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# The Impact of Using Blended Learning in Improving Pre-Service Teachers' Scientific Thinking and Self-Efficacy

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## Abstract

This study investigates the impact of blended learning on developing scientific thinking skills and self-efficacy among pre-service classroom teacher students. An experimental pretest-posttest design was employed to achieve the study's objectives. Two research instruments were developed: a scientific thinking skills test comprising 20 items and a self-efficacy scale of 23 items. The study sample included 31 female students enrolled in the bachelor's program for Classroom Teacher Education in the Physics and Earth Sciences course during the first semester of the academic year 2023-2024 at the World Islamic Sciences and Education University. The results revealed a statistically significant difference at the level of ($\alpha = 0.05$) between the mean scores of the students in the pre-and post-tests for both the scientific thinking skills test and the self-efficacy scale, favoring blended learning. Based on the findings, the study recommends adopting blended learning in teaching scientific courses to enhance students' scientific thinking skills and self-efficacy.

## Introduction

The advancements in science and technology in the 21st century have significantly impacted the educational process and the overall education system. Educators have increasingly focused on integrating modern teaching methods with advanced technologies, particularly e-learning techniques, to keep pace with technological progress. As a result, the preparation and training of teachers have become top priorities for educational institutions. Developing teachers' skills and self-efficacy is essential to meet the demands of scientific and technological advancements, equipping them with scientific thinking skills that enable them to keep up with developments and enhance the teaching and learning process.

Educational institutions are required to reconsider their educational policies and approaches. Consequently, modern educational reforms have focused on emphasizing and fostering students' thinking abilities, particularly by teaching them scientific thinking methods and training them in various thinking strategies. This aims to prepare students to thrive in society. It has become essential to adopt modern teaching methods that focus on developing students' thinking skills. Among the various types of thinking, scientific thinking is significant in motivating learners and preparing them to address challenges in diverse situations (Al-Saadi, 2013).

Thinking and teaching thinking have received unprecedented attention in recent years due to their importance in increasing students' awareness of the knowledge content they study and enhancing their ability to address life problems systematically, rather than randomly. Thinking does not occur suddenly or without preparation; it must be nurtured and taught. Therefore, it is essential to focus on students, equipping them with the tools and skills necessary to lead them toward seeking knowledge and developing their scientific thinking skills. This can be achieved through various appropriate activities, methods, and strategies that encourage students to engage in inquiry, research, and learning while considering individual differences. Such approaches also enhance their ability to connect personal experiences with new information (Shahadeh & Al-Bitawi, 2020).

Educational development emphasizes the competence, expertise, and effective teaching strategies of teachers, which play a crucial role in fostering students' thinking skills. If we want students to overcome future challenges, teachers must enhance their cognitive growth, supporting their ability to think critically (Ozsevgeco & Cepeni, 2006). Scientific thinking is the foundation of education and is a mental activity focused on organizing ideas and solving students' daily problems. It helps identify issues, observe, analyze, propose hypotheses, draw conclusions, and generalize findings to similar problems (Aktamis & Ergin, 2008).Koerber et al. (2015) describe scientific thinking as a set of mental processes related to the scientific content of curricula. It aids students in obtaining definitive evidence to rely upon and utilize when needed. Students' ability to acquire scientific thinking skills can be enhanced by asking precise questions, directing them toward students for responses using scientific reasoning methods, and gathering relevant data and information. This process encourages students to assess the data using abstract thinking, enabling effective explanations of phenomena, logical conclusions, and solutions. These solutions are tested against appropriate standards and considered multiple ideas, evaluating the compatibility of various hypotheses with the problem or phenomenon at hand. Furthermore, scientific thinking promotes collaboration among students to find the best solutions to problems (Noufal & Suayfan, 2011).

Scientific thinking involves several steps, starting with awareness of the existence of problems, recognizing and defining them, gathering data related to the issues, formulating hypotheses for potential solutions, testing these hypotheses, drawing conclusions related to the problems, applying them to solve the problems, and then reusing the solutions (Sarhan, 2016). Scientific thinking has great potential for applying experiments and exploratory processes, facilitating scientific practices. This would create future generations capable of applying scientific thinking skills. Through scientific thinking, teachers can pose deep questions to students, direct them toward formulating precise answers, collect as much relevant information and data as possible, and evaluate it by employing abstract ideas that help reach comprehensive explanations of phenomena. Teachers can also guide students to find solutions applicable to phenomena, aligning them with effective standards. Scientific thinking enables students to communicate effectively with others to arrive at the best solutions (Zakaria, 2017).

Self-efficacy in teaching science refers to the beliefs that teachers hold regarding their ability to perform teaching tasks related to science. These beliefs significantly influence their teaching behavior in science. Teachers' actions in science instruction depend on the beliefs developed during their pre-service training and their level of self-confidence, which ultimately impacts the educational outcomes in this subject (Bleicher & Lindgren, 2005).

