates interest, desire, and attention toward the learning situation, engaging actively and effectively, and continuing this activity until learning is achieved."

In this study, the researcher defines it as an internal state that motivates ninth-grade students (members of the study sample) to have a desire to learn mathematics and to engage in it actively and effectively. It is identified by the study sample's overall learning motivation score.

-Ninth-Grade Students

All students enrolled in the ninth grade, according to school records. This grade precedes the end of the compulsory basic education stage in the Jordanian educational system, with students' average age being approximately 15 years. In this study, the term refers to the students selected as members of the study sample in both the experimental and control groups, enrolled in

ninth-grade classes at Al-Hamra Secondary School for Boys at North-Western Badia Educational District in the first semester of the 2025/2026 school year.

6. Study Limitations

- **Human Limitations:** The study was implemented using a sample of 9 th -grade students in mathematics.
- **Temporal Limitations:** The study was carried out in the 1st semester of the 2025/2026 school year.
- **Subject Matter Limitations:** The study was confined to the use of self-regulated learning strategies of eight topics (lessons) of the unit on quadratic equations in the ninth-grade mathematics textbook, first semester, pages 3674.

These lessons required 12 classroom sessions, each lasting 45 minutes. The lesson topics included: the general formula for solving quadratic equations, factoring, completing the square, the square-foot method, and the graphical method.

- **Spatial Limits:** The study was carried out in the North-Western Badia Educational District's Al-Hamra Secondary School for Boys.

- **Study Delimitations:** The results of this study are determined by the psychometric characteristics of the study instruments in terms of validity and reliability, and the accuracy and seriousness of the respondents.

7. Methodology and Procedures

7.1 Study Method

In this study, the quasi- experimental method was applied due to the presence of two groups of the study: an experimental group which received the training with the use of the SRL strategies and a control group which received the training with the help of the traditional method.

7.2 Study Sample

The total of 60 9th-grade learners at the Al-Hamra Secondary School of Boy at North-Western Badia Educational District in the first semester of the 2025/2026 school year were the participants. They were separated into two equal classes consisting of (30) students each. The experimental and control group were allocated the two classes randomly. The experimental group was being taught on the basis of SRL strategies, whereas the control one was taught on the basis of the traditional method.

7.3 Equivalence of the Study Groups

In order to guarantee the similarity of the subjects in both experimental and the control group, the researcher used both experimental and the control group to pretest the final forms of the research instruments (the test and the motivation scale), upon confirming their validity and reliability. This is to ensure that there is similarity between the students of the experimental and the control group.

Students' scores on the study tools were calculated, along with their means and standard deviations. The t-test was employed to ascertain statistical differences between the means, as indicated in Tables (1) and (2) below.

Table (1)
Means, Standard Deviations, and t-Test for the Pretest Scores of the Study Groups in Solving Quadratic Equations

Group	N	Max	M	SD	t	df	Sig.
Experimental	30	20	8.11	2.04	0.548	58	0.076
Control	30	20	8.16	2.13			

Table (1) indicates no statistically significant differences between the means scores of the experimental and control groups on the pretest of solving quadratic equations, as the value of (**t = 0.548**) is not statistically significant (**α=0.05**). This confirms that the participants in both groups are equivalent on the quadratic equations test.

Table (2)
Means, Standard Deviations, and T-Test for the Pretest Scores of the Study Groups on the Learning Motivation Scale

Group	N	M.	SD	<i>t</i>	<i>df</i>	<i>Sig.</i>
Experimental	30	3.19	0.12	0.433	58	0.067
Control	30	3.21	0.16			

The data in Table (2) demonstrates that the experimental and control groups' mean scores on the learning motivation pretest did not differ statistically significantly, as the value of ($t = 0.433$) is not statistically significant ($\alpha=0.05$) level. This suggests that the motivation levels of the two groups are comparable.

8. Study Instruments

8.1 Solving Quadratic Equations Test

The study prepared the initial version of the test after analyzing the quadratic equations unit in the ninth-grade mathematics textbook and preparing a test specification table. The test was multiple-choice with four alternatives, only one of which was correct. The initial version consisted of (22) questions.

8.2 Test Validity

- Content Validity

Ten specialists in measurement and evaluation, mathematics curriculum, teaching, and educational supervision were shown the test's original configuration. They reviewed the clarity, linguistic accuracy, and relevance of the items. Taking the remarks of the experts, some items were modified, some alternatives were changed, and two items were deleted.

- Construct Validity

One of the students of the study population (30) obtained a pilot sample of (30) students who did not form part of the main sample that answered the test. Item difficulty indices ranged between (0.22 - 0.71), and discrimination indices fell between (0.46 - 0.89), which are acceptable. Item total correlations were (0.90). The final version totaled (20) items.

