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THE IMPACT OF USING PROGRAMMED INSTRUCTION METHOD ON THE ACHIEVEMENT OF 11TH GRADE /ACADEMIC TRACK STUDENTS IN MATHEMATICS (SECOND DERIVATIVE AND APPLICATIONS OF EXTREME VALUES) IN JORDANIAN SCHOOLS

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Abstract

This study aimed to investigate the impact of using the programmed instruction method on the academic achievement of 11th grade academic track students in mathematics, specifically in the topics of the second derivative and applications of extreme values, in Jordanian schools. The study sample consisted of (64) students from a private school in Amman, divided into two groups: a control group (32 students) taught using the traditional method, and an experimental group (32 students) taught using the programmed instruction method. To achieve the study's objectives, two tests were administered: a pre-test and a post-test after one month of instruction. The researcher used Analysis of Covariance (ANCOVA) to analyze the results. The results showed statistically significant differences at the significance level ($\alpha = 0.05$) in favor of the experimental group taught using the programmed instruction method, indicating that this method contributed to improving students' achievement and their ability to solve problems related to extreme values and use of second derivatives. The researcher recommends generalizing the use of the programmed instruction method in teaching mathematics to 11th grade students in all schools and encouraging teachers to use it due to its positive impact on improving academic achievement.

INTRODUCTION

Mathematics is a crucial foundation in building the scientific and technological capabilities of any nation. It represents the primary tool for understanding natural, economic, and social phenomena. (Abu Amara, 2024)

In the Hashemite Kingdom of Jordan, the education sector has witnessed a significant transformation in recent years with the implementation of the new mathematics curriculum in the academic year 2025. This came in response to the challenges revealed by international and regional studies, where the results of international assessment tests, national tests, and the quality of education index showed that the level of achievement among students in mathematics in Jordan is still below the required level. This reflects a clear weakness in understanding the basic core concepts and their applications.

With the start of the academic year 2025/2026, the new mathematics curriculum for the eleventh grade, prepared by the National Center for Curriculum Development, was implemented. The importance of the new textbook is highlighted in several aspects, including updating the content to align with the new national standards for secondary

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education and adopting a competency-based education methodology, which enhances students' ability to solve problems and think critically.

The new textbooks also aim to integrate technology through the use of mathematical software and digital applications. The book's questions and exercises are designed to cover the required objectives in national assessments. Additionally, the accompanying teacher's guide provides modern teaching strategies and interactive activities to help improve the quality of instruction. (Isleem, 2017)

Thus, the implementation of the new textbook represents an important step towards developing secondary education in Jordan, aiming to raise academic achievement and better prepare students for their academic and professional future.

The success of any new or modern curriculum primarily depends on the teacher's competence and ability to analyze the textbook content, develop effective teaching plans, and employ modern teaching strategies that meet students' needs.

In this context, the programmed instruction method has emerged as one of the teaching approaches that emphasize continuous interaction between students and educational material. It allows for individual progress with immediate feedback.

The programmed instruction method is characterized by its structured design, which begins with defining educational objectives, then dividing the content into small, interconnected units, each followed by evaluative questions that determine the student's level of comprehension before moving on to the next unit.

Programmed Instruction: Its Origin and Importance (Edan, Abasi, 2025)

Programmed instruction is the product of the combined efforts of psychologists and educators who sought to apply the principles of behavioral learning in designing effective educational materials. The idea began in the late 1940s when the psychologist B.F. Skinner developed the linear programmed instruction method. He believed that learning occurs best when content is divided into small units called frames, and the learner receives immediate feedback after each small unit, ensuring progression to the next unit.

Types of Programmed Instruction (Skinner, 1968)

1. **Linear Programming**: where the student progresses from one stage to another in a fixed, sequential manner. Each step contains information, a task, and an evaluative question.
2. **Branching Programming**: after answering and passing the first stage (linear programming), the student is directed to a sub-path based on the correctness of their answer. Correct paths continue, while incorrect paths provide correction, feedback, and redirection.
3. **Control Programming**: uses immediate reinforcement as a reward for each correct answer and minimizes negative reinforcement, aiming to reinforce correct behavior and reduce errors.

