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The Effectiveness of Educational Program Based on the 5Es Instructional Model in Developing Scientific Sense among Tenth-Grade Female Students in Physics in Jordan

فاعلية برنامج تعليمي قائم على نموذج التدريس (Es5) في تنمية الحس العلمي لدى طالبات الصف العاشر في مادة الفيزياء في الأردن

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Abstract:
Objectives: This study aims to evaluate the effectiveness of an educational program based on the 5Es instructional model in developing scientific sense among tenth-grade female students in physics in Jordan.
Methods: The study employed a quasi-experimental design with a purposive sample of 52 tenth-grade female students from the Directorate of Education in Al-Karak, Jordan. The students were randomly assigned to two groups: a control group (26 students taught using the traditional method) and an experimental group (26 students taught using the instructional program). A scientific sense test was developed, consisting of 25 multiple-choice items covering the following domains: recalling experiences and connecting them to the present, numerical sense, activating multiple senses, and metacognition (thinking about thinking). The validity and reliability of the test were confirmed through expert review and statistical analysis.
Results: The results indicate statistically significant differences in the dimensional measurement of the Scientific Sense Test in favor of the experimental group. The effect size at the total level was (0.901), indicating strong program impact.
Conclusions: The study recommends developing effective physics educational programs derived from constructivist-based models and strategies to achieve the intended scientific and practical objectives at various educational levels.
Keywords: *Educational Program; 5Es Instructional Model; Scientific Sense; Physics Subject.*

الملخص:
الأهداف: هدفت الدّراسة الوقوف على فاعلية برنامج تعليمي يستند إلى نموذج دورة التّعلم الخماسيّة في اكتساب الحس العلمي لدى طالبات الصّف العاشر في الفيزياء في الأردن.
المنهجية: استخدمت الدّراسة المنهج شبه التّجريبي لعينة قصدية تكونت من (52) طالبة من طالبات الصف العاشر في مديرية التربية والتعليم بمنطقة الكرك تم تعيينها عشوائيًا في شعبتين، وعلى مجموعتي الدراسة (ضابطة تكونت من (26) طالبة دُرست بالطريقة الاعتيادية، وتجريبية تكونت من 26) طالبة دُرست باستخدام البرنامج التعليمي)، وتم إعداد اختبار الحس العلمي وتكون من (25) فقرة من نوع الاختيار من متعدد غطى الأبعاد الآتية (استدعاء الخبرات وربطها بالحاضر، والحس العددي، وتفعيل غالبية الحواس، والتفكير في التفكير) وقد جرى التأكد من صدقه وثباته.
النتائج: أظهرت النتائج وجود فروق ذات دلالة إحصائية في القياس البعدي لاختبار الحس العلمي لصالح أفراد المجموعة التجريبية. بلغ حجم الأثر المحسوب (0.901) مما يؤكد فاعلية البرنامج التعليمي.
الخلاصة: أوصت الدراسة بضرورة تطوير برامج تعليمية لمبحث الفيزياء لتكون فاعلة بحيث تستمد شكلها من النماذج والاستراتيجيات المستندة إلى النظرية البنائية لتحقق الأهداف العلمية والعملية المنشودة لمختلف المراحل الدراسية.
الكلمات المفتاحية: *برنامج تعليمي؛ دورة التعلم الخماسية؛ الحس العلمي؛ الفيزياء.*

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1 Introduction

Developing educational programs grounded in contemporary educational theories is essential for improving the quality of teaching and learning. These programs are not limited to content delivery; rather, they aim to foster students' abilities in thinking, inquiry, analysis, and creativity. To achieve such outcomes, it is important for teachers to enhance their competencies across all educational areas, aiming to elevate students' cognitive levels and shift away from rote memorization toward more advanced mental processes that promote deep understanding.

A successful educational process depends on well-planned teaching strategies, thoughtful assessment methods, and the effective use of instructional programs. At the heart of effective teaching is coherent planning, where each instructional activity is intentionally designed to align with broader learning goals. It is important for teachers to use these goals as guiding principles, applying structured steps and skills when planning their lessons (Dakhil & Amin, 2022).

