

The Effect of Using the Project-Based Learning Strategy on Developing Scientific Research Skills and Academic Achievement in Science among Sixth-Grade Primary School Pupils

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Abstract

This study sought to examine the effectiveness of the project-based learning strategy in developing scientific research skills and improving academic achievement in science among sixth-grade primary school pupils, compared with the conventional teaching method. To achieve the study objectives and answer its questions, the researcher adopted a quasi-experimental approach with a pretest–posttest design involving two groups, an experimental group and a control group. The study sample consisted of 58 sixth-grade pupils at Al-Mujahideen Primary School, affiliated with the Karbala Directorate of Education, during the first semester of the 2025–2026 academic year. The participants were selected through simple purposive sampling and then allocated equally to the two study groups.

To collect data and conduct the experiment, the researcher developed a set of instruments, including a list of educational objectives, an achievement test to measure the cognitive aspects of the curriculum, and a test and a scale for scientific research skills. The topics assigned to the experimental group were also taught according to the stages of the project strategy, namely selection, planning, implementation, and evaluation.

The results revealed statistically significant differences at the level of $((\alpha \leq 0.05))$ between the mean scores of the control and experimental groups in the post-administration of the achievement test and the scientific research skills scale. These differences favored the experimental group pupils who learned through the project strategy. Calculating effect size using eta squared also indicated that this strategy had a large effect on developing academic achievement and scientific research skills.

Based on the results, the researcher recommended adopting the project-based learning strategy as one of the principal strategies for teaching science, incorporating a variety of school and environmental projects into the curricula, providing appropriate training for teachers, and carefully planning projects before their implementation in the field.

Keywords: Project-based learning, scientific research skills, academic achievement



Introduction:

Project-based learning (Project-Based Learning) has begun to occupy an increasingly prominent position within educational reform initiatives in the Kingdom of Saudi Arabia as a teaching strategy that aims to develop learners' various skills and competencies and increase their motivation to benefit from the scientific content presented to them. The project method is a teaching method that places the learner at the center of the educational process. It also represents a systematic scientific approach that combines theoretical knowledge with practical application and helps strengthen the student's connection with social and economic life within the local community. Projects have therefore been described as a rich source of educational opportunities (Hassanein, 2007 p 9).

The project-based teaching method is consistent with the principles of the constructivist theory developed by Piaget which emphasizes that individuals learn through experiences that serve as their means of interacting with the outside world and as a fundamental source for constructing knowledge (Zaitoun 2013). According to this theory, learners construct their knowledge internally under the influence of their surrounding environment. Each learner also has a particular way of understanding and assimilating information and this understanding may not necessarily correspond to what the teacher intends. Consequently, restricting the teacher's role to presenting repeating and reinforcing information does not guarantee that knowledge will be constructed in the learner's mind in the intended manner (Al-Tawati 2014).

The origins of the project method are associated with the efforts of the educational thinker John Dewey who worked to translate the modern educational ideas advanced by eighteenth- and nineteenth-century educators into practices that could be tested and implemented. Dewey sought to strengthen the connection between school and society by involving students in addressing real-life problems that they might encounter outside the school environment (Mar'i & Al-Hilah 2015).

This method involves presenting learning situations that are meaningful to pupils formulated as projects centered on a clearly defined social problem. These projects confront learners with an actual challenge that prompts them to seek solutions suited to their abilities under the teacher's guidance and supervision. The method also relies on engaging in various self-directed activities to help learners acquire knowledge through inquiry, self-directed learning and teamwork and to prepare them to integrate into their surrounding social and economic environment (Zouhi 2015).

Project-based teaching is associated with Kilpatrick who contributed to the development of this method based on John Dewey's educational ideas. He established the project as an educational model comprising a structured curriculum and a set of classroom and extracurricular activities centered on a main idea related to a particular topic. Kilpatrick, as cited in Bishr Jamil and Abu Zaid (2010), views the teacher as a guide and facilitator while the project method is defined as an activity undertaken by the learner to achieve specific objectives naturally within a social environment that simulates actual working conditions.

One of the most prominent characteristics of the project method is that the teacher reduces direct control over pupils and gives them greater trust and independence. This helps learners confront challenges, increase their participation and activity and assume responsibility for completing the projects on which they work over an extended period either individually or in small groups (Harman 2000).