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Mathematics is one of the most important subjects used to educate and nurture the mind, solve problems, and develop different types of thinking. Therefore, the interest in teaching mathematics in all Arab and global countries comes from the fact that it is one of the ways to enter the world of other sciences such as physics, chemistry, and others. (Abu Amara, 2023).

Programmed instruction: is a teaching approach that divides educational material into small, logically interconnected units called frames. Each unit engages the learner effectively: they read the information, answer a direct question, and receive immediate feedback on their answer before moving to the next frame. (Alkhalaila & alshare.2018)

This approach relies on the principles of behavioral theory developed by Skinner in 1954, emphasizing the importance of immediate reinforcement and gradual progression of material. (Skinner, 1954)

Some researchers believe that the roots of programmed instruction go back to the Socratic method of dialogue. Others think it's one of the engaging and attractive methods used by many educators throughout history. This method relies on a strong connection with psychology in terms of preparing an environment and conditions that encourage active learning, using rewards to reinforce correct behavior. (Neetika, 2023)

In short, programmed instruction is a structured teaching strategy that relies on the learner's self-activity, continuous learning, continuous reinforcement, and gradual progress toward specific goals. It's influenced by the history of educational philosophy and the principles of behavioral psychology. (Skinner, 1968)

The main characteristics of programmed instruction include: individual interaction between the learner and the material, reinforcement and rewards for correct answers, a coherent sequence of gradually increasing complexity, and repetition and reinforcement of correct behavior until it is mastered.

Skinner identified three drawbacks of traditional teaching methods: (1) delayed reinforcement, where students receive feedback on exams weeks later; (2) large class sizes preventing individualized attention; and (3) lack of immediate, consistent reinforcement. He argued these limitations hinder achieving educational goals. (Alkhalaila & alshare.2018).

The principles of programmed instruction include: clear behavioral objectives, empirical testing and revision, active and overt learner participation, immediate reinforcement, step-by-step progression, individual pacing, success achievement, logical sequencing, and hinting and guidance.

Previous Studies

Abu Khalifa (2015) study investigated the effect of using computerized programmed learning in teaching statistics on academic achievement and achievement motivation among students of the Faculty of Educational Sciences and Arts (UNRWA). The sample consisted of 76 first-year students divided into two groups: experimental (computerized programmed learning) and control (traditional method) for the unit on normal distribution

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curve and standard scores. An achievement test and achievement motivation scale were administered, and independent samples t-test was used to analyze results at ($\alpha \leq 0.05$). Results showed statistically significant differences in academic achievement and achievement motivation in favor of the experimental group.

Al-Khalayleh and Al-Share (2018) study, titled "The Effect of Using Programmed Instruction on the Achievement of Upper Basic Stage Students in Science in Jordan", aimed to reveal the impact of programmed instruction on 7th grade students' achievement in science. A software program for the cell unit and a 30-item achievement test were developed. The sample included 72 female students selected purposively, divided into experimental and control groups. Results showed an effect of teaching method in favor of the experimental group

Anad (2020) study titled "The Effect of Using Programmed Instruction Method According to Linear and Branching Programming in Learning the Accuracy of Long Jump Shooting for Basketball Students". The study aimed to prepare educational units using programmed instruction methods (linear and branching) and identify their impact on learning long jump shooting accuracy. Results showed both methods are effective in learning long jump shooting in basketball.

Al-Ma'afi (2021) study aimed to investigate the effect of using programmed instruction with Nearpod strategy on improving learning outcomes in computer and information technology course and increasing motivation towards self-learning among female students at the 33rd Secondary School in Jeddah. The sample consisted of 68 students divided into experimental (34 students using Nearpod) and control (34 students using traditional method) groups. An achievement test and self-learning motivation questionnaire were used. Results showed statistically significant differences in post-test in favor of the experimental group, and improved self-learning motivation among students using Nearpod.