Educational programs play an important role in facilitating the acquisition of thinking skills, which enhances deep understanding and information retention. They offer personalized learning experiences tailored to individual student needs, enabling them to progress according to their unique learning pace. Such programs promote self-directed learning and critical, independent thinking, thereby helping students cultivate scientific sense and develop positive attitudes toward science-leading to greater engagement, responsibility, and productivity.

Scientific sense emerges from the thinking skills individuals practice in their daily lives. It exists across all areas of life, yet its manifestation varies depending on how frequently and effectively an individual applies it. It also relies on one's mastery of previously acquired skills. For instance, scientific sense in medicine differs from that in engineering or scientific research. The emphasis on scientific sense has become one of the core objectives of science education, aiming to instill scientific attitudes, intellectual honesty, and respect for scientific achievements (Arifij & Suleiman, 2014). Global educational initiatives—such as Project 2061—have highlighted scientific sense as a foundational goal of science teaching. Therefore, this research aims to evaluate the effectiveness of an educational program based on the (5Es) Instructional Model in developing Scientific Sense among tenth grade female students in Physics in Jordan.

1.1 Research Problem

Physics is one of the scientific disciplines that is rapidly evolving in terms of tools and scientific value. It is concerned with studying a wide range of natural phenomena, including the universe, matter, energy, and their interactions, in addition to its practical applications.

Learning physics can sometimes involve facts and information that are difficult for some students to comprehend and internalize. Although there are various instructional methods that teachers can implement when teaching physics—such as the use of models or modern educational strategies aimed at fostering aspects of scientific sense (Qushta, 2018; Al-Salamat, 2018)—many physics teachers still rely on traditional teaching methods that emphasize rote memorization and direct instruction. These approaches often render students passive recipients of information that they neither understand nor are able to integrate into their cognitive structures or process meaningfully. This method has negatively impacted their academic achievement and limited their ability to develop scientific sense. Consequently, students' interest in physics has declined, especially since current educational practices often fail to provide learners with opportunities to actively engage in scientific activities themselves (Abu Shama, 2017; Putra et al., 2018).

The results of the evaluation of tenth-grade students in the Program for International Student Assessment (PISA), supervised by the Organization for Economic Co-operation and Development (OECD), indicated a weakness in acquiring thinking skills, applying scientific knowledge, and drawing evidence-based conclusions in the science domain in Jordan. The findings showed that tenth-grade students scored a low level (Level 2) out of six proficiency levels on the PISA science assessment (OECD, 2019).

In addition, the 2020/2021 academic year witnessed a significant development in school curricula, particularly in tenth-grade physics. The content was aligned to match the sequence of educational stages, and scientific equations were adopted in English to facilitate students' transition to university-level studies. Based on this, the current research problem emerges in the form of the following central question: ***What is the effectiveness of an educational program based on the 5Es learning cycle in developing scientific sense among tenth-grade female students in physics in the Karak region?***

1.2 Research Question

- What is the effectiveness of an educational program based on the 5Es learning cycle in developing scientific sense among tenth-grade female students in physics in the Karak region?

1.3 Research Objective

This study aimed to investigate the effectiveness of an educational program based on the 5Es learning cycle model in developing scientific sense among tenth-grade female students in physics in the Karak region.

1.4 Importance of the Research

Theoretical Importance:

This research addresses the 5Es learning cycle strategy, which is grounded in the assumptions of constructivism—through which students construct new knowledge by connecting it to their prior knowledge and through interaction with their peers.

Applied Importance:

By presenting this educational program, the study may draw the attention of teachers, curriculum planners, and educational supervisors to the importance of focusing on activities that highlight physical science concepts, take into account students' prior experiences, interests, and needs, and place students in situations where they become active producers of knowledge.