Numerous studies and research investigations have demonstrated the possibility of developing different forms of thinking and their associated skills through education. Scientific and creative research skills are among the areas that have received increasing attention in the present era because of their significance in educational settings and in the life of societies. Al-Tayeb (2007 p 121) indicates that scientific research skills play an important role at both the individual and societal levels. They enable individuals to arrive at multiple solutions and original outcomes for the problems they encounter and help them adapt to and harmonize with their environment, enhancing their sense of self-worth and their position in society. At the societal level, individuals' possession of these skills contributes to progress and prosperity, increased and improved production, crisis management, problem-solving, and group leadership.

Study Problem:

Through her work as a science teacher, the researcher observed that students need assistance in discovering and developing their latent skills, particularly given the extensive curricula and the emphasis of available activities, strategies, and teaching methods on acquiring knowledge. Science at this stage also focuses on the facts, concepts, and information that constitute the curricular content, which confines students' thinking to lower levels based on memorization and recall, without attending to the creative dimension of science.

Science represents a technological tool that offers extensive opportunities for developing scientific research skills through its various applications. There is therefore a need to develop these skills among students, particularly in science, to help them adapt to future life requirements and prepare them to assume leading roles in society, given that science constitutes the foundation of development in the current era.

The study problem lies in the need to develop scientific research skills in science among primary school students. Given the nature of this objective and the distinctive characteristics of science compared with other school subjects, it has become necessary to employ a teaching strategy suited to the subject that contributes to achieving the intended objective. Because project-based learning is one of the modern strategies whose effectiveness has been demonstrated by numerous studies, the researcher decided to investigate its effect on teaching the science curriculum to sixth-grade primary school students in the Al-Baha region.

The researcher's conviction regarding the use of the project-based learning strategy arose from her observation of low levels of achievement and scientific research skills among primary school students. This conviction was also supported by the findings of previous studies and literature that emphasized the importance of this strategy and its role in developing students' achievement and thinking across different school subjects. Accordingly, the study seeks to answer the following main question:

1. How effective is the project-based learning strategy in developing scientific research skills and academic achievement in science among sixth-grade primary school students?
2. The following two questions derive from this main question:
3. How effective is the project-based learning strategy in developing scientific research skills in science among sixth-grade primary school students?
4. How effective is the project-based learning strategy in developing academic achievement in science among sixth-grade primary school students?

Research Objectives:

The study aimed to investigate the effectiveness of the project-based learning strategy in developing scientific research skills and academic achievement in science among sixth-grade primary school students, compared with the usual teaching method. To this end, a set of educational projects was prepared and used to teach the experimental group students.

Significance of the Research:

Science content is closely connected with reality and the surrounding environment, as its applications extend across different areas of life and work. This characteristic necessitates training sixth-grade primary school students to apply their scientific knowledge and benefit from it more broadly through a strategy that relies on cooperative learning, problem-solving, and connecting learning with real-life situations and practical applications.

The project-based learning strategy is one of the strategies that place the learner at the center of the educational process. Educational studies have confirmed its effectiveness in developing several learner skills, foremost among them cooperative work, learning, and communication skills. Project implementation involves dividing students into small groups in which they exchange information and ideas and communicate with their peers and experts who share the same interests. Students also assume responsibility for seeking, organizing, and formulating information, allowing them to explore topics related to their inclinations and interests.

The significance of the study is reflected in the following:

1. Clarifying the concept of the project in education and encouraging teachers to train their students to apply it
2. Training students to prepare projects, including planning and implementing them collectively, thereby providing initial experience that will benefit them when preparing graduation projects in the future
3. Presenting a proposed set of science-related projects, together with their implementation steps and the evaluation instruments used
4. Contributing to the enrichment of Arabic educational literature, given the scarcity of Arabic studies on project-based learning, to the researcher's knowledge

Theoretical Framework and Previous Studies:

The Concept of the Project Method:

William Heard Kilpatrick (W H Kilpatrick), a professor of education at Teachers College, Columbia University in the United States, was among the first to introduce the project method. He described a project as purposeful work accompanied by intrinsic enthusiasm and undertaken within a social environment. It is not carried out in isolation from others, particularly in the case of projects that seek, directly or indirectly, to serve the community. Educators have expressed different views in defining this method. Kilpatrick considers a project to be intentional work directed toward a specific goal and connected to real-life situations. A manual or mental activity constitutes a project when it is purposeful and connected with real life (Mar'i & Al-Hilah, 2015).

Kilpatrick, as cited in Al-Husari and Al-Enezi (2005, p 190), defines a project as a unit of activity undertaken naturally by the learner in a manner similar to everyday activities, with the intention of achieving a clear, appealing, and attainable goal

Thomas (2000) defines it as an educational model that organizes the learning process around a set of projects

Al-Harthi (2005, p 7) considers a project to be an open-ended task undertaken by one student or a group of students inside or outside school to investigate an aspect of learning related to the curricula, culminating in the production of various outputs

Al-Nashif (2009) defines a project as a set of extracurricular activities undertaken inside or outside school under the teacher's supervision. These activities may be individual or collective, like other scientific activities. However, collective implementation is considered more appropriate for integrating the project components and achieving objectives related to students' affective domain.