Neetika (2023) conducted a study titled "Effect of Programmed Learning on Academic Achievement of Secondary School Students in English Language". The study was conducted on groups of male and female students in government and private schools. Results showed no statistically significant differences in academic achievement in English between government and private school students, no differences between male and female results, and no differences in academic achievement attributed to traditional teaching method or using programmed instruction.

Edem and Abasi (2025) studied the effect of programmed instruction on secondary school students' understanding of quadratic equations in ITU Local Government Area of Akwa Ibom State. The study used a non-equivalent control group quasi-experimental design with pre-test and post-test. 104 SS2 students from two co-educational public schools were sampled randomly. Data was collected using the Quadratic Equations Comprehension Test (QECT) validated with 0.82 reliability (KR-20). Two research questions and null hypotheses were addressed. Data was analyzed using mean, standard deviation, and independent t-test at 0.05 significance. Results showed

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students taught with programmed instruction had significantly higher comprehension scores than those taught traditionally. No significant difference existed between male

The Study Problem:

Teaching mathematics in Jordanian secondary schools suffers from low academic achievement among students, especially in light of the challenges posed by new academic tracks. Results of international (TIMSS, PISA) and local tests indicate weak student performance in mathematics, reflecting the urgent need to adopt innovative teaching methods that enhance students' understanding of mathematical concepts and increase their motivation towards the subject. This study aims to explore the effect of using programmed instruction as an effective teaching method in improving the achievement of first secondary grade students in mathematics compared to the traditional method.

The study problem led to the following main question:

What is the effect of using programmed instruction compared to the traditional method on the achievement of first secondary academic track students in mathematics in Jordanian secondary schools?

The null hypothesis H_0 of this study was determined as follows:

There are no statistically significant differences at ($\alpha \leq 0.05$) between the mean scores of the achievement test of students in the experimental group (programmed instruction) and the control group (traditional method)

The Objectives of the Study:

1. Measuring the effect of using programmed instruction on the achievement level of first secondary grade students (academic track) in mathematics compared to the traditional teaching method.
2. Identifying the differences in performance between the experimental and control groups in terms of the mean scores of the achievement test.
3. Highlighting the effectiveness of using the programmed instruction method on the newly implemented mathematics curricula in Jordanian schools.

Importance of the Study:

Theoretical Significance, this study is the first to address the impact of programmed instruction in teaching mathematics for the first secondary grade in all new academic tracks, contributing to expanding knowledge about the effectiveness of this method in enhancing academic achievement.

Practical Significance, the study provides a new teaching approach for mathematics teachers, encouraging them to adopt programmed instruction to improve student performance and increase their engagement with the subject in the first secondary grade across all tracks.

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Practical Importance of the Study- Programmed instruction enhances students' understanding of mathematical concepts gradually and systematically, especially in complex topics.

- It develops students' abilities to solve mathematical problems efficiently through interactive exercises and sequential steps.
- Programmed instruction allows students to learn individually at their own pace, enhancing their comprehension and raising their achievement levels

Operational and Conceptual Definitions:

1. **Programmed Instruction Conceptual Definition**: An educational system based on dividing content into small, interconnected units (frames), where the learner interacts actively with each unit: reading information, answering a direct question, and receiving immediate feedback on their answer before moving to the next unit. This system is grounded in the behaviorist learning principles developed by B.F. Skinner (1954).

   Operational Definition (for the study): In this study, programmed instruction is a teaching method that divides the content of "Second Derivative and Applications of Extreme Values" into small, progressive units. Concepts are presented interactively with questions, activities, and immediate feedback. This is followed by exercises that progress from easier to more complex, focusing on problem-solving and tailored to students' levels. It includes a student guide, a teacher guide, and a review of relevant mathematics laws from previous years (e.g., areas and volumes).

2. **Achievement Conceptual Definition**: The level of knowledge and skills acquired by a student in a specific subject, typically measured through standardized achievement tests.

