



THE EFFECT OF USING LEARNING SCAFFOLDS IN DEVELOPING PROBLEM-SOLVING SKILLS IN PHYSICS AMONG TENTH-GRADE FEMALE STUDENTS IN THE CAPITAL SECRETARIAT

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Article history:	Abstract:
<p>Received: 7th August 2025 Accepted: 6th September 2025</p>	<p>This study investigated the effect of using learning scaffolding on the development of physics problem-solving skills among tenth-grade female students in the Capital Secretariat, Yemen. To achieve the research objectives, the researchers employed a quasi-experimental design to examine the impact of learning scaffolding on developing physics problem-solving skills. The research instrument was a physics problem-solving skills test prepared by the researchers.</p> <p>The study was applied to a sample of 70 tenth-grade female students selected by a simple random method from two schools: Al-Yamaniyya Al-Haditha and Al-Oula, both affiliated with the Al-Sabeen Directorate in the Capital Secretariat, Sana'a. The sample was divided into two groups: an experimental group of 35 students from Al-Yamaniyya Al-Haditha School and a control group of 35 students from Al-Oula Private School.</p> <p>The research yielded the following results:</p> <ol style="list-style-type: none">1. There were statistically significant differences at a significance level of ($\alpha \leq 0.05$) between the mean scores of the experimental group students and their peers in the control group on the physics problem-solving skills test, in favour of the experimental group.2. There were statistically significant differences at a significance level of ($\alpha \leq 0.05$) between the mean ranks of the high-achieving students in the experimental group and their peers in the control group on the physics problem-solving skills test, in favour of the experimental group.3. There were statistically significant differences at a significance level of ($\alpha \leq 0.05$) between the mean ranks of the low-achieving students in the experimental group and their peers in the control group on the physics problem-solving skills test, in favour of the experimental group. <p>The study's most important recommendations are:</p> <ul style="list-style-type: none">• Teachers should use learning scaffolding in teaching physics.• Teachers, supervisors, and curriculum developers should consider incorporating learning scaffolding into physics curriculum design.• Training courses should be conducted for male and female physics teachers to train them on how to use learning scaffolding in teaching physics.• Teachers should focus on using physics problem-solving skills when solving physics problems.

Keywords:

Translation of the text into English is as follows:

Introduction:

Today's world is characterised by rapid growth in various fields, which has resulted in scientific and technological developments and revolutions, leading to a huge leap in education. Education is considered one of the main pillars for the advancement and renaissance of societies. Therefore, the need arose to develop modern teaching methods that emphasise considering the needs and individual differences of students and the diversity of modern teaching methods.

The educational process depends on the nature of the learners and understanding their diverse characteristics, desires, and skills, as well as their needs. It requires a deep understanding of how the learning process occurs. It also cares about developing the learner's personality and changing their behaviour in all aspects of their personality more than it cares about merely gaining and memorising abstract knowledge and information (Hadi Rabie and Tariq Al-Dulaimi, 2009, 21).

For this reason, some experts in the field of science teaching methods believe that the prevailing traditional science teaching methods are often not effective in achieving the goals of science teaching, and that effective science education can produce students who can manage their daily lives, be productive individuals who can rely on themselves and are independent, and have the ability to make sound decisions, be creative, and think of multiple alternatives (Al-Harthy, 2003, 65).

Constructivist theory believes that experiences and knowledge can be built over time through cumulative experiences. It is an active process of making meaning based on experience, and it must happen in a real situation. Assessment must be integrated with the task in non-separate learning activities. All this requires creating different science curricula and teaching strategies that are compatible with the learning processes of children and individual learners to activate knowledge.

The applications of constructivist theory have become numerous in the field of science teaching, acquisition, and understanding (Zaitoun, 2007, 20).

Many studies have appeared that have focused on educational scaffolding in teaching, such as the study by Aziz (2004) and the study by Al-Jundi and Ahmed (2009). Due to the importance of physics, the process of developing physics curricula has gone through multiple stages, including conducting many studies and research to develop the content of the physics curriculum and its teaching methods to suit the level of students in different educational stages. Thus, the roles of both the teacher and their students have changed, so the teacher has become a guide and mentor for their students' education, and the students have become more active and effective in learning.

There is no doubt that solving physical problems is one of the most important challenges facing both the teacher and the learner (Al-Za'ain and Shabat, 2002, 36). Solving problems is also one of the most important activities through which educational goals are achieved. Educational scaffolding can lead to effective learning in developing female students' physical problem-solving skills, and thus facilitate the teaching of physics and make it an enjoyable subject for female students.

Research Problem

The problem of this research is rooted in the weakness of female students' skills in solving physics problems. The researchers observed this during their over nine years of experience teaching high school and college students. This observation was supported by physics teachers and supervisors who identified several reasons for this weakness:

- Many physics teachers, both male and female, use traditional teaching methods that rely on rote memorisation.
- Most students have a low level of academic achievement in physics.
- Students frequently complain about their inability to develop their physics problem-solving skills.
- Parents express concern about the difficulty of physics and their daughters' inability to understand and solve physics problems easily using good skills.
- This situation prompted the researchers to explore modern teaching methods that simplify the subject matter and help students easily grasp it, thereby developing their physics problem-solving skills. Among these modern methods is the use of **educational scaffolding**.