From the preceding definitions, the researcher concludes that a project is a planned field activity that may be manual or mental and is undertaken inside or outside school to achieve specific goals and address a particular problem within a social context, preferably through teamwork.

Types of Electronic Projects:

Kilpatrick, according to Al-Yamani and Askar (2010), classified projects into four types in terms of preparation and content:

Construction or Production Projects

These projects have a practical, productive, and design-oriented character and aim to complete tasks or produce tangible items, such as making soap, producing vegetable oils, and raising pets.

Enjoyment Projects

These projects combine application with recreation, as students acquire experience and knowledge through the enjoyable activities they involve.

Problem-Based Projects

These projects aim to involve learners in addressing intellectual or environmental problems, or other problems of interest to students, by investigating their causes and identifying appropriate solutions, such as a poultry-raising project. The project method differs from the problem-solving method in that the former usually culminates in a tangible sensory outcome that learners use their senses to test in practice, whereas the latter relies on mental activity and generally culminates in a logical outcome.

Skill-Acquisition Projects

These projects aim to equip learners with various skills, such as training students to develop devices, equipment, or systems in a manner consistent with technological development and scientific progress.

Projects are classified into two types according to the number of participants:

Individual Projects

Each student is assigned to carry out a project independently. All students may undertake the same project individually, or each student may select a particular project from a set proposed by the teacher or students, or determined jointly by both parties.

Group Projects

These are projects in which all class members or members of the same study group participate to accomplish a shared task, cooperating in its planning, implementation, and achievement of its objectives

Project Steps:

The project method is implemented through a set of steps and stages that define the roles of the teacher and learner, as outlined below:

Step One: Selecting and Defining the Project

Projects of all types, whether construction, economic, commercial, cultural, educational, or agricultural, originate from a clear idea and a specific objective. For example, the idea of constructing water dams arose from observing that large quantities of rainwater went unused, leading to consideration of retaining and utilizing it later.

This step is one of the most important stages of the project. The teacher collaborates with students to identify their needs, desires, and intended objectives, culminating in the selection of a project suited to their abilities and interests.

Step Two: Planning the Project

After agreeing on and defining the project idea, students usually tend to begin implementation immediately because of their enthusiasm for the work. However, project success depends largely on preparing a sound plan that specifies how it will be completed. Students should assume the greater share of planning responsibility, as acquiring this skill requires continuous and deliberate practice.

Students may make some mistakes during planning, at which point the teacher intervenes to prevent recurrent or dangerous errors. The teacher may allow some minor mistakes because they help students recognize the importance of attentiveness and precision throughout the work stages. The teacher also monitors the planning process and guides students to ensure the project's success and safe implementation (Al-Rawi, Habib, Al-Imam, & Abbas, 1965).

Step Three: Implementing the Project

This stage represents the transition of the project plan and proposals from thought and conceptualization to actual practice. Students begin carrying out tasks, and each student assumes the assigned responsibilities. The teacher provides appropriate conditions, addresses difficulties, offers educational guidance, and monitors the time allocated for completion.

The teacher also observes students' performance during implementation, encourages them to continue working, and meets with them when needed to discuss problems and make necessary adjustments (Jamil, 2002). The teacher must also ensure that all students participate in carrying out the tasks, that some do not monopolize the work, and that the agreed plan is followed, while maintaining the flexibility required during implementation (Saadah & Ibrahim, 2011).

Step Four: Evaluating the Project

Evaluation takes place after the project has been selected, planned, and implemented. At this stage, the teacher examines what students have accomplished, explains strengths and weaknesses, and identifies errors that arose during the work and ways to avoid them in subsequent projects. This process provides feedback that helps students improve their performance and develop their experience.