   Achievement Operational Definition (for the study): In this study, achievement refers to the scores students obtain on two tests (pre-test and post-test) designed to measure their understanding of "Second Derivative and Applications of Extreme Values" after implementing the programmed instruction method. The difference between the test results is used to compare the effectiveness of the teaching approach

3. **Mathematics Curriculum for 11th Grade – Academic Track Conceptual Definition**: The curriculum approved by the Jordanian Ministry of Education for 11th-grade students in the academic (non-vocational) track, covering fundamental topics in calculus, including limits, continuity, differentiation, second derivative, and its applications.

Mathematics Curriculum for 11th Grade -Operational Definition (for the study): In this study, the content is limited to the second unit of the 11th-grade mathematics textbook (academic track),

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Specifically:

- Lesson 4: Second Derivative and Its Applications (curve concavity, inflection points).
- Lesson 5: Applications of Extreme Values in Differentiation (finding maxima and minima, solving real-life problems)

Study Tools:

Included the following:

1. Educational Content for the Experimental Group:

Covered topics of differential applications, higher derivatives, identifying concavity domains, and inflection points through derivation or graphical representation. It includes:

- Teacher's Guide:

- Instructions and explanations of the material using programmed instruction.
- Skills for presenting a 45-minute class session (preparation, stimulus variation, closure).
- Detailed classroom presentation skills based on the teacher's guide.

- Student Workbook:

- Contains diverse practice exercises taken from the textbook, reformatted in a sequential and organized manner aligned with the programmed instruction method

Achievement Tests:

– **Pre-test:**

A test designed to measure students' level before teaching the unit "Second Derivative and Applications of Extreme Values". It consists of 30 questions covering:

- Factorization
- Trigonometric ratios
- First derivative
- Differentiation rules
- Derivatives of trigonometric functions
- Finding areas and volumes of geometric shapes (rectangle, triangle, circle, and its parts)
- Applications of Pythagoras' theorem
- Sine rules

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– **Post-test:**

A test designed to measure students' understanding of "Second Derivative and Applications of Differentiation". It consists of 30 multiple-choice questions covering:

- Calculating the second derivative
- Applications of the second derivative
- Determining concavity and inflection points for functions (polynomials and similar textbook questions)
- Solving applied problems on extreme values in various contexts.

This unit was taught over four weeks, with three sessions per week for each group (experimental and control)..

Study Population and Sample:

Study Population:

Includes all 11th-grade students (academic track) in schools of the Hashemite Kingdom of Jordan, as the new curriculum has been recently implemented.

Study Sample:

A purposive sample was selected from Al-Rai School, affiliated with the Private Education Affairs schools in Amman. The sample consisted of 64 students (32 in the control group and 32 in the experimental group). They were divided into two sections (A and B), taught by the same teacher who was trained in both methods: programmed instruction and traditional teaching.The Teacher: The same teacher taught both sections and was trained in both methods (programmed instruction and traditional teaching).

Table (1): Statistics of Students in Pre-test exam

Group	#	Mean	Standard Deviation
Control Group (Pre-test)	32	19.00	5.33
Experimental Group (Pre-test)	32	19.34	5.37
total	64	19.17	5.36

Study Variables:

Independent Variable:

- **Teaching Method**

- Level 1: Teaching using Programmed Instruction
- Level 2: Teaching using Traditional Method (lecture and class discussion)

Dependent Variable:

- **Students' achievement** in mathematics, specifically in the unit "Applications of Differentiation and Higher Derivatives" for 11th grade academic track.
- Measured by the achievement test applied after the teaching period.

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The teaching tool for mathematics education using programmed instruction was designed according to the following steps:

1. Planning and Analysis:

- The 11th-grade mathematics textbook (academic track) was thoroughly analyzed, focusing on lessons 4 and 5 of Unit 2 (Derivatives and Limits).

2. Lesson Design:

- A series of 8 lessons were developed covering the mentioned topics, implemented over three weeks.
- Each lesson is designed according to programmed instruction principles: brief concept presentation → interactive question → immediate feedback → progression to the next part

3. The teaching tool underwent the following stages:

1. Initial Trial:

- The tool was applied to a random sample outside the study population (another public school) to ensure its validity and effectiveness.

2. Expert Evaluation:

- The designed lessons were reviewed by 5 mathematics professors and teaching method specialists, along with assessment and evaluation faculty members.
- Their feedback was incorporated, and necessary adjustments were made until the tool reached its final form.