1.5 Research Delimitations and Limitations

- **Subjective delimitation:** This study was limited to examining the effectiveness of a comprehensive educational program based on the 5Es learning cycle model in developing scientific sense in tenth-grade physics. The program was designed around two units: *Motion* and *Force*
- **Temporal delimitation:** The study and its tools were applied during the first semester of the 2021/2022 academic year, according to the calendar issued by the Ministry of Education in Jordan.
- **Spatial delimitation:** The study was conducted at Noor Al-Hussein Secondary Comprehensive School for Girls, within the upper basic education stage, under the Directorate of Education in the Karak region.
- **Human delimitation:** The study was limited to tenth-grade female students at Noor Al-Hussein Secondary Comprehensive School for Girls in the Karak Directorate of Education.
- **Delimitations:** The generalizability of the study's findings is limited to populations similar to the study sample. Moreover, the results are bound by the statistical significance levels used in the analysis via the SPSS software.
- **Limitations:** The study sample was limited to a single public school, and the relatively small sample size (52 students) may limit the statistical power of the findings. Also, the study focused solely on female students.

1.6 Research Terminology

- **Educational Program:**

Theoretical Definition: "An educational programme is a coherent set or sequence of educational activities designed and organized to achieve pre-determined learning objectives or accomplish a specific set of educational tasks over a sustained period" (UNESCO Institute for Statistics, 2012, p. 83).
Operational Definition: A comprehensive and integrated educational content consisting of all practices, experiences, activities, and procedures that the students—specifically the study sample—interact with. The program is designed to develop scientific sense in tenth-grade physics, taking into account the learners' characteristics, and providing the necessary instructional materials, tools, and available resources within the learning environment. It aims to foster scientific sense and contribute to serving the local community during the designated program duration.

- **5Es Instructional Model:**

Theoretical Definition: Atiyah (2020) defined the 5Es learning cycle as a method of both learning and teaching, through which the learner can conduct inquiry-based activities that enable meaningful learning. It is characterized by its consideration of learners' abilities and its progression from parts to wholes, as understanding the part is cognitively easier than grasping the whole.

Operational Definition: A structured sequence of activities that the student engages in, designed to support and train her to use prior knowledge in constructing new understanding of a specific concept. The model consists of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation.

- **Scientific sense:**

Theoretical Definition: Mazen (2013) defined scientific sense as: "The ability to make judgments and choose appropriate methods to achieve goals based on causality in the shortest possible time, relying on awareness, understanding, and perception of the phenomenon toward which the learner develops sensibility."

Operational Definition: In this study, scientific sense refers to the score students achieve on a test covering four domains: recalling prior experiences, numerical sense, sensory engagement, and metacognitive skills.

2 Theoretical Framework and Previous Studies

2.1 Definition of Scientific sense

Scientific sense is a dynamic process in which ideas are developed, new evidence is presented, and theoretical concepts are refined, changing them in the sense of coordinating theory and evidence (Newman et al., 1993). For example, in the lesson, "Motion in Two Dimensions," the following question is posed: Does the horizontal component of the initial velocity change along the motion path, or does it remain constant? Follow-up questions such as "How do you know?" and a simple reformulation of the theory occur in response to a request for a second piece of evidence ("How can you confirm that?").

Asking such questions helps develop a scientific sense among students because it stimulates them to think and strive to provide evidence, and it connects theory with the provision of evidence. This is what we lack in our schools, which have turned learners into passive recipients who do not possess even the slightest thinking skills.

Scientific sense represents one of the highest intellectual activities naturally exercised by individuals. Its importance lies in helping learners recognize problems encountered in daily life, address them effectively, and make well-informed decisions faster (Mazen, 2013).

Constructivism has emphasized the development of scientific sense, viewing learning as a process in which learners build and derive meaning through sensory understanding or experience. Constructing meaningful knowledge is a demanding and time-consuming process that can be facilitated by effective teaching but is not solely a result of it. From a constructivist perspective, any activity that engages students in building knowledge is preferred and highly required (Zaytoun, 2007).

Effective teaching should begin with a sensory-engaging question or concept that is intriguing, enjoyable, and familiar to students. Each lesson should present a clear and tangible summary, grounded in real-life examples, and the learning process should harness students' curiosity and intelligence.