Blended learning is a form of learning that combines electronic education with traditional teaching methods within a unified framework. It employs educational tools and interpretations to enhance the learning process. The knowledge that future teachers must possess includes their understanding of the subject matter, effective methods for presenting theoretical content to make it easier for students, awareness of student characteristics, and technological knowledge. Technological knowledge has become an essential prerequisite for advancing the educational process. It is no longer sufficient for teachers to only be skilled in computer use; numerous technological tools have emerged to help teachers achieve professionalism in their profession. Among these tools is blended learning, which is considered a means of meeting the needs of both the present and the future. Blended learning is an integrated system that combines face-to-face traditional methods with online electronic learning to guide and assist learners throughout their educational journey. It is one of the modern approaches based on utilizing technology in education (Al-Faqi, 2011).

Since integrating technology into the educational process has become a necessity rather than an option, especially after educators realized that traditional teaching methods are no longer suitable for the current generation of students, it is evident that old traditional teaching methods, where the teacher is the sole authority in the learning process, have become ineffective. These methods fail to engage students or spark their interest, and they do not foster critical thinking skills because they are disconnected from the students' out-of-school environment, which is heavily influenced by technology. The modern generation of students is in dire need of adding excitement and enthusiasm to school curricula, classrooms, learning materials, and communication between students and teachers (Sams & Bergmann, 2012).Contemporary educational institutions, especially universities, can benefit from these advanced technological tools to enhance teaching methods and approaches, delivering information to students in the most effective way to foster learning and bring about changes in their behaviors and scientific thinking. Additionally, these technologies can be utilized outside of class hours to improve students' self-efficacy. As a result, several strategies have emerged, including blended learning, which can provide students with information and integrate technology and online programs. This approach allows for course preparation, content knowledge, and the intended objectives, offering opportunities for engaging in educational activities, enabling teachers to create small groups, and facilitating student-teacher discussions (Marai & Al-Hila, 2016). Al-Mutairi and Al-Mufrej (2007) emphasized the importance of implementing training programs to prepare and train teachers to keep up with the rapid advancements of the modern era. They also highlighted the need to transition from traditional training to modern technological training while examining global trends in teacher preparation and training in advanced countries, adapting them to each country's educational system. The researcher believes that blended learning can be used to help pre-service teachers acquire scientific thinking skills and self-efficacy. This leads to the study problem, which aims to measure the impact of using blended learning to teach physics and earth sciences in developing scientific thinking skills and self-efficacy among pre-service teachers.

**Statement of the Problem**

Teaching science in the first three grades is of great importance, as learning science at this critical age fosters students' curiosity, develops their inclination for exploration, and meets their needs for understanding the natural world around them. This can only be achieved by having a well-trained, competent teacher who can create a classroom environment that encourages student questions and enables them to engage in investigative activities. However, in many countries worldwide, teachers in the first three grades often feel uncomfortable teaching science (Bencze & Upton, 2006) and consider it one of the most challenging tasks. In Jordan, for example, many teachers avoid teaching science, especially because they are not specialized in the subject and are often not graduates of the scientific stream in high school. As a result, they lack a deep understanding of the science content, pedagogical knowledge, and the necessary skills to teach it, which negatively impacts their self-efficacy in teaching. Enhancing their self-efficacy largely depends on teacher preparation programs at the undergraduate level. Pre-service teachers often hold a certain level of self-efficacy regarding their teaching abilities, shaped early on by their observations during their studies and the educational knowledge they acquired at the university. They tend to cling to these beliefs, as it is difficult to change them (Lorna, Neelam, & Kyesha, 2002).

Most teachers do not establish direct and strong connections between the subjects they teach and modern technologies, leading them to rely heavily on spoken language, as well as using images and models for presentation. This approach often fails to connect with students' minds in a way that helps them achieve the learning objectives of the subject. As a result, this leads to a lack of connection between physics and the students' real-life experiences and weakens their scientific thinking skills. Therefore, the responsibility falls on the bachelor's teacher preparation program to employ teaching methods such as blended learning, which can provide pre-service teachers with ideas that offer better explanations for the experiences they encounter. This, in turn, equips them with scientific thinking skills and enhances their self-efficacy.

Given that one of the objectives of the teacher preparation programs for primary education is to enable teachers to acquire scientific thinking skills and apply appropriate teaching strategies for delivering subject content—especially in science—it is crucial to work on developing the self-efficacy of pre-service teachers. The extent of improvement in their scientific thinking skills, and the corresponding changes in their self-efficacy, serve as indicators for evaluating the effectiveness of teaching science courses in the teacher preparation program and its ability to achieve its set objectives. Studies by Asmik and Al-Samkari (2022) and Saada and Anas (2022) have emphasized the importance of learning and developing scientific thinking skills to connect academic subjects with the real-life experiences of students and their ability to solve problems they face. Thus, the current study aims to investigate the effect of blended learning on scientific thinking and self-efficacy development in physics and Earth sciences courses for pre-service teachers at the World Islamic Sciences and Education University.

**Research Questions**

The main research question is:

- What is the impact of blended learning on scientific thinking and the development of self-efficacy in the Physics and Earth Sciences courses for pre-service classroom teacher at the World Islamic Sciences and Education University?

The following sub-questions:

- Are there statistically significant differences at the ($\alpha = 0.05$) level between the mean scores of students in the pre-test and post-test of scientific thinking, attributed to the teaching method (blended learning)?
- Are there statistically significant differences at the ($\alpha = 0.05$) level between the mean scores of students in the pre-test and post-test of self-efficacy, attributed to the teaching method (blended learning)?