The teacher may involve students in evaluation. If the project is individual, each student presents the project results to classmates, who then discuss them and express their views. If the



project is collective, group members may present and discuss their results with another group of students (Mar'i & Al-Hilah, 2011)

Operational Definition of Creativity:

General creative ability or skill-based ability refers to the score achieved by the learner on the Torrance Test of Creative Thinking Using Figures, Form B This score represents the mean of the standardized scores for four skills: fluency, flexibility, originality, and elaboration

A high score in general creative ability indicates that the learner possesses a high level of creativity, whereas a low score indicates a low level of creative skill abilities (Sayed, 2000, p 198)

Approaches to Studying Scientific Research Skills:

There are four approaches to studying creativity: studying creativity by focusing on the creative product, studying creativity as a mental cognitive process, studying it by identifying the traits of the creative personality, and, finally, studying creativity by identifying the nature of creativity (Zaitoun, 1999: 15–21)

1 Studying Scientific Research Skills by Focusing on the Creative Product:

The creative product is viewed as an entity in its own right, whose existence can be perceived and recognized through the senses Definitions have emerged that identify the concept of creativity in terms of its outcomes Meed (1959) views creativity as a process undertaken by an individual that culminates in producing something new to that individual

In this definition, novelty is attributed to the individual rather than to the field in which the creation emerged Views have differed concerning the criterion of novelty and whether product originality requires absolute newness or whether being new to its creator is sufficient Questions have also been raised about the source of judgments of novelty and whether they rely on the individual's internal evaluation or require an external judgment (Abdul-Ghaffar, 1977, p 12)

Novelty in creative work or a creative product means that it is different, unfamiliar, distinctive, and capable of eliciting surprise This includes various forms of expression, such as writing, painting, music, and others Novelty therefore represents one of the fundamental characteristics required to distinguish a creative product

Creative products take various forms that can be classified into two main types:

a A Tangible Product Relatively Independent of Its Creator

This type includes literary works, such as poetry and prose, inventions, scientific devices, sculptures, paintings, musical compositions, furniture and interior designs, and other tangible products

b A Product Inseparable from Its Creator

This type is connected with the personality of its producer and cannot be separated from that person, such as portraying a disguised character on stage, a physician's performance in the operating room, or performing an acting or dance role

Novelty alone is not sufficient to judge a work or activity as creative The product must also possess some value This value may be intrinsic and related to the work itself, or social, with effects extending to the group or society in which it emerged The value of a creative product is neither fixed nor absolute It varies according to the nature of the work and the characteristics of the society or group because of differences in the criteria used to evaluate creative products

1. Creativity as a Mental Cognitive Process:

Guilford (1982) defines creativity as a mental cognitive process or a form of divergent thinking characterized by fluency, flexibility, originality, and sensitivity to problems, culminating in the production of a creative product

Torrance (1999) views creativity as a process involving the recognition of problems, gaps, deficiencies, contradictions, or inconsistencies in knowledge related to a field valued by the group Mednick (1992), meanwhile, defines creativity as the reorganization of associated elements into new configurations suited to the requirements of the situation The novelty and originality of these configurations increase as the degree of remoteness between their elements increases

Guilford's conception of creative thinking evolved from viewing it as a set of factors revealed by factor analysis to considering it a system of processes According to this conception, creative thinking involves deriving new solutions from the individual's store of knowledge to meet the demands of a problematic situation This is achieved through the succession and concurrence of cognitive processes, beginning with attention and proceeding through cognition, memory, convergent thinking, and divergent thinking, and ending with evaluation

In light of the preceding definitions that address creativity as a product or a mental cognitive process, the researcher considers that the creative product does not emerge independently of the mental activity responsible for producing it Cognitive processes constitute the foundation underlying the formation of this product It is therefore difficult to separate the creative process from its outcome because they represent two interconnected aspects of a single concept

1. Studying Skill-Based Ability by Identifying the Personality Traits That Distinguish the Creative Individual:

Taylor (1991), as cited in Al-Sheikh (1978, p 295), described the characteristics of the creative person and distinguished from the outset between that person and the intellectually gifted individual An intellectually gifted individual achieves a high level on conventional intelligence tests, whereas the creative individual possesses a set of traits that Taylor classified into the following categories:

Intellectual Traits

The creative person possesses several intellectual abilities, such as memory and evaluation, alongside divergent thinking abilities that include originality and sensitivity to problems

Personality Traits

The creative individual is characterized by independence, flexibility, willingness to take risks, avoidance of rigidity in thinking, and other personality characteristics

Motivational Traits

The creative individual tends to explore and discuss ideas and also has a strong need for achievement associated with intellectual persistence and sustained effort

The creative person seeks challenges and tends to engage with complex topics and situations. Although it is difficult to establish a fixed list of creative personality characteristics, these traits provide a general conception of the principal characteristics of creative individuals. Several researchers have agreed with Taylor on many of the characteristics he identified. In a study conducted by Torrance (1998), two groups of middle school students who differed in their levels of creative thinking were compared to identify some of the traits distinguishing creative individuals.