Main Research Question

- The research problem can be summarised in the following main question:
- What is the effect of using **learning scaffolding** on developing **physics problem-solving skills** among tenth-grade female students in the Capital Secretariat?

Sub-questions

This main question is branched into the following sub-questions:

1. Is there a statistically significant difference at the significance level of **0.05** between the mean scores of the female students in the experimental group who learned using learning scaffolding and the mean scores of their peers in the control group who learned using the traditional method in the post-test?
2. Is there a statistically significant difference at the significance level of **0.05** between the mean scores of the high-achieving female students in the experimental group who learned using learning scaffolding and the mean scores of their peers in the control group who learned using the traditional method in the post-test?
3. Is there a statistically significant difference at the significance level of **0.05** between the mean scores of the low-achieving female students in the experimental group who learned using learning scaffolding and the mean scores of their peers in the control group who learned using the traditional method in the post-test?

Research Hypotheses

The researchers aim to test the following hypotheses:

1. There is no statistically significant difference at a significance level of **0.05** between the mean scores of the female students in the experimental and control groups in the post-test for physics problem-solving skills.

2. There is no statistically significant difference at a significance level of **0.05** between the mean scores of the high-achieving female students in the experimental group (who used learning scaffolding) and their peers in the control group (who used the traditional method) in the post-test.
3. There is no statistically significant difference at a significance level of **0.05** between the mean scores of the low-achieving female students in the experimental group (who used learning scaffolding) and their peers in the control group (who used the traditional method) in the post-test.

Research Objectives

This research aims to:

1. Determine the effect of using **learning scaffolding** on developing **physics problem-solving skills** in the experimental group compared to the control group, which uses traditional methods.
2. Identify the effect of using educational scaffolding in teaching physics on **high-achieving students**.
3. Identify the effect of using educational scaffolding in teaching physics on **low-achieving students**.

Importance of the Research

The importance of this research lies in:

1. Introducing a new method for teaching physics by studying the effect of using **learning scaffolding** on developing students' physics problem-solving skills.
2. Potentially drawing the attention of educational supervisors in the field of physics to the effect of using learning scaffolding on developing physics problem-solving skills.
3. Potentially contributing to overcoming some negative phenomena in the teaching and learning processes, such as the phenomenon of not involving learners in the learning process.

Research Scope

This research is limited to:

Subject-matter Boundaries:

The study focuses on the second unit of the 2015 edition of the 10th-grade physics textbook, titled "Motion in a Straight Line." This unit was chosen because it contains many physics problems that develop students' skills. The 10th grade was selected because physics is taught as an independent subject from chemistry and biology at this stage. The researchers will train the students at this stage in physics problem-solving skills (preparing to solve the problem, identifying terms, creating a calculation plan, implementing the solution, and verifying its correctness) in a good manner.

Human Boundaries:

The research will be applied to 10th-grade female students.

Time Boundaries:

The research will be conducted during the first semester of the 2019-2020 academic year, as this unit is taught in the first semester.

Geographical Boundaries:

The study will take place in Modern Yemeni Schools and Al-Oula National Girls' Schools in the Capital Secretariat. These schools were chosen because they cooperated with the researchers and allowed them to conduct their study there.

Research Terms

Here are the definitions of the key terms in the research:

1. Effect :

- **Linguistically:** The remainder of something. Plural is **Effect**.
- **Technically:** The outcome of a desired or undesired change that occurs in the learner as a result of the learning process (Shehata et al., 2003).

2. Educational Scaffolding:

A modern teaching method used by the researcher that relies on a cooperative effort between the teacher and the student, according to a set of organised steps. It is a temporary assistance needed by the learner to facilitate their overcoming educational situations with their individual efforts (Beljoune, 2015, 178) .

3. Skill :

- **Linguistically:** To master something and become proficient.
- **Technically:** Ease and accuracy in performing a task (Saleh, 2012, 449). The researchers define it as the ability to accomplish a specific task in the shortest possible time.

4. Physics Problem:

"Any new and unique situation that a student faces for which they do not have a ready-made solution at that moment. It is common for a problem to consist of a question that requires an answer, although not every question that needs an answer is a problem" (Salameh, 2003, 582).

5. Physics Problem-Solving Skills:

"The learner's ability to face a problem that requires them to think of possible solutions with a high degree of proficiency, speed, and efficiency" (Madhi, 2011, 45). The researchers define these skills as the step-by-step process that students follow to solve physics problems, leading them to the appropriate solution.

- **Procedurally:** The researchers define these skills as the students' ability to solve physics problems and develop their skills according to an organised set of steps to reach correct solutions, which is measured by the score the students obtain in the physics problem-solving test.

6. Tenth Grade:

"One of the secondary education grades that falls under the fourth cycle of general education as stipulated by the Education Law" (General Education Law, 1992).

The Theoretical Framework and Previous Studies

This section covers the theoretical foundation of the research, focusing on constructivist learning theory and instructional scaffolding, and their historical context and applications.