**Objectives of the Study**

This study addresses a topic that links the selection of a teaching strategy suitable for both the learning and teaching processes and e-learning, specifically blended learning. The aim is to provide pre-service female teachers with the experience that enables them to develop scientific thinking skills and self-efficacy. Therefore, the current study aims to:

1. Determine whether there are statistically significant differences at the ($\alpha = 0.05$) level between the mean scores of students in the pre-test and post-test of scientific thinking, attributed to the teaching method used (blended learning).
2. Determine whether there are statistically significant differences at the ($\alpha = 0.05$) level between the mean scores of students in the pre-test and post-test of self-efficacy, attributed to the teaching method used (blended learning).

**Significance of the Study**

The significance of this study stems from the need to use modern teaching methods, such as blended learning, to keep up with the era's demands. The aim is to develop scientific thinking skills and self-efficacy for teachers of the first three grades in teaching science to this crucial age group in an individual's life, as it has a significant impact on their educational behavior related to teaching science in these grades. It is important to understand the nature of self-efficacy in teaching science for these teachers, and the effectiveness of pre-service training courses, which prepare them to teach science efficiently to first-grade students.

The results of this study provide indicators that could help improve the teacher preparation programs at Jordanian universities, specifically concerning science education. This is particularly significant as there is, to the best of the researcher's knowledge, a gap in local studies addressing the impact of blended learning on the development of scientific thinking skills and the formation of self-efficacy for pre-service teachers. Most Arab and local studies, such as Abed (2009) and Nawafleh and Al-Omari (2013), focused on examining the level of self-efficacy for science teachers before service and its relationship with only some factors.

**Operational Definitions**

*Blended Learning* Blended learning refers to the combination of traditional classroom practices with technology-based learning tools (Docsa & Szlavik, 2015: 3). It is operationally defined as a teaching method practiced by the instructor that combines traditional teaching with the use of technology tools in teaching the unit on motion and connections in the Physics and Earth Sciences course for pre-service classroom teacher.

*Scientific Thinking* Scientific thinking is defined as "a set of purposeful and organized mental activities that individuals use to address problems by identifying them, gathering related information, forming hypotheses, testing them, and providing logical explanations, in order to arrive at conclusions that can be generalized" (Sada, 2015: 47). In this study, scientific thinking is operationally defined as the set of skills including problem identification, hypothesis selection, hypothesis testing, explanation, and generalization, and it is measured by the score obtained by the students in the scientific thinking test.

*Self-Efficacy in Teaching Science* Self-efficacy is defined as an individual's belief in their ability to organize and execute the actions required to achieve well-defined performance patterns (Bandura, 1997). In this study, self-efficacy in teaching science refers to the confidence and belief of the pre-service teacher in their ability to teach science effectively to first-grade students and positively influence their learning of the subject. This includes two aspects: personal self-efficacy in teaching science, which refers to the teacher's judgment of their skills and ability to teach science effectively, and general self-efficacy, which refers to the teacher's judgment of their teaching ability and effectiveness in positively impacting student learning in science. It is measured in this study by the score obtained in the Science Teaching Efficacy Beliefs Instrument (STEBI-B).

*Pre-service classroom teacher* A pre-service school teacher is a student enrolled in the Physics and Earth Sciences courses as part of the elementary education program at the World Islamic Sciences and Education University, registered for the first semester of the academic year 2023-2024.

**Scope and Limitations of the Study**

*Human* The study was limited to a sample of pre-service classroom teacher enrolled in the Physics and Earth Sciences courses.

*Place* The study was conducted at the Faculty of Educational Sciences at the World Islamic Sciences and Education University.

*Time* The study was conducted during the first semester of the academic year 2023-2024.

*Topic* The study focused on using blended learning to develop scientific thinking skills and self-efficacy in teaching science. Specifically, it addressed two aspects of self-efficacy in teaching science: personal self-efficacy in teaching science and expectations of science teaching outcomes, as well as scientific thinking skills. The focus was on the unit of motion in the Physics and Earth Sciences course. Moreover, the generalization of the study's results is limited by the validity and reliability of its tools.

## Theoretical Framework

Scientific thinking is not necessarily limited to scientists. While scientists often focus on specific problems within areas that the average person may not engage in, they use a specialized language, including symbols and terminology, to communicate with other experts in the field. Scientists concentrate on vast amounts of information and utilize everything humanity has invented throughout history within a specific domain of knowledge (Zakaria, 2017). The researcher believes that a scientific approach to thinking skills has become a necessity for both the individual and society in order to solve the problems facing humanity.

Scientific knowledge is cumulative, and although it may reveal new dimensions, it develops and increases in importance as one progresses through life or encounters experiences. This stimulates the student's cognitive abilities and motivation to think across all patterns, levels, and cognitive skills. Thinking processes are organized, interconnected, and intertwined across levels, beginning with basic skills such as observation, comparison, and organizing information, up to more complex processes.

As Esmik and Samkari (2022) clarified, scientific thinking skills are the student's ability to perform a series of invisible mental operations, such as measurement, observation, classification, using numbers, identifying relationships, and making predictions when faced with a stimulus. The student then strives to link this stimulus to previous knowledge or works to solve a problem upon its occurrence, engaging in complex thinking like critical thinking, problem-solving, and decision-making. Saber (2018) identified the characteristics of scientific thinking, including the cumulative nature of knowledge, where scientific knowledge is akin to a structure being built with one floor above another. Additionally, it involves organization through hypothesis formulation and testing in a coordinated manner that ensures sequence and order to reach conclusions and solve problems.