3. Final Application:

- After refinement, the tool was presented in its final form to students at Al-Rai School, where it was used for actual teaching of the experimental group.

Thus, the tool went through planning, design, trial, expert evaluation, and final application stages.

Table (2): Study Design:

Control Group (Section A)	O1	------	O2
Experimental Group (Section B)	O1	X	O2

Where:

- O1: Pre-test

- O2: Post-test

-X: Programmed Instruction

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Statistical Analysis:

SPSS was used to calculate means and standard deviations of students' scores in pre-test and post-test for both experimental and control groups. A t-test was used to check for statistically significant differences between the mean achievements of students in the experimental and control groups.

Table (3): Statistics of Students in Post-test exam

Group	#	Mean	Standard Deviation
Control Group (Post-test)	32	18.38	4.218
Experimental Group (Post-test	32	21.97	4.322
total	64	20.17	4.607

DISCUSSION OF RESULTS AND RECOMMENDATIONS

Study Results

To test the null hypothesis stating that **There are no statistically significant differences at ($\alpha \leq 0.05$) between the mean scores of the achievement test of students in the experimental group (programmed instruction) and the control group (traditional method)**, the researcher used Analysis of Covariance (ANCOVA).

Table (4): Analysis of Covariance (ANCOVA) for the Data of the Experimental and Control Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1068.533[a]	2	534.267	121.345	<.001	.799
Intercept	209.819	1	209.819	47.655	<.001	.439
Pre	861.892	1	861.892	195.756	<.001	.762
Set	179.851	1	179.851	40.849	p<.001	.401
Error	268.576	61	4.403			
Total	27379.000	64				
Corrected Total	1337.109	63				
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared

As seen in the previous Table(4), the results indicated rejecting the null hypothesis H_0 and accepting the alternative hypothesis, suggesting statistically significant differences attributed to the teaching method, in favor of the experimental group. This means students who studied using programmed instruction performed better than those who studied using the traditional method.

Considering the partial eta squared = 0.401, the effect size is high, as 40.1% of the post-test variance is attributed to the treatment through teaching using programmed instruction.

Also, since the p-value(p<.001) is less than 0.05, we reject the null hypothesis and accept the alternative hypothesis, indicating the differences were in favor of the experimental group that studied using programmed instruction

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The results of this study are consistent with the findings of Abu Khalifa (2015) , Al-Khalil and Al-Shara (2018), Al-Ma'afi (2021), and Nidam and Abasi (2025). However, this study differs from the studies of Anad (2020) and Neetika (2023). This discrepancy was observed in the results.

It is noteworthy that this study also differs from previous studies in that it focused on the mathematics curriculum for 11th grade academic track students in Jordanian schools. Additionally, it employed the Analysis of Covariance (ANCOVA) method as a statistical analysis technique.

Major Findings of the Study

1. The results showed that using the programmed instruction method contributed to improving the academic achievement of 11th grade students in mathematics.
2. It was observed that using programmed instruction helped students better understand the topic of the second derivative and its related proofs.
3. The programmed instruction method helped students understand the applications of extreme values better, which increased their ability to solve various problems related to this topic.
4. The results indicated that using programmed instruction led to improving students' attitudes towards mathematics, fostering a spirit of challenge and engagement with the subject.
5. The programmed instruction method is an easy-to-use teaching tool that teachers can apply directly and consistently in mathematics classes.
6. Using programmed instruction is suitable for teaching mathematics to 11th grade academic track students and can be generalized to other grades

Study Recommendations

At the end of this study, the researcher recommends the following

1. The researcher recommends using the programmed instruction method in teaching mathematics for 11th grade academic track students, due to its effectiveness in improving student achievement.
2. Encourage mathematics teachers to use programmed instruction in teaching, with the necessity of providing them with the required training to prepare appropriate educational software.
3. Conduct future studies to examine the impact of using programmed instruction in teaching other mathematics units and for different grade levels, aiming to generalize the results to various educational stages and subjects.

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