First: Constructivist Learning Theory

1. Historical Roots of Constructivism

Although constructivism has gained significant popularity in recent years, its core ideas aren't new. Its roots can be traced back to ancient Greek philosophers like **Socrates**, **Plato**, and **Aristotle**, who all discussed the "formation of knowledge." Plato (470-320 BC) believed that personal knowledge is not inherited and that the role of teachers is to help students recall this inherent knowledge. For Plato, remembering was a process of searching and discovering vital ideas, from which new concepts could be derived. Similarly, Socrates believed in a form of teaching that led students to deduce ideas on their own without him explicitly stating them. Thus, the ideas of Plato and Socrates form the basis of modern constructivist thought, which views education as a process of discovery where knowledge is derived from the senses (Dhamra, 2002, 161).

2. Foundations of Constructivist Theory

Constructivism is based on several key principles (Al-Khalili, 2000, 255-271; Shihab, 2004; Wills, 2000, 83):

- It focuses on **learning**, not just teaching.
- It encourages and accepts learners' **autonomy** and initiative.
- It promotes learners' **creativity**.
- It views learning as a **process**.

3. The Role of the Learner in Constructivist Education

Zaitoun (2007, 57) outlines the roles of the learner in constructivist education as follows:

- **The Learner is Active:** Knowledge and understanding are acquired actively. The student discusses, dialogues, and interacts.
- **The Learner is Social:** Knowledge and understanding are built socially. The student constructs knowledge not only individually but also socially through dialogue, discussion, and social negotiation with others.
- **The Learner is Creative:** Knowledge and understanding are created. Students need to create knowledge, and it is not enough to assume their role is just active. As Piaget said, "To understand is to invent."

Second: Instructional Scaffolding

Instructional scaffolding is a practical application of the **social constructivist theory** developed by the Russian psychologist **Lev Vygotsky**. This theory emphasises the collaborative activity of the learner, who builds knowledge on their own with the assistance of more experienced individuals. Learning and knowledge construction occur through social communication and interaction with people in the learner's environment, such as siblings, friends, parents, and teachers (Wang, 2012, 15).

1. The Concept of Instructional Scaffolding

- **Hamada (2011, 177)** notes that the concept of scaffolding is based on providing **temporary assistance** that the learner needs. This help can be in the form of hints or guiding information aimed at giving them certain skills and abilities to continue their learning. Afterwards, they are left to complete the rest of their learning independently, relying on their own abilities to discover new concepts and knowledge (Nwosu & Azih, 2011, 86).
- **Bikmaz (2010, 26)** defines it as "teaching steps that rely on a collaborative effort to solve problems, exerted by students with the help of a teacher or their peers in a learning situation."
- **Beljoune (2015, 178)** defines it as "the activities a teacher undertakes to provide temporary assistance that makes it easier for their students to overcome learning situations through their individual efforts."

Based on these definitions, the researchers view instructional scaffolding as the **intelligent assistance** provided by a teacher or a more experienced peer to students inside the classroom. This assistance helps students build new knowledge, enabling them to solve a problem, perform a task, or achieve a specific goal by assimilating new information that helps them accomplish that goal.

2. The Importance of Scaffolding in Science Education

Scaffolding in science education is important because it gradually shifts support from the teacher to the student, aiming to create an **independent learner**. It also encourages **peer learning** and **collaborative learning**, which are emphasised by modern learning theories. **Davis & Linn (2000, 837)** presented a framework for teaching with scaffolding that highlights its importance:

- It makes abstract scientific concepts tangible, allowing learners to see them while thinking and reflecting.
- It facilitates access to knowledge and makes it available to learners.
- It provides social support to all students during science instruction.
- It encourages participation during the learning activity (Rodger, 2004).

3. Types of Instructional Scaffolding

Wang (2006, 47) identifies four types of instructional scaffolding:

- **Procedural Scaffolding:** Provides the learner with a series of steps and directions on how to use the necessary resources, tools, and equipment to complete a learning task.
- **Conceptual Scaffolding:** Defines the steps and materials needed for the student to master the concepts within the learning task. Concept maps and detailed diagrams can be used to accomplish this.
- **Strategic Scaffolding:** Suggests alternative ways to accomplish a learning task and helps the learner choose the best method.
- **Metacognitive Scaffolding:** Guides the learner on how to think about a learning task, monitor their own learning processes, and recognise their strengths and weaknesses while performing the task.

The researchers believe that using a variety of scaffolding types helps the learner access knowledge and complete the learning task. In their study, the researchers used procedural, conceptual, and metacognitive scaffolding.

Consequently, the researchers adopted the stages outlined by Al-Jundi, Ahmed, and Qatami to implement their study.



Figure (1-1) show:

When using educational scaffolding in the educational process, it's essential to use appropriate teaching methods and techniques to simplify the scientific material, such as using visual and auditory hints, keywords, partial solutions, and direct instructions. The two researchers adhered to these steps in the current study while teaching the second unit (Motion in a Straight Line).

Third: Physics Problem-Solving Skills

1- Definition of Skill:

According to Abu Hatab and Sadiq (2002, p. 657), a skill is defined as "a description of a person having a degree of efficiency and quality in performance."

Abu Zina (2001, p. 181) defined it as "an individual's ability to perform work quickly, accurately, and proficiently."

After reviewing the previous definitions of skill, the two researchers found that most of them agreed that a skill is "a task completed quickly, accurately, and proficiently, which may be a mental or procedural task."

In light of this, the two researchers theoretically define skill as "the ability of female students to complete a mathematical task quickly, accurately, and proficiently."