Studying Creativity by Focusing on the Skill-Based Process

Despite the ambiguity surrounding the skill-based process, researchers have attempted to trace its course by identifying a set of stages believed to precede invention or discovery. Charters (1929) developed a model of the skill-based process consisting of four stages:

Preparation Stage

During this stage, the thinker collects the facts, data, and information necessary to address the problem.

Incubation Stage

This represents a period of mental relaxation during which the thinker makes no conscious effort to reach a solution, but allows the mind to continue processing the problem until the solution emerges spontaneously.

Insight Stage

During this stage, the solution appears suddenly to the thinker after a period of thinking or incubation.

Verification Stage

At this stage, the product undergoes examination and evaluation to ascertain its validity and value.

Scientific research skills proceed through a series of stages:

Readiness

This means the individual's preparedness to confront a difficult situation or enter a field characterized by risk or ambiguity. During this stage, the individual's imagination receives a set of data that will later be used to formulate original ideas. This stage is not without difficulty, as information related to the problem may be complex and diverse, potentially prompting the individual to abandon it. Attention may also shift toward secondary topics or problems that divert the individual from the main objective.

Incubation

Whereas readiness represents the stage of conscious activity, incubation expresses the activity of the unconscious mind. At this stage, the idea moves from its initial form toward a clearer cognitive structure that may appear as tangible results.

Illumination

This stage represents the moment of inspiration or insight when the idea for the solution or discovery emerges and the creative individual reaches the answer.

Verification

At this stage, the creative individual reviews, examines, and evaluates the outcome to ascertain its correctness and applicability.

Previous Studies:



Abd (2010) conducted a study examining the effect of employing the project-based learning strategy on developing problem-solving ability and academic achievement in mathematics among students at the Faculty of Educational Sciences affiliated with UNRWA in Jordan. The study sample consisted of 61 students, whom the researcher allocated to an experimental group and a control group. To establish the equivalence of the two groups, the researcher administered an achievement test and a problem-solving test before the intervention. The post-administration results revealed the superiority of the experimental group, indicating the strategy's positive effect on developing students' problem-solving ability. The researcher recommended further studies to examine the effectiveness of this strategy in developing learners' mathematical skills at different school and university levels.

Mussman's (2012) study sought to identify the effect of project-based learning on reducing the likelihood of students dropping out of school from their perspective. The sample consisted of 100 tenth-grade students at a school in the United States who were at risk of dropping out. The researcher used interviews to collect data and determine the extent to which this type of learning contributed to motivating students to continue their education. The results indicated that students learned better and gained a greater understanding of the topics after completing projects. The data also showed that students participating in project-based learning preferred this approach and that its implementation contributed to improving grades and increasing graduation rates.

Al-Hanaki's (2012) study aimed to investigate the effect of the project-based learning strategy on developing mathematical thinking, academic achievement, and motivation to learn mathematics among female students in the Kingdom of Saudi Arabia. The researcher selected a sample of 52 female students in the second year of middle school in the Riyadh region and divided them into an experimental group and a control group. The strategy was applied to three units of the mathematics textbook. Instructional material comprising seven projects was also prepared, a mathematical thinking test was constructed, and a learning motivation scale was developed. After establishing the validity and reliability of the instruments, the results revealed statistically significant differences between the mean performances of the two groups, favoring the experimental group.

Al-Musaid (2014) conducted a study aimed at measuring the effectiveness of a proposed program based on the project method in teaching oral English skills and developing female students' attitudes toward them. The study included a random sample of 80 tenth-grade female students at Umm Nuwara School in the capital, Amman. The researcher used three instruments: a pretest and posttest of oral skills, a questionnaire measuring attitudes toward learning these skills, and a scale measuring their performance. The results revealed statistically significant differences at the level of $(\alpha = 0.05)$ in the oral skills test and students' attitudes toward these skills. No statistically significant differences in performance or attitudes were attributable to the interaction effect associated with the proposed program. Accordingly, the researcher recommended organizing training workshops for English language supervisors and teachers, equipping them with the necessary knowledge and experience, and increasing the number of projects included in English textbooks.

Harris's (2015) study aimed to identify the challenges and difficulties teachers encounter when implementing project-based learning in middle schools. The study was conducted at a middle school in the suburbs of Pittsburgh, Pennsylvania, with the participation of 49 teachers. A questionnaire was used to collect data on teachers' perceptions of obstacles to project implementation. The results showed that the principal challenges were time constraints, government agencies holding teachers accountable for these projects, and the difficulty of incorporating their implementation into the school timetable.