Scientific thinking also seeks to identify causes, interpret their occurrence, and is characterized by comprehensiveness and certainty. The goal is to reach results that can be applied to similar situations and problems. It emphasizes accuracy and abstraction, with careful selection of the proper language to ensure the accuracy of results. This process is purposeful, precise, and based on reality and tangible facts, with results that can be generalized.

Hasyim (2020) conducted a study to describe students' critical scientific thinking skills through online learning using PhET simulations. The study used a quasi-experimental design with a single-group design, and the sample consisted of 27 eighth-grade students. Pre- and post-tests on critical scientific thinking skills were administered, and the results indicated that learning science online with the help of the mentioned simulation improved students' critical scientific thinking skills. Similarly, Habibi, Jumadi, and Mundilarti (2020) conducted a study to analyze the effects of PhET simulations on thinking skills. They used a quasi-experimental design based on a single-group design and administered pre- and post-tests as measurement tools. The sample consisted of 32 high school students, and the results showed positive effects of the simulation on thinking skills.

In 2020, Al-Halalmah aimed to investigate the effect of an educational program based on practical demonstrations for teaching science in developing scientific thinking skills and social interaction skills among seventh-grade students in Jordan. To achieve this objective, a quasi-experimental approach was used, with a sample of 40 students divided into two groups: an experimental group (20 students) and a control group (20 students). The study used a scientific thinking skills test and a social interaction skills scale. The results showed a significant statistical effect at the (∝=0.05) level, indicating that the experimental group performed better on the post-test of scientific thinking skills compared to the control group, which was influenced by the teaching method.

**Self-Efficacy**

The term "self-efficacy," according to Bandura's Social Learning Theory, refers to an individual's judgment of their ability to accomplish a specific level of performance, their beliefs about their ability to organize and execute the required actions, their perseverance, the effort they will exert in completing the task, and their flexibility in handling challenges. Self-efficacy forms a self-regulation system that enables individuals to control their thoughts, emotions, and behaviors, allowing them to learn from others and develop alternative strategies for self-regulating their actions (Bandura, 1997).Self-efficacy is considered a key driving force behind an individual's behavior, as it relies on their beliefs about their effectiveness, skills, and successful interactions with challenges and problems. Individuals with strong self-efficacy focus on problem analysis and exert effort in solving them. In contrast, those lacking self-confidence in their self-efficacy tend to turn inward, becoming preoccupied with worries and anxieties about their perceived deficiencies, which limits their effective use of cognitive abilities. They often expect failure, leading to disengagement and poor performance on tasks, or sometimes leaving tasks unfinished (Bandura & Wood, 1989; Abu Ghazal & Alawneh, 2010).

In the context of teaching, a teacher's self-efficacy is reflected in their educational outcomes. Teachers with high self-efficacy instill confidence in their students, as self-efficacy is contagious. A science teacher with high self-efficacy is capable of grasping scientific concepts and applying them in real-world situations, using effective teaching strategies, being open to new ideas, and adapting well to technology (Tschannen-Moran & Woolfolk, 2001; Fives, 2005). In contrast, teachers with low self-efficacy may lack scientific knowledge and appropriate teaching methods, providing fewer opportunities for students to develop their scientific understanding (Upton, 2006; Bencze & Kaya, 2006).

Although global attention has been paid to studying the impact of teacher preparation programs on self-efficacy in science teaching, there has been relatively little focus on the role of practical teaching experiences in this regard. Few Arabic and local studies have addressed this topic. One such study by Kaya (2013) aimed to investigate the impact of a course on constructivist science teaching methods on self-efficacy beliefs in science teaching. The sample consisted of 91 students from a Turkish university, using the Science Teaching Efficacy Belief Instrument Form B (STEBI-B). The results indicated a statistically significant positive effect on personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE).

Bursal (2009) conducted a study to examine the impact of a science teaching course on changing self-efficacy levels and science anxiety among pre-service teachers in a Turkish university. The sample consisted of 154 students, using the STEBI-B and science anxiety scale. The results showed no significant statistical effect on self-efficacy or reduction in science anxiety. The study suggested several recommendations for improving teacher preparation programs in Turkish universities.

Bayraktar (2009) conducted a study to explore the effects of a teacher preparation program for primary school teachers in a Turkish university on improving self-efficacy in science teaching and attitudes toward it. The sample consisted of 282 students, categorized by their teaching experience. The results showed a significant positive effect on personal science teaching efficacy (PSTE), but no significant effect on science teaching outcome expectancy (STOE). The study recommended further research on factors influencing pre-service teachers' self-efficacy, such as the trainer's personal qualities and learning strategies.