2- Definition of Physics Problem-Solving Skills:

Madi (2011, p. 45) defined it as "the learner's ability to face a problem that requires them to think about finding possible solutions with a high degree of proficiency, speed, and efficiency."

Afana (2000, p. 75) defined it as "the learner's ability to identify the given information and the required solution from the scientific problem and to use their mathematical skills to reach possible solutions."

The two researchers theoretically define physics problem-solving skills as "the ability of female students to find suitable solutions by thinking and logical attempts to extract the required and given information and substitute them to find the appropriate solution to the problem."

First: Studies on Educational Scaffolding

This section aims to identify previous studies that dealt with educational scaffolding, how they addressed this topic, and how to benefit from them. This section includes the most important Arabic and foreign studies, some of which we will review:

Table (2-1) Table of Previous Studies (Educational Scaffolding)

Researcher's name and year	Research objective	Research Tools	Results

Aziz (2017)	To determine the effect of using multimedia-supported learning scaffolds on developing thinking and reducing math anxiety among middle school students in Egypt.	Teacher's Guide, Student Workbook, Mathematical Reasoning Skills Checklist, Mathematical Reasoning Test.	The effectiveness of educational scaffolding in developing thinking and reducing math anxiety was demonstrated, with statistically significant differences in favour of the experimental group.
Qaoud (2017)	To identify the effect of the interaction of the cognitive (simplify-complexity) approach with the educational scaffolding strategy on interactive thinking in mathematics among tenth-grade female students in Egypt.	Simplification-Cognitive Complexity Scale, Interactive Reasoning Scale, Teacher's Guide, Student Workbook.	Statistically significant differences in interactive thinking were demonstrated in favour of the experimental group.
Races et al. (2011)	To identify the effect of using educational scaffolds presented through websites on developing mathematical physics problem-solving skills among ninth-grade students in Belgium.	Content Analysis, Physics Problem-Solving Skills Test.	Statistically significant differences in the post-test were demonstrated in favour of the three experimental groups.

Commentary on Previous Studies on Educational Scaffolding

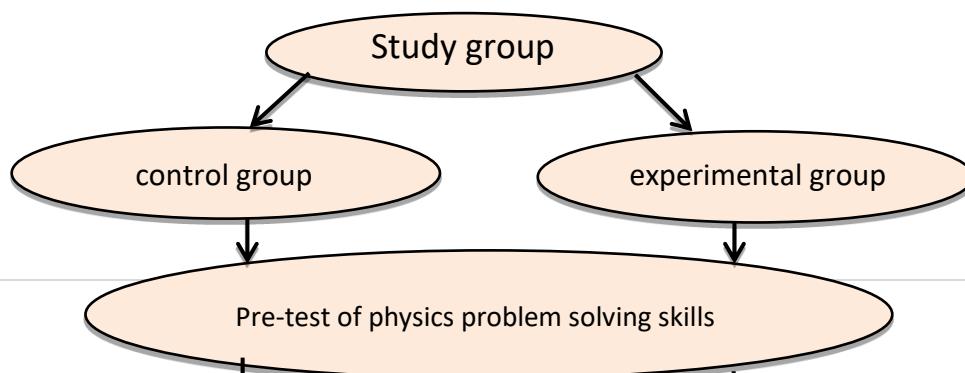
- **Objectives:** The current research and all previous studies agree on using educational scaffolding as an independent variable and examining its effect on dependent variables. However, a key difference is that the current study aims to investigate the effect of learning scaffolds on developing **physics problem-solving skills** among tenth-grade female students, a topic not addressed in the previous studies.
- **Methodology:** Similar to some of the previous studies, the current research employed a **quasi-experimental design**. This was chosen as the most suitable methodology because it allows for the examination of causal relationships between variables. The current study is consistent with the methodology used in similar research.
- **Sample:** The current research sample aligns with most of the previous studies, which focused on the **secondary school stage**.
- **Research Tools:** The current study differs from previous research in its use of a specific **test for physics problem-solving skills**, which was developed by the two researchers.
- **Results:** The findings of the current study are expected to confirm the results of most of the previous studies, which have demonstrated a **positive and effective impact** of using educational scaffolding on dependent variables.

Research Methodology and Procedures

Introduction:

First: The Current Research Methodology:

The researchers adopted a quasi-experimental method for this study. This approach is defined as a method that reveals causal relationships between variables by controlling all factors affecting the dependent variables, except for one variable manipulated by the researcher to measure its effect on the dependent variables (Al-Hamdani et al., 2006, p. 156). The quasi-experimental design was chosen, involving an experimental group and a control group, as shown in the following figure:



"Figure (2-2) illustrates the quasi-experimental design for the two groups (experimental and control)."

Secondly: The Research Sample"

The Research Sample

The current research sample consists of two groups:

- **The Pilot Sample:** A total of **30 female students** from the **10th-grade science class** were selected from outside the main group to serve as a pilot sample. This was done to confirm the validity and reliability of the test to be administered.
- **The Main Sample:** The main research sample consisted of **70 female students** from the **10th grade**. The sample was chosen using a **simple random sampling method** and was divided into two groups: an **experimental group** of **35 students** from Al-Yemeniyah Al-Haditha School, and a **control group** of **35 students** from Al-Oula Al-Ahliya School. The following table shows the distribution of the current research sample by group.