Al-Jundi's (2015) study also aimed to identify the effectiveness of project-based e-learning in developing e-course design skills among educational technology students. The study adopted descriptive and quasi-experimental approaches, and its sample comprised 30 third-year students in the Department of Educational Technology at the Faculty of Specific Education, Menoufia University.

The study instruments included an achievement test measuring the cognitive aspect associated with e-course design skills, an observation checklist measuring practical performance, and a checklist evaluating the skill-related aspect of designing these courses. The theoretical framework addressed two themes. The first focused on the concept, characteristics, advantages, and importance of the project-based e-learning strategy. It was presented as an instructional strategy in which learners participate in addressing a particular problem by undertaking a set of tasks and activities organized as projects to achieve a specific objective, thereby enhancing their motivation to learn.

The second theme addressed e-courses as a set of educational pages interconnected through the Internet that use multimedia elements to present educational content in a manner that achieves the objectives for which they were designed.

The results revealed statistically significant differences at the level of $((005))$ between the sample members' mean scores in the pre- and post-administrations of the achievement test for e-course design skills, favoring the post-administration. Statistically significant differences at the same level also emerged between the mean scores in the pre- and post-administrations of the observation checklist for e-course design, favoring the post-measurement. The study recommended training faculty members to use modern technologies and apply the project-based e-learning strategy when working with students.

Research Method:

The researcher used a quasi-experimental approach involving pre- and post-measurements for two groups, one experimental and the other a control group, to determine the effectiveness of the project-based learning strategy in developing scientific research skills and achievement in science among sixth-grade primary school students.

Research Population:

The population of the present study consisted of sixth-grade primary school students in the Karbala region attending Al-Mujahideen Public Primary School, affiliated with the Iraqi Ministry of

Education, during the first semester of the 2025–2026 academic year The sample was selected from the same population category

Research Sample:

The sample was selected through simple purposive sampling and comprised (58) sixth-grade primary school students representing the experimental and control groups

Study Procedures:

The study aimed to investigate the effectiveness of the project-based learning strategy in developing scientific research skills and academic achievement in science among sixth-grade primary school students, compared with the usual method To achieve this, the researcher prepared a set of educational projects and then used them to teach the experimental group students Following the presentation of the study's theoretical framework in the previous chapter, this chapter addresses the procedures followed by the researcher in preparing the measurement instruments and experimental treatment materials, according to the following themes:

First: Preparing a List of Sixth-Grade Primary School Curriculum Objectives

The researcher prepared a list of educational objectives for the sixth-grade primary school science curriculum The list included the general curriculum objective and the cognitive, skill-based, and affective objectives associated with each instructional unit These objectives were formulated systematically, with an emphasis on the objectives of the third curriculum unit

The researcher then presented the list to a group of experts and evaluators specializing in educational technology, science, and educational psychology to obtain their views on the soundness and appropriateness of the objectives' formulation She made the required amendments in light of their comments until the final version of the list was reached

Second: Preparing the Measurement Instruments

The measurement instruments used in the study were the achievement test and the scientific research skills test The procedures followed by the researcher in preparing each instrument are presented below:

Constructing the Achievement Test

The test aimed to measure the cognitive aspects of the science curriculum content among sixth-grade primary school students The researcher constructed the test based on the behavioral objectives that students were expected to achieve after learning through the proposed project strategy, as well as the curriculum content Test preparation proceeded through the following steps:

Determining the Purpose of the Achievement Test

The researcher prepared the test to measure sixth-grade primary school students' achievement in the science curriculum The test was administered before teaching the content using the project-based learning strategy and was then used to measure the extent to which students had acquired the cognitive aspects included in the behavioral objectives across the levels of

remembering, understanding, application, analysis, synthesis, and evaluation Comparing the results made it possible to determine the effectiveness of the proposed strategy in developing the achievement of the study sample students

Determining the Question Types and Number and Formulating the Items

The researcher reviewed the types of tests used in previous studies to measure academic achievement and concluded that objective tests were among the most appropriate and precise types for achieving the study objectives These tests consist of questions with specific meanings, each having one correct answer Their items should also demonstrate linguistic and semantic clarity and convey the same meaning to all sample members to whom the test is administered (Khattab, 2001)

In light of the study objectives, the nature of the content, and the cognitive aspects to be measured, the researcher prepared an objective test, ensuring variety in its questions and formulating its items to suit the students' levels and the curriculum content

Score Allocation and Scoring Method

Two marks were allocated to each correct answer, whereas an incorrect answer or an unanswered question received zero The total test score was 40 marks, equivalent to twice the number of items

Preliminary Version of the Test

The researcher presented the preliminary version of the achievement test to a group of professors and experts specializing in educational technology, curricula and teaching methods, and educational psychology Their views on the test items were sought, and the necessary amendments were made in accordance with their comments