Blended learning refers to integrating of teaching methods and strategies with various technologies, meaning there is no single approach to this integration. The success of blended learning depends on how well the components are integrated in a cohesive, harmonious, and practical way, supporting the different essential elements of learning effectively (Abu Mousa, 2009). One of the key advantages of blended learning is the significant reduction in costs compared to purely online education. It also allows learners to enjoy face-to-face interaction with their teachers and peers, which enhances human aspects and social relationships between students, as well as between students and teachers. Additionally, blended learning caters to individual needs and accommodates the diverse learning styles, levels, ages, and schedules of students. The use of technological advancements in design, implementation, and usage also enriches human knowledge. Furthermore, it improves the quality of the educational process, the educational product, and teacher effectiveness. Blended learning also promotes cultural communication between different cultures, facilitating the exchange and dissemination of new knowledge in various fields of science (Krause, 2010).

**Blended Learning**

Blended learning is not a new concept, but in the past, its components were limited to traditional classrooms. Today, it allows for the integration of various methods, tools, and training activities, including virtual classrooms, traditional classrooms, web pages, email, computers and software programs, voice chat, video conferences, and platforms like Microsoft Teams.

A study by Boyle (2005) aimed to develop a curriculum suited for blended learning and investigate its impact on student performance. The study sample consisted of 1,000 students from the University of London and Bolton Institute. The experimental approach was adopted because it was most suitable for this kind of research. The study developed a blended learning environment to address the problems faced by students, and the project was in its third year of implementation. Several requirements were set to ensure the success of the blended learning-based curriculum, including continuous material and technical support, encouragement of collaborative work and teamwork, and teacher involvement in the development process. The curriculum was developed, tested, and evaluated with students. The results showed notable improvements in students' retention, recall, and comprehension. The researcher recommended finding solutions to potential challenges in implementing the blended learning-based curriculum, such as continuous material and technical support and emphasized the need for ongoing evaluation during the application of the curriculum.

The study conducted by Moteir (2015) aimed to explore the effectiveness of blended learning in developing inductive thinking skills in the subject of Islamic education among 11th-grade students in Gaza. The sample consisted of 67 students from the 11th grade at Adnan Scientific Secondary School for Boys, which has eight 11th-grade classes. Two classes were randomly selected, with one group assigned to the experimental group using blended learning, and the other group taught through the traditional method. The researcher adopted the experimental approach due to its suitability for the nature of the study. To achieve the study's objectives, the researcher applied a content analysis tool and a test to measure inductive thinking skills, which was developed by the researcher herself. The study concluded that there were statistically significant differences at the (0.05) level in the development of inductive thinking in the subject of Islamic Education between the pre-test and post-test for the experimental group, with improvements in the post-test.

This study stands out from previous studies by linking a modern strategy—blended learning—with the development of scientific thinking skills and self-efficacy among pre-service teachers in physics and earth sciences courses. This combination has not been addressed in previous research, making this one of the first studies—according to the researcher's knowledge—that integrates these variables: blended learning, scientific thinking skills, and self-efficacy. The researcher benefited from previous studies in constructing the theoretical framework, the teacher's guide, and in developing the study tools (the test for scientific thinking skills and self-efficacy). Additionally, the methodology for sample selection and the results and recommendations from previous studies were used to inform the current study.

## Methods

A pre-experimental approach was used, as it is considered one of the most suitable research methodologies for this type of study to achieve the study objectives and answer its questions.

### Participants

The study consisted of 31 students enrolled in the "Physics and Earth Sciences" course, majoring in pre-service classroom teacher, at the World Islamic Sciences and Education University, for the academic year 2023-2024.

### Tools

Two tools were developed to collect data from the study sample: the Scientific Thinking Skills Test and the Self-Efficacy Scale to achieve the study's objectives and answer its questions. Below is an overview of each tool:

### First: Scientific Thinking Skills Test

Through reviewing educational literature and previous related studies, a Scientific Thinking Skills Test was developed for the "Physics" course (Unit of Motion). The test measures five skills: problem recognition and definition, hypothesis selection, hypothesis testing, interpretation, and generalization. The test was developed following the procedures below:

- Reviewing educational literature related to the topic of scientific thinking skills, especially studies that used similar tests, such as the study by Al-Qadri (2005), Asmik and Al-Samakri (2022), and Habibi, Jumadi, and Mundilarti (2020).
- Identifying the list of scientific thinking skills that the test aims to measure. These skills included: problem recognition and definition, hypothesis selection, hypothesis testing, interpretation, and generalization.
- Developing the test in its preliminary form, consisting of 15 items distributed across the five scientific thinking skills, with three items for each skill. The items were multiple-choice questions with three alternatives, allowing them to identify the skills necessary to develop scientific thinking abilities in the learner.
- The test was evaluated by a group of experts.

***Difficulty and Discrimination Indices for the Scientific Thinking Test***

Using the SPSS program, the responses of a group outside the study sample (consisting of 20 individuals) were analyzed to calculate the difficulty and discrimination indices for the test items. The difficulty index for each item was determined by the percentage of students who answered the item incorrectly while the discrimination index for each item was calculated as the correlation between the item and the total score.The difficulty indices of the items ranged between 0.50 and 0.75, and the discrimination indices ranged between 0.46 and 0.87. Based on the guidelines provided by Auda (2010) for acceptable difficulty levels, which range between 0.20 and 0.80, and for item discrimination, where an item is considered good if its discrimination index is above 0.39, acceptable but needs improvement if its discrimination index is between 0.20 and 0.39, weak and needing removal if its discrimination index is between 0 and 0.19, and negatively discriminating items should be removed. Therefore, no items were removed based on either their difficulty or discrimination indices.