Table (2-2): Distribution of the Current Research Groups (Experimental and Control)

Current research group	Number of female students	Teaching Method	the school
Experimental group	35	Learning Scaffolding	Modern Yemen
Control group	35	Conventional Method	The First National

The tenth grade was chosen as the study sample for several reasons, including:

1. During this stage, female students are exposed to the physics curriculum for the first time during their years of study after the basic stage as a separate subject from the science curricula.
2. The two researchers have experience teaching this stage for more than (9) consecutive years.
3. The tenth-grade physics subject is the beginning of the foundation for the rest of the academic levels, and therefore, female students must be taught how to solve physics problems.
4. Tenth-grade female students face many difficulties when solving physics problems.

Fourth: Current Research Variables:

The current research methodology and its quasi-experimental design depend on the following variables:

- **Independent Variable:** Educational scaffolding in teaching Unit Two (Motion in a straight line) from the tenth-grade physics textbook in the Capital Secretariat.
- **Dependent Variable:** Physics problem-solving skills, which are (the skill of preparing to solve a physics problem, the skill of understanding the physics problem, the skill of setting a computational plan to solve the physics problem, the skill of implementing the solution to the physics problem, the skill of checking the correctness of the physics problem's solution).
- **Extraneous Variables that were controlled:** Social, economic, cultural environment, and chronological age.

Fifth: Controlling the Current Research Variables:

The two researchers sought to control the following variables:

A- Equivalence of the groups: The equivalence of the control and experimental groups in the pre-test was confirmed using the (T-Test) as shown in the following table:

Table (3-2) shows the results of the (T-Test) selection in the pre-application for the control and experimental groups.

Skill	Group	Number	Average	standard deviation	T***	significance value	Significance Level
Skill of preparing to solve a physics problem	Experimental	35	2.57	1.378	0.393	0.695	Statistically Not Significant
	Control	35	2.43	1.650			
Skill of defining the terms of a physics problem	Experimental	35	3.11	1.659	0.238	0.813	Statistically Not Significant
	Control	35	3.00	2.314			
Skill of developing a computational plan to solve a physics problem	Experimental	35	3.91	1.687	0.246	0.807	Statistically Not Significant
	Control	35	3.77	2.991			
Skill of implementing a solution to a physics problem	Experimental	35	3.43	2.104	0.228	0.821	Statistically Not Significant
	Control	35	3.57	3.061			
Skill of verifying the correctness of a solution to a physics problem	Experimental	35	2.66	1.474	0.295	0.769	Statistically Not Significant Significance Level
	Control	Number	2.54	1.755			
Total Score	Experimental	35	15.69	6.781	0.196	0.846	Statistically Not Significant
	Control	35	15.31	8.963			

This result indicates that there are no statistically significant differences at the 0.05 significance level between the average scores of the experimental group and the average scores of the control group in the pre-test. This proves the equivalence of the scores of both the experimental and control groups in all questions of the physical problem-solving skills test before the experiment.

B- Chronological Age:

The two researchers were careful to refer to the student enrollment records at both schools, and they confirmed that all students in the sample were in the same age range (15-16 years old).

C- Socioeconomic Status of the Sample Students:

The socioeconomic factor was controlled by selecting the sample from a single geographical environment with similar socioeconomic levels and living conditions. Students were asked about their parents' professions, and it became clear that their economic status was similar because the sample members were from two schools located in a residential area that is socioeconomically similar and within the same educational district.

Sixth: Preparing a List of Physical Problem-Solving Skills

To identify the necessary skills to be developed in tenth-grade students, the two researchers prepared a list of physical problem-solving skills by following these steps:

- 1- Reviewing previous references and studies in the field of physical problem-solving.
- 2- Consulting some scientific sources and books on physics to benefit from them in constructing the list of physical problem-solving skills.
- 3- Consulting the opinions of curriculum and science teaching methods experts from the College of Education.
- 4- Identifying skills that are appropriate for the students' academic level, which were set at five main skills. Each main skill includes a set of sub-skills. A preliminary list of physical problem-solving skills was thus created.

5- After the initial list was prepared, it was presented to a group of expert reviewers in curricula and science teaching methods from the College of Education, and physics teaching specialists from the College of Science who had more than ten years of experience in teaching physics.

6- Making the modifications agreed upon by most of the reviewers and arriving at the final version of the list of physical problem-solving skills.

Seventh: The Current Research Tool

The two researchers prepared the current research tool, which is a physical problem-solving skills test. The process of building the test, based on a review of relevant literature, went through the following steps:

A- Defining the Test's Objective

B- Defining the Test's Dimensions

C- Defining the Test's Type

D- Preparing the Specifications Table

E- Determining the Test's Validity

F- Determining the Test's Reliability on a Pilot Sample to Calculate the Following:

G- Difficulty Index of Test Items

H- Discrimination Index of Test Items

I- Test Reliability

J- Determining the Time Required to Answer the Test

K- The Final Version of the Test

A- Defining the Test's Objective:

The physical problem-solving skills test aims to measure the ability of tenth-grade students to solve physics problems.