8.3 Test Reliability

- Test-Retest Reliability

The test was administered twice to a pilot sample with a two-week interval. Pearson's correlation coefficient between the two administrations was (0.84).

- Internal Consistency

Using the Kuder-Richardson (KR-20) formula, the reliability coefficient was (0.82).

8.4 Determining Test Time

The average completion time of the first five students (30 minutes) and the last five students (40 minutes) was calculated. The test duration was 35 minutes.

8.5 Test Scoring

The final test included (20) multiple-choice items. Each correct answer was given one point and each incorrect answer zero, giving a total score of (20).

- Learning Motivation Scale

The scale was created based on literature and studies that were related. It had 20 items that were rated on a 5-point Likert scale with 1 (Strongly Disagree) to 5 (Strongly Agree).

8.6 Validity of the Scale

- Content Validity

The scale was reviewed by (11) experts in curriculum, teaching, and educational psychology. Minor linguistic modifications were made. The final version contained (20) items.

- Construct Validity

The scale was administered to a pilot sample of (30) students of the study population but not of the main sample. The acceptable coefficient of reliability was obtained (0.85).

- Reliability of the Scale

A pilot sample comprising (30) students was given the scale. With the alpha of Cronbach, the coefficient of reliability was (0.85), which is fitting in this research.

9. Study Procedures

To carry out the study, the researcher followed the following procedures:

- Examining theoretical literature and earlier research on the subject of the inquiry.
- Choosing the unit of instruction that will be taught to participants in the experimental and control groups
- Analyzing the content of the instructional unit and preparing the test specification table.
- Preparing the quadratic equations test and developing the mathematics learning motivation scale in their initial forms.
- Official approvals from the relevant authorities to conduct the study were obtained.
- Choosing volunteers and allocating them at random to two groups: a control group and an experimental group.
- Verifying the validity and reliability of the two research instruments and calculating the difficulty and discrimination indices of the test.
- Preparing the two instruments in their final forms.
- Administering the two instruments as pre-tests to both groups to ensure the equivalence of the experimental and control groups.
- Selecting one teacher to teach both groups.
- Preparing a teacher's guide for teaching the experimental group according to some self-regulated learning strategies.
- Training the teacher to implement the guide with the experimental group, while the control group was taught using the conventional method described in the teacher's guide.
- After ensuring the equivalence of the two groups, the teacher began implementing the experiment with both the experimental and control groups for three weeks, comprising (12) class periods, under the supervision and follow-up of the researcher.
- Administering the two instruments as post-tests to both groups after completing the experimental procedures.
- Collecting the data from the study sample and analyzing it statistically.
- Deriving the results, discussing them, and presenting recommendations and suggestions considering those results.

10. Research Design and Variables

The study followed the following design:

EG	O1	O2	X	O1	O2
CG	O1	O2	-	O1	O2

The symbols in the above design represent the following:

- A: Experimental group
- C: Control group
- O1: Quadratic Equations Test
- O2: Learning Motivation Scale
- X: Teaching according to self-regulated learning strategies
- : Teaching according to the traditional method

11. Variables of the Study

First: Independent Variable

The teaching method, which has two levels:

Self-regulated learning strategies

Traditional teaching method

Second: Dependent Variables

Solving quadratic equations

Learning motivation

12. Statistical Analysis

An experimental and controls group were computed on means, standard deviations, adjusted means both in the pre-post-administrations of quadratic equations test and the mathematics learning motivation scale.

The total test score was analyzed using one-way analysis of covariance (One-Way ANCOVA) to establish the difference between the post-test mean of the experimental and control group whilst adjusting the effect of the pre-test scores with the ignore of the first and the second research question.

13. Results and Discussion

First: Results Related to the First Research Question

Do the mean scores of the experimental and control groups reach statistically significant differences at the level of significance (0.05) in the post-test of solving quadratic equations as a result of using SRL strategies and the traditional approach as outlined in the teacher guide?

To answer this question, the arithmetic means, standard deviations, adjusted means and standard errors of the scores of students in both experimental and control groups on the quadratic equations test (pre- and post-test) based on the teaching method (self-regulated learning strategies vs. conventional) were calculated as demonstrated in Table (3).

Table (3)
Means, standard deviations, adjusted means, and standard errors of the scores of the experimental and control groups on the quadratic equations test in the pre- and post-tests according to the teaching method

Group	N	Pre- test		Post- test		Standard error	Adjusted mean
		M	SD	M	SD		
Experimental	30					17.32	0.27
Control	30	8.11	1.04	17.58	1.46	12.46	0.37

Table (3) shows that there are some apparent differences between the arithmetic mean and adjusted mean of the experimental and control group in the quadratic equations test based on the teaching approach. The adjusted post-test mean of experimental group was 17.32 and a standard error of 0.27 and the adjusted mean of the control group was 12.46 and a standard error of 0.37.