Costa and Kallick (2006), in their work Discovering and Exploring Habits of Mind, emphasize the importance of employing senses and enhancing individuals' sensory abilities in constructing knowledge. Knowledge fundamentally arises from sensory data, which the mind transforms into mental, cognitive, and advanced patterns. The challenge lies in creatively utilizing our sensory perceptions in the knowledge-building process, making this one of the essential habits and skills that a critical mind must acquire.

2.2 Dimensions of Scientific Sense

Literature (Abu Jado and Nofal, 2015; Abu Shama, 2017; Al-Afoun and Al-Saheb, 2012; Al-Osaimi, 2019) mentions various dimensions of scientific sense, which can be explained as follows:

First: The Cognitive Domain, which includes:

- **Recalling Experiences and Connecting Them to the Present:**

This refers to the ability to extract knowledge or experiences acquired from past learning and apply them to different life situations. The effectiveness of recalling and linking prior experiences to the present depends on how information is stored by the learner in terms of organizing and coding it. When a teacher employs a strategy to activate prior knowledge, the learner is then able to retrieve previously learned information in order to interpret or evaluate, based on the knowledge structures already constructed in their cognitive framework.

- **Numerical Sense:**

Numerical sense encompasses a set of ideas such as the meaning of numbers, methods of number representation, relationships between numbers, relative magnitude, and the skill of working with numbers. It involves a range of mathematical abilities that enable learners to comprehend and analyze numerical information with the aim of drawing logical conclusions and making informed decisions to solve problems.

Moreover, these skills include the ability to express ideas and situations using numbers and various forms of mathematical data.

- **Activating Most Senses:**

This refers to the deliberate and attentive use of sensory pathways to gather information and comprehend elements within the surrounding environment. Since all information enters the brain through sensory paths, it is essential for teachers to design learning activities that maximize opportunities for sensory engagement; the greater the number of senses involved in the learning process, the deeper and more effective the learning becomes.

- **Metacognition (Thinking about Thinking):**

This refers to an individual's awareness and understanding of mental activities, learning strategies, and self-regulation processes that occur before, during, and after learning. These processes support memory, comprehension, planning, management, and problem-solving. Metacognition involves a form of internal dialogue about the cognitive strategies used to address a problem, how they are implemented, and how their outcomes are evaluated. It enables students to learn from others, enhances their awareness of their own thought processes, and involves planning, monitoring, and evaluating skills that govern and refine cognitive functions with precision.

Second: The Affective Domain Includes:

- **Scientific Curiosity:** This refers to engaging in thinking driven by internal motivation and a desire to explore and inquire.
- **Scientific Alertness:** This refers to a high level of concentration and attentiveness.
- **Enjoyment of Scientific Work:** This involves a sense of satisfaction derived from solving problems, finding joy in tackling challenging questions, and taking pleasure in discovering solutions and keeping learning lifelong.
- **Perseverance:** Defined as commitment to a task, it entails maintaining focus and sustained effort until the task is completed, without giving up.
- **Impulse Control:** This refers to exercising caution when solving problems, thinking carefully before solving them, and formulating a clear action plan before beginning a task.

These affective dimensions of scientific sense are among the most prominent habits of mind that help shift learners from passive recipients to active participants. They foster intellectual creativity and engagement, enabling students to enter the broader world of thinking.

2.3 Acquiring Aspects of Scientific sense

Arthur Costa (2004), in his work Activating & Engaging Habits of Mind, identified a set of practices that teachers can employ to help create a learning environment conducive to the development of scientific sense among students. These practices include: giving students time to think, providing effective feedback, being open to their opinions, asking for clarification when needed, and showing empathy for their circumstances.

Such practices reflect the positive impact of an educational process that is rooted in establishing a rich and interactive learning environment—one in which learners engage all their senses to acquire knowledge and practice various thinking skills.

Abu Shama (2017) emphasizes the importance of guiding students to use their senses and engage their minds in a conscious and deliberate manner to perceive observed phenomena, reflect on their learning, and critically analyze the information presented to them. He underscores the importance of linking new information to prior knowledge in order to create meaningful learning contexts that enhance cognitive development. This highlights the functional role of information and real-life experiences, reinforcing the need to adopt instructional models that foster the practice of diverse thinking skills.