B- Defining the Test's Dimensions:

The test dimensions were set to revolve around five physical problem-solving skills identified by the two researchers: (Preparing to solve the physical problem - Identifying the terms of the physical problem - Creating a calculation plan to solve the physical problem - Executing the solution of the physical problem - Verifying the correctness of the physical problem's solution). The two researchers decided to base the test items on objective and short essay questions, with one question for each sub-skill, according to the prepared skills list and within the scope of the chosen experimental unit. The total score for the test was set at 55 marks, with one mark for each correct answer and zero for a wrong answer.

D- Preparing the Specifications Table:

To construct the physical problem-solving skills test, the two researchers prepared a test specifications table to determine the relative weights for each skill. This was done by analysing the "Motion in a Straight Line" unit from the tenth-grade physics textbook in light of the physical problem-solving skills list and the number of questions for each skill, as shown in Table (2-4).

Table (2-4) shows the relative weights for each skill in developing physics problem-solving.

e. Determining Test Validity

Main and Sub-Skills	Repetitions	percentage %	Number of questions
First: The skill of preparing to solve a physical problem	41	16.33	9
1. Identify the physical terms used in the problem.	18	43.9	4
2. Restate the problem in the learner's own language.	14	34.1	3
3. Describe the computational steps and what is required for the problem	9	21.9	2
Second: The skill of identifying the terms of a physical problem	55	21.91	12
1. Identify its main components	16	29.1	3
2. Convert verbal information into symbolic information, writing its value next to each symbol.	15	27.3	3
3. Extract data.	12	21.8	3
4. Identify the required (unknown) information.	12	21.8	3
Third: Develop a computational plan to solve the physical problem	56	22.31	13
1. Draw the problem in a simplified diagram, if possible	7	12.5	2
2. Relate the problem to previous problems	8	14.3	2
3. Analyse the problem and break it down into simple, solvable parts.	8	14.3	2
4. Unify the units of measurement using a specific system	7	12.5	2
5. Derive the relationship used to solve the physical problem from the chosen main law	4	7.1	1
6. Select the correct main law	16	28.6	3
7. Write the sub-laws used to solve the problem, if any.	6	10.7	1
Fourth: Implementing the solution to the physical problem	63	25.11	12
Substitute the mathematical values into the appropriate formula - 1	21	33.3	4
2- Perform the mathematical operations correctly to arrive at the results.	21	33.3	4
3- Abbreviate any values and units of measurement that can be abbreviated in the problem to arrive at the desired value and unit of measurement.	21	33.3	4
Fifth: Verify the correctness of the solution to the physical problem	36	14.34	9
Review the mathematical steps and arrange them logically and correctly.	12	33.3	3
1	12	33.3	3
2- Verify the final result by substituting its value into the formula used to arrive at one of the values.	12	33.3	3
3- Verify the unit of measurement of the final result by substituting it into the formula to arrive at one of the units of measurement present in the problem.	251	100%	55

Validity of the Arbitrators 

After developing the test, the two researchers presented it to a group of **arbitrators** with expertise and specialisation in science curricula and teaching methods. This group included physics specialists from the College of Science, supervisors, and individuals with over ten years of experience teaching physics to tenth-grade students.

The researchers modified the test based on the recommendations of the arbitrators. After these adjustments, the test consisted of **55 items** divided into **9 questions**, covering all skills with a mix of objective and short-answer items. This was further detailed in Appendix No. 5.

Test Internal Consistency Validity 

To confirm the test's **internal consistency validity**, it was administered to a pilot sample of **30 tenth-grade female students** from outside the main study sample. **Pearson's correlation coefficient** was calculated between the main skills, which represent physics problem-solving skills, and the test's total score. The values of Pearson's correlation coefficient between each main skill's score and the total test score ranged from **(0.93) to (0.84)**. All

values were statistically significant at a significance level of **(0.01)**, indicating the internal consistency validity and, consequently, the overall validity of the test.

f. Test Reliability

The researchers used the scores from the pilot sample to calculate the test's **reliability**.

g. Difficulty and Ease Coefficient

The **difficulty and ease coefficients** for the test items were calculated after correction using the following formula:

Difficulty Coefficient = (Number of female students who answered incorrectly) \div (Total number of female students)

An item is considered to have acceptable ease if the coefficient ranges between **(0.2-0.8)** (Al-Ajili, 2004, p. 84), which are considered acceptable values. After calculating the difficulty and ease coefficients for all test items, it was found that the values ranged between **(0.2-0.63)**, meaning all items were within the specified range.

h. Calculating the Item Discrimination Coefficient

The **item discrimination coefficient** was then calculated as shown in the table.

Table 5-3 shows the values of the difficulty and discrimination coefficients for the physics problem-solving skills test items.