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One-way ANCOVA was then conducted on the post-test scores of the quadratic equations test, controlling for pre-test scores, to determine whether these differences were statistically significant at the level ($\alpha = 0.05$). The results are shown in Table (4).

Table (4)
Results of the One-Way Analysis of Covariance (ANCOVA) for testing the significance of differences between the mean scores of the experimental and control groups on the quadratic equations test

Source of variance	sum of squares	df	Mean Square	f	Sig.	Eta Square (η^2)
pre-test	136.284	1	136.284	56.362	0.000	0.1250
Teaching method	146.132	1	46.1321	60.435	0.000	0.4340
Error	122.112	57	2.418			
	404.548	59				

The results in Table (4) show statistically significant differences at the level ($\alpha = 0.05$) in students' scores on the quadratic equations test according to the teaching method, in favor of the experimental group taught using self-regulated learning strategies.

The effect size ($\eta^2 = 0.434$) indicates that 43.4% of the variance in students' performance is attributable to the use of self-regulated learning strategies, which represents a large effect according to Cohen's criteria.

This positive result can be attributed to the structured and sequential steps of self-regulated learning strategies, which helped students organize their learning, connect prior knowledge with new information, and improve their problem-solving performance.

Second: Results Related to the Second Research Question stating: "Do the mean scores of the experimental and control groups on the post-test of Learning Motivation Scale differ at the significance level (0.05) which can be ascribed to the teaching method?"

Table (6)

Means, standard deviations, adjusted means, and standard errors of the experimental and control groups on the Learning Motivation Scale in the pre- and post-tests

Group	N	Pre- test		Post- test		Standard Error	Adjusted Mean
		M	SD	M	SD		
Experimental	30	3.19	1.01	4.47	1.04	4.72	0.19
Control	30	3.21	1.23	3.28	1.15	3.26	0.21

The data in Table (6) indicate apparent differences between the arithmetic means and adjusted means of the experimental and control groups on the Learning Motivation Scale in both pre- and post-tests according to the teaching method (self-regulated learning strategies vs. conventional). The adjusted post-test mean for the experimental group was (4.72) with a standard error of (0.19), whereas the adjusted mean for the control group was (3.26) with a standard error of (0.21).

In order to establish the statistical significance of these apparent differences a one-way analysis of covariance (referred to as ANCOVA) was applied to the post-test scores of the Learning Motivation Scale controlling the effect of the pre-test scores. The findings are presented in Table (7).

Table (7)

One-Way ANCOVA for testing the significance of differences between the mean scores of the experimental and control groups on the Learning Motivation Scale

Source of variance	Sum of squares	df	Mean Square	f	Sig.	Eta Square (η^2)
Pre- test	38.486	1	38.486	23.467	0.000	.14600
Teaching method	62.541	1	62.541	38.135	0.000	.39400

Error	32.722	57	1.640			
Total	168.184	59				

Table (7) results show that the means of the experimental and control groups in the responses concerning the Learning Motivation Scale are statistically different with the level of 0.05 based on the teaching method (self-regulated learning strategies vs. conventional). The F-value was (38.135) and the significance (0.000) was not found, which means that there was statistically significant difference in the favor of the experimental group, the members of which were trained with the help of self-regulated learning strategies rather than the conventional method in contrast to the control group.

The adjusted mean values for both groups, as shown in Table (6), confirm that self-regulated learning strategies have a statistically significant effect on stimulating learning motivation among ninth-grade students.

To clarify the magnitude of this effect, eta squared (η^2) was calculated and reached (0.3940), meaning that 39.4% of the variance in responses on the Learning Motivation Scale can be explained by the use of self-regulated learning strategies (explained variance), while the remaining variance is due to other factors. According to Cohen (as cited in Al-Kilani & Al-Sharifain, 2011), this represents a large effect size.

This positive result can be attributed to several factors, including the role of self-regulated learning strategies in enhancing students' confidence through achieving learning objectives, increasing intrinsic motivation for learning, and promoting lifelong learning skills. Consequently, this contributed to raising the learning motivation of the experimental group in mathematics.

Sequential and orderly stages of self-regulated learning strategies enabled students to arrange their learning which enhanced motivation and interest, and yet the control group did not have such orderly steps.

14. Conclusion and Recommendations

This study ended up demonstrating that the experimental group was more successful than the control group in solving quadratic equations and provoking the motivation to learn in students. On the findings, the research suggests the application of certain self-regulated learning strategies by ninth-grade mathematics teachers when they are teaching the unit of Equations in the student textbook. These plans have been shown to be efficient in assisting ninth-grade students to solve quadratic equations as well as to get more motivated to learn.

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