***Validity of the Scientific Thinking Test***

*Content Validity*

To verify the content validity of the Scientific Thinking Test, it was presented to a panel of 9 experts in the fields of curriculum and teaching methods, as well as measurement and evaluation, from Jordanian universities. The purpose was to assess the alignment of the test items with the specified objectives, the clarity of the wording, and the representation of the test items to the content and goals of the subject. Based on the feedback from the panel, revisions were made to some items, with changes being implemented when at least 80% of the experts agreed on the modifications.

*Reliability of the Scientific Thinking Test*

To ensure the reliability of the test, the test-retest method was applied. The test was administered to a group of 20 students outside the study sample, and it was re-administered two weeks later. The Pearson correlation coefficient between the two sets of scores was calculated, yielding a reliability coefficient of 0.91 for the entire test.

Additionally, internal consistency reliability was calculated using the Kuder-Richardson formula 20 (KR-20), resulting in a coefficient of 0.86 for the entire test. These values were deemed adequate for the purposes of this study.

**Scoring the Scientific Thinking Test**

The test was scored according to the following procedure:

- The correct answer key for the test items was prepared in a table of correct answers, and the points for each item were assigned.
- One point was allocated for each correct answer for the respective item in the test .Therefore, the highest possible score on the test was 20 points, and the lowest possible score was 0.

**Self-Efficacy Scale**

In this study, the *Self-Efficacy Beliefs in Science Teaching Scale (STEBI-B***)** developed by Enochs and Riggs (1990) was used, based on Bandura's self-efficacy theory. The scale consists of 23 items, rated using a five-point Likert scale: Strongly Agree, Agree, Uncertain, Disagree, and Strongly Disagree. The items are distributed across two main domains as follows:

1. *Personal Science Teaching Efficacy (PSTE***)**: This domain includes 13 items that assess the students' confidence in their ability to teach science effectively.
2. *Science Teaching Outcome Expectancy (STOE):* This domain consists of 10 items measuring students' beliefs about the effectiveness and benefits of teaching science.

***Validity of the Self-Efficacy Scale***

*Content Validity*

The translation of the scale and its alignment with the original version were reviewed by experts, including specialists in the English language. The translations were further refined based on feedback from studies (Ayasra, 2016; Hassouna, 2009; Abed, 2009**)**. These revisions addressed linguistic issues in the phrasing of most items.

*Construct Validity*

To assess the construct validity of the scale, correlation coefficients were calculated between each item and the total score, as well as between each item and its respective domain. Additionally, the correlation between the two domains (PSTE and STOE) and the total score was computed. The data were collected from a pilot sample و consisting of 20 students outside the main study sample. The correlation coefficients for the individual items with the overall scale ranged from 0.50 to 0.67 while the correlations between the items and their respective domains ranged from 0.47 to 0.77, indicating satisfactory construct validity as shown in Table 1. All correlation coefficients were statistically significant, with most values falling within an acceptable range. Based on these results, no items were removed.

Table 1. Correlation Coefficients Between Items, Domain, and Overall Scale

| Item No. | Correlation with Domain | Correlation with Overall Scale |
|---|---|---|
| 1 | 0.54* | 0.66** |
| 2 | 0.63** | 0.66** |
| 3 | 0.64** | 0.50* |
| 4 | 0.77** | 0.51* |
| 5 | 0.62** | 0.67** |
| 6 | 0.64** | 0.52* |
| 7 | 0.53* | 0.58** |
| 8 | 0.69** | 0.56** |
| 9 | 0.62** | 0.51* |
| 10 | 0.68** | 0.55* |
| 11 | 0.71** | 0.67** |
| 12 | 0.59** | 0.55* |
| 13 | 0.75** | 0.58** |
| 14 | 0.75** | 0.58** |
| 15 | 0.73** | 0.60** |
| 16 | 0.47* | 0.55* |
| 17 | 0.63** | 0.57** |
| 18 | 0.74** | 0.54* |
| 19 | 0.71** | 0.59** |
| 20 | 0.71** | 0.51* |
| 21 | 0.59** | 0.67** |
| 22 | 0.75** | 0.52* |
| 23 | 0.75** | 0.67** |

Note: Statistically significant at the 0.05 level (*), (**) Statistically significant at the 0.01 level

Table 2 presents the correlation coefficients between the two domains and the total score of the Self-Efficacy Scale. The values demonstrate the strength and significance of relationships between the domains and the overall scale.

Table 2. Correlation Coefficients Between Domains and Total Score

| Domains | Personal Science Teaching Efficacy | Science Teaching Outcome Expectancy | Self-Efficacy (Overall) |
|---|---|---|---|
| Personal Science Teaching Efficacy | 1.00 | 0.818** | 0.644** |
| Science Teaching Outcome Expectancy | 0.818** | 1.00 | 0.580** |
| Self-Efficacy (Overall) | 0.644** | 0.580** | 1.00 |

*Note: Statistically significant at the 0.05 level (*); Statistically significant at the 0.01 level (**); All correlation coefficients were statistically significant and within acceptable ranges, indicating a strong and positive relationship between the two domains and the overall self-efficacy scale.