Question number	Difficulty factor	discrimination coefficient	Question number	Difficulty factor	discrimination coefficient
Q1(2)	0.27	0.33	S6(7)	0.27	0.53
(4)1S	0.33	0.4	Physics Problem-Solving Skills		
(5)1S	0.37	0.6	1- The skill of preparing to solve a physics problem		
Q1(7)	0.40	0.4	2- The skill of defining the terms of a physics problem		
Q2(1)	0.43	0.5	3- The skill of developing a computational plan to solve a physics problem		
(2)2S	0.47	0.2	4- The skill of implementing a solution to a physics problem		
(3)2S	0.50	0.5	5- The skill of verifying the correctness of the solution to a physics problem		
(1)3S	0.53	0.3	The test as a whole		
Q3(3)	0.56	0.4			0.94
Q3(4)	0.63	0.60	S7(7)	0.34	0.43
Q4(1)	0.30	0.56	S7(8)	0.37	0.50
(2)4S	0.23	0.37	S7(9)	0.27	0.33
(3)4S	0.20	0.27	S8(1)	0.37	0.60
(4)4S	0.67	0.33	S8(2)	0.53	0.57
(5)4S	0.37	0.37	S8(3)	0.30	0.30
Q4(6)	0.33	0.43	S8(4)	0.23	0.56
Q4(7)	0.30	0.60	S8(5)	0.37	0.43
(8)4S	0.40	0.37	S9(1)	0.30	0.53
(1)5S	0.43	0.27	S9(2)	0.33	0.37
(2)5S	0.33	0.65	S9(3)	0.37	0.40
Q5(3)	0.23	0.56	S9(4)	0.56	0.50
(4)5S	0.56	0.30	S9(5)	0.37	0.63
(1)6S	0.50	0.50	S9(6)	0.43	0.60
Q6(2)	0.63	0.40	S9(7)	0.33	0.37
Q6(3)	0.20	0.27	S9(8)	0.37	0.27
Q6(4)	0.23	0.30			
Q6(5)	0.37	0.60			
Q6(6)	0.33	0.37			

Test Development and Scoring

The researchers determined that all test items were **distinctive** and **valid** for use because their discrimination coefficient was no less than 0.25, as shown in Table (5-3).

Test Reliability

To calculate the reliability of the test, Cronbach's alpha coefficient was applied to the results of the pilot sample using the **SPSS program**. Table (6-3) shows the reliability coefficients for the physical problem-solving skills. The overall reliability coefficient was **0.94**, which is a high value indicating the test's **stability** and **suitability** for the study.

Time Allotment and Final Version

The time needed to complete the test was calculated by finding the average time spent by the participants. The average time was found to be **45 minutes**. Based on all the procedures, the final test for physical problem-solving skills consists of **55 items** across **9 questions**. These questions cover all skills and include both objective and short-answer types, along with test instructions.

Test Scoring

The test was scored by assigning **1 point** for each correct answer and **0 points** for each incorrect answer. This means the total possible score for the test is **55**.

Current Research Results and Interpretation:

Answering the First Hypothesis:

- There are no statistically significant differences at the significance level of 0.05 between the average scores of the students in the experimental and control groups in the post-test of the physics problem-solving skills test. To verify the validity of this hypothesis, a t-test was used for two independent samples. The effect size was also used to determine whether the differences were due to chance. To calculate the effect size, the researchers calculated eta square (η^2) using the equation mentioned above (Afaneh, 2000, 38).

$$\frac{\eta^2}{t^2 + df}$$

To reveal the significance of the difference between the mean scores of the experimental and control groups in the post-test for physical problem-solving skills, Table (4-1) illustrates the results of using the **T-test** for two independent samples.

Table (4-1): Shows the results of using the **T-test** for two independent samples to reveal the significance of the differences between the mean scores of the students in the experimental and control groups in the post-test for physical problem-solving skills.

Skill	Group	number	Average	standard deviation	value of (t)	Degree of freedom (df)	Significance level	Value η^2
The skill of introducing a solution to a physical problem	Experimental	35	5.57	2.627	2.066	68	0.04	0.060
	Control	35	4.23	2.808				
The skill of defining the terms of a physical problem	Experimental	35	8.60	3.466	2.269	68	0.03	0.071
	Control	35	6.60	3.897				
Skill of developing a computational plan to solve a physical problem	Experimental	35	10.49	3.302	2.549	68	0.01	0.087
	Control	35	8.46	3.355				

Skill of implementing a solution to a physical problem	Experimental	35	9.14	3.379	2.550	68	0.01	0.087
	Control	35	6.91	3.914				
Skill of verifying the correctness of the solution to a physical problem	Experimental	35	7.31	2.506	2.271	68	0.03	0.071
	Control	35	5.66	3.514				
Total Score	Experimental	35	41.11	8.256	4.494	68	0.00	0.23
	Control	35	31.86	8.964				

Results of the T-test and Effect Size

Table (1-4) shows the results of the **T-test** for two independent samples and the significance of the differences between the mean scores of the students in the experimental and control groups. The table also includes the value of **Eta squared (η^2)**, which was **0.23**. This value is greater than 0.14, which, according to Cohen's guidelines, indicates a very large effect size.

This result leads to the **rejection of the null hypothesis** and the **acceptance of the alternative hypothesis**. This means there are statistically significant differences at the 0.05 significance level between the mean scores of the experimental and control groups in the post-test for physical problem-solving skills, in favour of the **experimental group**. This finding suggests that the instructional scaffolding had a **very large effect size** on the dependent variable (physical problem-solving skills).

The results indicate that using instructional scaffolding provides clear guidance and instructions to students, ensuring they are correctly directed on how to approach and solve a physics problem. This includes the ability to rephrase the problem in their own words, describe the computational steps, and identify what is being asked in the problem.

Overall Test Score Analysis

The mean score for the experimental group in the post-test was **41.11**, which is higher than the mean score for the control group, which was **31.86**. The t-value was **4.494** with 68 degrees of freedom, and the significance level was **0.000**, which is less than 0.05. This confirms that there are statistically significant differences in the test scores between the experimental and control groups, in favor of the **experimental group**.