Pilot Administration of the Achievement Test

The researcher administered the final version of the test to a pilot sample of 15 sixth-grade primary school students outside the main sample Their scores were recorded to establish the test's validity and reliability

The researcher used expert judgment to establish test validity The validity coefficient was 0.90, indicating a high degree of validity The reliability coefficient was also calculated using the split-half method with the Spearman–Brown formula and SPSS statistical analysis software Its value was 0.86, indicating a high level of test reliability

Constructing the Scientific Research Skills Test

The researcher prepared the scientific research skills test based on an analysis of the curricular content studied by students and in a manner suited to their surrounding technological environment She ensured that the questions addressed situations students had not previously encountered during instruction The questions were also formulated as open-ended essay questions that were not restricted to a particular answer

Abdul-Ghaffar (1977) indicates that Guilford used the term “divergent thinking” to denote this type of thinking, which can be measured through an individual's performance on tasks that do not have a single specific answer

Given the unavailability of a suitable test to measure the development of these skills and identify the effect of the project-based learning strategy on developing scientific research skills in science among primary school students, the researcher prepared a test appropriate to the nature of the study and serving this purpose

Third: Developing the Experimental Treatment Instrument (the Strategy)

After analyzing the content objectives and identifying a set of lessons to be converted into projects, as shown in the appendix, the researcher applied the stages of the project strategy to each lesson according to the following steps:

Step One: Selecting and Defining the Project

This stage begins with the teacher collaborating with students to identify their purposes, inclinations, and intended objectives, and ends with the selection of a project suited to their abilities and needs. The project should be related to the subject's educational content to ensure the achievement of cognitive, skill-based, and affective objectives and enable the learner to benefit from its implementation. Each project should also center on one clear main idea.

Step Two: Planning the Project

Project success depends on preparing a precise plan for its implementation and completion. The student assumes the greater part of the planning process because mastering this skill requires deliberate and continuous practice. Some errors may arise during this stage, but the teacher intervenes to limit their recurrence and prevent errors that could hinder project implementation.

When students participate in preparing the plan, details concerning the implementation stages should be recorded, each step in completing the project examined, and the time required for its completion determined. The teacher also gives all students the opportunity to participate and share their views on aspects of the plan and encourages them to express their perspectives, thereby strengthening their self-confidence.

Step Three: Implementing the Project

At this stage, the project plan and proposals move from thinking and conceptualization to practice and application. Students begin performing the tasks, and each student assumes the assigned responsibility.

The teacher's role involves providing appropriate working conditions, addressing the difficulties students encounter, offering educational guidance, and monitoring their adherence to the specified period for completing the project. The teacher also observes their performance during implementation, motivates them to continue working, and meets with them when necessary to discuss problems and make essential adjustments.

The teacher also verifies that all students participate in performing the project tasks and that some do not monopolize the work to the exclusion of others. The teacher further monitors their adherence to the agreed plan while allowing the flexibility needed to make changes required by implementation conditions.

Step Four: Evaluating the Project

Evaluation takes place after project selection, detailed planning, and implementation have been completed. At this stage, the teacher reviews the work accomplished by students, explains its strengths and weaknesses, identifies the mistakes they made, and clarifies how to avoid them in subsequent projects. These procedures provide feedback that represents one of the main benefits of project evaluation.

The teacher may involve students in evaluation. If the project is individual, each student presents the results to classmates, who then discuss the project and offer their views. If the project is undertaken collectively, it may be presented and discussed with another group of students.

Study Results and Discussion:

Results of the First Hypothesis

To test the study's first hypothesis, which states that “There are no statistically significant differences at the significance level of $((\alpha \leq 0.05))$ between the mean scores of control group students taught using the conventional method and experimental group students taught using the project strategy in the post-administration of the achievement test,” the researcher used the independent samples t-test

The test was used to determine the significance of the difference between the mean scores of the control and experimental groups in the post-administration of the achievement test related to the sixth-grade primary school science curriculum. The statistical analysis yielded the results presented in Table (1)

Table (1): Significance of the Difference between the Mean Scores of the Experimental and Control Groups in the Post-Administration of the Achievement Test

Significance Level	“t” Calculated	Control Group		Experimental Group		Sample Size
		Standard Deviation	Mean	Standard Deviation	Mean	
0.0000	0.5834	4.9401	139.41	2.7300	137.19	2