**Reliability**

In the original study by Enochs and Riggs (1999), the internal consistency reliability for the Personal Science Teaching Efficacy (PSTE) domain was 0.76, and for the Science Teaching Outcome Expectancy (STOE) domain, it was 0.76. In the current study, reliability was assessed using both the test-retest method and the internal consistency method (Cronbach's Alpha). The results are summarized in Table 3 below.

Table 3 Cronbach's Alpha Internal Consistency and Test-Retest Reliability for Domains and Total Score

| Domain | Test-Retest Reliability | Internal Consistency (Cronbach's Alpha) |
|---|---|---|
| Personal Science Teaching Efficacy (PSTE) | 0.81 | 0.79 |
| Science Teaching Outcome Expectancy (STOE) | 0.83 | 0.80 |
| Self-Efficacy (Overall) | 0.88 | 0.85 |

**Study Design and Variables**

The study used a pre-post experimental design with a single group, as shown in the following format:
Design: GE O1 O2 × O1 O2
Where:

- GE represents the experimental group.
- O1 is the pre-test for the Scientific Thinking Skills and Self-Efficacy.
- O2 is the post-test for both the Scientific Thinking Skills and Self-Efficacy.
- X refers to the blended learning strategy implemented between the pre-test and post-test.

Variables of the Study:

- Independent Variable: Blended learning in the Physics course with two levels: before and after the course.
- Dependent Variables:
    - Scientific Thinking (measured via the Scientific Thinking Skills Test).
    - Self-efficacy in Science Teaching with two sub-domains:
        1. Personal Science Teaching Efficacy.
        2. Science Teaching Outcome Expectancy.

## Results

**Question 1: Are there statistically significant differences at the ($\alpha$ = 0.05) level between the mean scores of students in the pre-test and post-test of scientific thinking, attributed to the teaching method (blended learning)?**

To answer this question, the mean scores and standard deviations of the students' grades in the scientific thinking test in the pre-test and post-test were calculated. To identify the statistical differences between the mean scores, a paired sample "t-test" was used. Table 4 illustrates this.

Table 4. Mean Scores, Standard Deviations, and "t" Test for the Students' Grades in the Scientific Thinking Test in the Pre-Test and Post-Test

| Topic | Test | N | Mean | SD | t | DF | Significance |
|---|---|---|---|---|---|---|---|
| Problem Identification | Pre-test | 30 | 1.97 | 0.999 | -6.966 | 29 | 0.000 |
| | Post-test | 30 | 3.27 | 0.740 | | | |
| Hypothesis Formulation | Pre-test | 30 | 2.17 | 0.791 | -4.583 | 29 | 0.000 |
| | Post-test | 30 | 2.87 | 1.008 | | | |
| Testing Hypotheses | Pre-test | 30 | 1.77 | 1.073 | -7.761 | 29 | 0.000 |
| | Post-test | 30 | 2.97 | 0.928 | | | |
| Interpretation | Pre-test | 30 | 1.97 | 1.217 | -7.180 | 29 | 0.000 |
| | Post-test | 30 | 3.57 | 0.817 | | | |
| Generalization | Pre-test | 30 | 1.97 | 0.999 | -8.601 | 29 | 0.000 |
| | Post-test | 30 | 3.63 | 0.669 | | | |
| Total Scientific Thinking Test | Pre-test | 30 | 9.83 | 2.151 | -19.125 | 29 | 0.000 |
| | Post-test | 30 | 16.30 | 2.136 | | | |

From Table 4, it is evident that there are statistically significant differences ($\alpha$=0.05) in the students' scores on the scientific thinking test between the pre-test and post-test, with the differences favoring the post-test.

**Question 2: Are There Statistically Significant Differences at the ($\alpha$ = 0.05) Level between the Mean Scores of Students in the Pre-Test and Post-Test of Self-Efficacy, Attributed to the Teaching Method (Blended Learning)?**

To answer this question, the mean scores and standard deviations of the students' grades in self-efficacy in both the pre-test and post-test were calculated. To identify the statistical differences between the mean scores, a paired sample "t-test" was used. The table below illustrates this.

Table 5. Mean Scores, Standard Deviations, and "T" Test for the Students' Grades in Self-Efficacy in the Pre-Test and Post-Test

| Topic | Test | N | Mean | SD | t | DF | Significance |
|---|---|---|---|---|---|---|---|
| Personal Self-Efficacy in Teaching Science | Pre-test | 30 | 1.79 | 0.220 | -7.662 | 29 | 0.000 |
| | Post-test | 30 | 2.94 | 0.787 | | | |
| Self-Efficacy in Predicting Science Outcomes | Pre-test | 30 | 1.64 | 0.241 | -11.451 | 29 | 0.000 |
| | Post-test | 30 | 2.60 | 0.440 | | | |
| Total Self-Efficacy | Pre-test | 30 | 1.72 | 0.174 | -11.377 | 29 | 0.000 |
| | Post-test | 30 | 2.79 | 0.493 | | | |

It is evident from Table 5 that there are statistically significant differences ($\alpha$=0.05) in the students' self-efficacy scores between the pre-test and post-test, with the differences favoring the post-test.