The effect size for the total score was **0.23**, which, when compared to Cohen's values, is greater than 0.14. This indicates that using instructional scaffolding in teaching the "motion in a straight line" unit contributed to a better development of physical problem-solving skills among tenth-grade female students compared to the traditional method. These findings are consistent with most previous studies that investigated the effect of using instructional scaffolding on the development of physical problem-solving skills, such as the studies by Aziz (2017) and Race (2011).

Interpreting the Experimental Group's Superiority

The superiority of the experimental group, which used instructional scaffolding, over the control group, which used the traditional method, can be attributed to the following reasons:

- **Active Learning:** Instructional scaffolding transforms the learner from a passive recipient of information into an active knowledge seeker.
- **Collaborative Environment:** Scaffolding provided an atmosphere of discussion between the teacher and students, which helped the learners develop the skills to solve physics problems independently.
- **Enhanced Problem-Solving Focus:** Instructional scaffolding concentrated on developing physical problem-solving skills by helping students understand and think critically about the problem. This was further supported by the teacher's guidance throughout the lesson.
- **Increased Motivation:** The use of educational aids and instructional cards during class had a significant impact on increasing student motivation toward learning.
- **Meaningful Learning:** Working in groups and the students' participation and interaction during the lesson, combined with their confidence in their abilities and experience, led to meaningful learning and an increase in academic achievement.

Answering the Second Hypothesis

The second hypothesis states: **There are no statistically significant differences at the 0.05 significance level between the mean scores of high-achieving students in the experimental group, who learned using instructional scaffolding, and the mean scores of their peers in the control group, who learned using the traditional method, in the post-test.**

To verify this hypothesis, the **Mann-Whitney U test** was used to compare the mean ranks of the scores of high-achieving students in both the experimental and control groups.

Table shows

Significance level		U	Total ranks	Average rank	number	The group	Level	(2-4) the
Level	The group	number	Average rank	Total ranks	Experiment	Experimental	The	Significance level
High	Experimental	18	181.00	26.36	10.65	474.50	Officer	.000
	The officer	18		10.64		191.50		
Level	The group	number	Average rank	Total ranks	U	Significance level		
High	Experimental	18	26.36	474.50	20.500	.000		
	The officer	18	10.64	191.50				

calculation of the average ranks of the scores of the experimental and control group students with high achievement at the significance level (0.05).

Through a comparison of the results of the high-achieving experimental and control groups, the table shows that the experimental group's mean rank was 26.36, with a sum of ranks of 474.50, which is greater than the control group's mean rank of 10.64 and a sum of ranks of 191.50. The significance level for both groups was 0.000.

This indicates that there are statistically significant differences at the 0.05 significance level between the mean scores of high-achieving students in the experimental group and their peers in the control group in the physical problem-solving test. Consequently, we reject the null hypothesis and accept the alternative hypothesis (that there are statistically significant differences between the mean scores of the experimental and control groups). This demonstrates the positive impact of using instructional scaffolding in developing physical problem-solving skills among students in the experimental group.

Answering the Third Hypothesis

The third hypothesis states: There are no statistically significant differences at the 0.05 significance level between the mean scores of low-achieving students in the experimental group, who learned using instructional scaffolding, and the mean scores of their peers in the control group, who learned using the traditional method, in the post-test.

To verify this hypothesis, the Mann-Whitney U test was used to compare the mean ranks of the scores of low-achieving students in the experimental and control groups.

Table (3-4) shows the calculation of the average ranks of the scores of the experimental and control group students with low achievement at the significance level (0.05).

Based on the comparison between the results of the experimental and control groups with low achievement, we find from the table that the experimental group, with a mean rank of (24.35) and a sum of ranks of (414.00), is greater than the control group, which has a mean rank of (10.65) and a sum of ranks of (181.00). The significance level of the two groups is (0.000), which is less than 0.05.

This indicates that there are statistically significant differences at the 0.05 significance level between the mean scores of low-achieving students in the experimental group and the mean scores of their peers in the control group on the physical problem-solving test.

Consequently, we reject the null hypothesis and accept the alternative hypothesis (that there are statistically significant differences between the mean scores of the experimental group and the control group, in favor of the experimental group). This demonstrates the effect of using educational scaffolding in developing the skills of the experimental group students, who were taught using educational scaffolding, in solving physical problems.

Research Recommendations

In light of the findings of the current research, the researchers recommend the following:

1. Encourage teachers to use educational scaffolding in teaching physics at the secondary level due to its positive effect on developing physical problem-solving skills.
2. Urge teachers, supervisors, and curriculum specialists to use educational scaffolding in teaching physics and to design curricula based on it.
3. Conduct training courses for male and female physics teachers to train them on how to use educational scaffolding in teaching physics.
4. Encourage teachers to use physical problem-solving skills when solving physical problems and to train students on how to solve them.

Research Suggestions

In light of the current research findings and its recommendations, the researchers believe it is essential to follow up on this research in the following areas or to suggest the following studies:

1. A study on the effect of educational scaffolding on academic achievement and the development of creative thinking skills in physics courses at other secondary school levels.

2. Conducting field studies to identify the effect of using educational scaffolding in teaching science at different levels.

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