The results in Table (4) indicate a higher level of academic achievement among experimental group students who learned using the project-based learning strategy than among control group students taught using the conventional method. The mean score of the experimental group in the post-administration of the achievement test was (17310), whereas the mean score of the control group was (14931). The calculated t-value was (3850), and a significance level of (0000) was recorded, indicating a statistically significant difference at the level of $((\alpha \leq 0.05))$. This difference favored the experimental group, which had the higher mean score. Based on these results, the null hypothesis was rejected and the alternative hypothesis accepted, stating that “There are statistically significant differences at the level of $((\alpha \leq 0.05))$ between the mean scores of control group students taught using the conventional method and experimental group students taught using the project strategy in the post-administration of the achievement test, favoring the experimental group”

To determine the effect size of the project-based learning strategy in developing the cognitive aspect of the science curriculum among sixth-grade primary school students, the researcher used the eta-squared formula. The eta coefficient was (0.458), while the eta-squared value was (0.209), exceeding the reference value of (0.14). This result indicates a large effect size for the strategy and confirms that the superiority recorded in favor of the experimental group was attributable to its instruction using the project-based learning strategy.

The researcher attributes this result to the nature of instruction using this strategy, which includes elements that help attract students' interest, increase their motivation, and reduce monotony and rigidity in the learning situation. It also helps stimulate students' attention and encourage participation, thereby enhancing their understanding and retention of information and sustaining the effect of learning for a longer period. Accordingly, the project-based learning strategy is an approach that makes the learning process more engaging and attracts students' attention.

Results of the Second Hypothesis

To test the study's second hypothesis, which states that “There are no statistically significant differences at the level of $(\alpha \leq 0.05)$ between the mean scores of control group students taught using the conventional method and experimental group students taught using the project strategy in the post-administration of the scientific research skills scale,” the researcher used the independent samples t-test

This test was used to determine the significance of the difference between the mean scores of the experimental and control groups in the post-administration of the scientific research skills scale. The statistical analysis yielded the results shown in Table (2)

Table (2): Significance of the Differences between the Mean Scores of the Experimental and Control Groups in the Post-Administration of the Scientific Research Skills Scale

Significance Level	“t” Calculated	Control Group		Experimental Group		Sample Size
		Standard Deviation	Mean	Standard Deviation	Mean	
0.000	4.577	8.222	68.531	8.561	68.571	19
						2

The results in Table (5) show a higher level of performance in scientific research skills among experimental group students taught using the project-based learning strategy than among control group students taught using the conventional method. The mean score of the experimental group was (17586), compared with (13586) for the control group. The calculated t-value was (7754), and the significance level was recorded as (0000), indicating a statistically significant difference at the level of $(\alpha \leq 0.05)$. This difference favored the experimental group students, whose mean score was higher.

In light of these results, the null hypothesis was rejected and the alternative hypothesis accepted, stating that “There are statistically significant differences at the level of $(\alpha \leq 0.05)$ between the mean scores of control group students taught using the conventional method and experimental group students taught using the project strategy in the post-administration of the scientific research skills scale, favoring the experimental group.”

To measure the effect size of the project-based learning strategy in developing scientific research skills among sixth-grade primary school students, the researcher used the eta-squared formula. The eta coefficient was (0.720), while the eta-squared value was (0.518), exceeding the reference value of (0.14). This result indicates a large effect of the strategy on developing scientific research skills and also shows that the differences between the two groups were attributable to the experimental group's use of the project-based learning strategy.

The researcher attributes this result to the characteristics of the strategy used, as it accommodates individual differences among students, supports individualized instruction, and responds to their needs and inclinations, particularly when selecting project topics. It also encourages students to participate with their peers and work as a team to achieve shared objectives and contributes to developing structured competition among them. The effect of these characteristics is more apparent in group projects.

Study Recommendations:

In light of the research findings, the researcher recommends the following:

- Adopting the project-based learning strategy as one of the principal strategies for teaching science
- Incorporating projects related to science topics that can be implemented within the school or its surrounding environment
- Employing project-based learning in implementing the comprehensive assessment system
- Attending to the development of programming and creative thinking among learners at various educational stages because of their effects on their academic and practical lives
- Enriching science content at different educational stages with topics and activities that help improve achievement and develop scientific research skills
- Providing teachers with sufficient training before implementing the project-based learning strategy, beginning with instructional units that are easy to apply and implementing them under the supervision of a teacher or trainer experienced in this strategy
- Preparing the project carefully and developing a detailed plan before implementation, including a timetable for its stages, lists of evaluation criteria, and the time frame for the instructional unit
- Beginning with the parts of the curriculum that suit project-based learning and in which the strategy can be readily applied, so that the teacher acquires the necessary experience before moving to more complex topics

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