## Discussion

### Discussion of Results Related to the First Research Question

The first research question asked: "Are there statistically significant differences at the ($\alpha = 0.05$) level between the mean scores of students in the pre-test and post-test of scientific thinking, attributed to the teaching method (blended learning)?"The results showed a statistically significant difference at the ($\alpha = 0.05$) level between the mean scores of the group in the pre-test and post-test for those taught using the blended learning strategy. The mean score in the post-test for scientific thinking was (16.30) at the overall level, and these differences were in favor of the post-test scores, where students taught with the blended learning strategy excelled in all scientific thinking skills at the overall level.

This result can be attributed to the fact that blended learning is a teaching method that allows students to receive new educational content through video files or online platforms, followed by discussion and practice under the teacher's guidance in the classroom. This contrasts with the traditional method where the teacher presents the new content in class and students train themselves at home. Learning through blended learning enabled students to acquire scientific thinking skills because it provided them with the opportunity for electronic learning in a manner that they preferred, giving them a sense of responsibility since their learning would be assessed in the classroom upon their return. Furthermore, the questions and worksheets given to students in the subjects of Physics and Earth sciences were closely related to scientific thinking skills and problem-solving. Therefore, the researcher observed during the implementation of blended learning how engaged the students were with the material and their high response during teaching, which contributed to the development of their scientific thinking skills across all skills and at the overall level.

Blended learning also allows for better utilization of class time for practice, training, and interaction between educational elements to accommodate individual differences among students. It also helps students identify problems they encounter when completing their assignments during class and allows for feedback from the teacher that students can refer to at any time. Consequently, the classroom environment in this strategy becomes an interactive, participatory one focused on the student, helping students acquire abilities in meaning construction, organizing information, and experimenting, thus developing their scientific thinking skills through the practice of higher-order thinking skills. This result aligns with the studies of Hasyim (2020) and Al-Halalmah (2020), who used e-learning and practical demonstrations to develop scientific thinking skills in teaching scientific subjects. Therefore, blended learning works to complete the lower level of cognitive work before class, enabling students to engage in higher cognitive levels of learning with their peers and the teacher, contributing to the development of their scientific thinking skills in the subject of physics. Moreover, blended learning aligns with the constructivist view as outlined by Zaitoun (2007) and Hasna (2016), which emphasizes that learning is an active interaction process in which the student uses their prior ideas to understand the meanings of new experiences and knowledge, thus constructing new concepts or expanding old ones. As a result, students become capable of using scientific thinking skills to solve problems.

**Discussion of Results related to the Second Research Question**

The second research question asked: "Are there statistically significant differences at the ($\alpha = 0.05$) level between the mean scores of students in the pre-test and post-test of self-efficacy, attributed to the teaching method (blended learning)?"It appears from Table 5 that blended learning significantly improved self-efficacy beliefs in the area of personal self-efficacy in teaching science. The difference between the mean scores of the study sample in both the pre-test and post-test of the scale was statistically significant at the ($\alpha = 0.05$) level, with the post-test in favor of the blended learning method. This result can be attributed to the fact that students, during their study of physics and earth sciences, gained real experiences in teaching that allowed them to apply what they had learned in both scientific and pedagogical knowledge. This sparked their interest in studying science and physics, making them feel more competent, which in turn increased their self-confidence and improved their self-efficacy.

Additionally, the continuous follow-up through the Teams platform and the support, encouragement, guidance, and electronic files (such as recorded lectures and videos related to the physical concepts explained during class) provided by the physics instructor contributed to improving the students' self-efficacy in science teaching and personal self-efficacy. According to Bandura, as mentioned in Hassouna (2009), factors affecting self-efficacy include feedback on academic performance and supportive environmental factors. This result is consistent with the findings of Bayraktar (2009), who noted that a teacher preparation program had a statistically significant positive impact on personal self-efficacy related to science teaching skills. It can be attributed to the important roles played by the teacher in blended learning, such as preparing the lesson in advance, defining the objectives to be conveyed, preparing a visual file explaining new concepts using auditory and visual techniques, and designing interactive classroom activities. This support helped develop self-efficacy skills among the students, providing appropriate support during classroom activities.

On the other hand, the role of the student stands out as the center of the educational process in blended learning. The student seeks information from multiple sources, engages in various activities in the classroom, and feels active, positive, and effective. They interact with their peers, ask questions, make comments, and present new ideas or opinions to enrich the discussion and dialogue, which develops their personality and ability to express themselves. This approach enhances the student's sense of responsibility, as they are required to participate actively and will be assessed based on their contributions to the learning process. Thus, blended learning fosters a cooperative and integrated learning environment among students, with the student at the center of the educational process. This approach helps the student take responsibility for achieving the learning goals and reaching the facts and information, making them the primary force in achieving effective learning.

**Recommendations and Suggestions**

In light of the results obtained, the researcher recommends the following:

- The use of the "blended learning" strategy in teaching undergraduate courses to enhance the acquisition of scientific thinking skills and to develop students' self-efficacy.
- Educational leaders should guide teachers in developing students' scientific thinking skills appropriately.

- Curriculum developers should reconsider incorporating courses in the Teacher Education program, especially in science subjects, that could be taught using the blended learning strategy, including topics and activities designed to develop students' scientific thinking skills.
- Conducting Workshops and training sessions for faculty members to familiarize them with and train them on using the blended learning strategy.
- Offering training courses for faculty members across all university disciplines, teaching them how to design activities that align with 21st-century skills in developing scientific thinking and self-efficacy.

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