Similarly, Tekerci & Kandir (2017) argue that teaching science based on meaning-making and the use of all senses encourages learners to acquire knowledge and increases their cognitive awareness. Moreover, practical activities and experiments support the development of scientific thinking skills.

The researcher believes that emphasizing the development of scientific sense in learners contributes to the advancement of their knowledge, skills, and thinking abilities. It also encourages them to engage with real-life problems and strive to find solutions.

2.4 Constructivist Learning

According to Yager, the principle of constructivist learning is based on the idea that learners construct new knowledge by building upon their prior knowledge through mental processes and interaction with others.

Conceptual understanding emerges from the learner's sensory engagement with the environment and their ability to adapt to it. The primary role of knowledge, therefore, is to facilitate adaptation to the data and demands of the external world. As a result, constructing cognitive structures and schemas is a matter of coordinating knowledge with reality rather than simply mirroring or replicating it (Darb & Abbood, 2021).

Bell and Driver, as cited in (Reece & Walker, 2000), outlined several core assumptions of constructivist learning, as follows:

First, what a student currently believes—whether accurate or not—is important. Second, although learners may undergo the same learning experience, each individual constructs meaning in a unique, personal way based on their prior knowledge. Third, Understanding or constructing meaning is an active and ongoing process. Fourth, Learning often involves conceptual change. Fifth, when students encounter new concepts, they may not immediately accept them; instead, they might grant temporary acceptance or even reject them altogether. Finally, learning is not a passive process, but rather an active one that requires students to take responsibility for their own learning.

Constructivist learning takes place when the learner modifies existing ideas, reorganizes previously acquired knowledge, or adds new concepts and information. Learning is an ongoing and active process that involves the construction of new cognitive structures or the reconstruction of existing knowledge systems within the learner (Abu Zeina, 2011).

Among the key conditions for meaningful constructivist learning are reception, readiness, and active engagement. When teachers focus their students' attention on a specific problem and provide them with a framework, structure, or advance organizer, the conditions of reception and readiness are fulfilled. The condition of active engagement, on the other hand, is met through modeling inquiry processes, skillfully employing questioning techniques, and allowing students to take responsibility for their own learning (Borich, 2019).

2.5 Phases of the 5Es Learning Cycle

The 5Es learning cycle model consists of five sequential and interrelated phases that form the core structure of the model. These phases are outlined as described by Zaytoon (2007), Atiya (2020), and Quteit (2011), as follows:

- **Engagement Phase:**

This phase aims to stimulate students' interest, spark their curiosity, and draw their attention to the learning topic or concept. It typically begins with thought-provoking questions such as "Why did this happen?", "What do you already know?", or "What can I discover about this topic?"

- **Exploration Phase:**

This phase sparks students' curiosity by providing students with opportunities to engage in hands-on experiences and work collaboratively to grasp and make sense of the concept. During this stage, students are encouraged to think freely, investigate ideas, and formulate scientific hypotheses. The teacher's role is to support and guide the students with minimal direct instruction, observing their participation, listening actively, and ensuring that all students are involved in the exploratory process. The teacher may also pose challenging or open-ended questions to deepen inquiry and maintain engagement.

- **Explanation Phase:**

This phase focuses on clarifying and explaining the target concept and introducing terminology. During this stage, the learner takes an active role by consulting various sources of knowledge—such as discussion sessions and interacting with the teacher—to arrive at definitions and explanations related to the concept under investigation. The teacher's role is to encourage students to articulate their understanding, clarify concepts and terms, explain observations, and support their reasoning by asking them to provide evidence and justification.

- **Elaboration Phase:**

This phase encourages students to discover new applications of the concept, use terminology in various contexts, ask questions using these terms, and reach well-supported conclusions. The teacher's role is to guide students in applying and expanding concepts and skills in new situations, asking them to clarify evidence and asking them about what they already know.

- **Evaluation Phase:**

In this phase, continuous evaluation is carried out to assess the outcomes achieved and the extent to which learning objectives have been met. It also considers the availability and use of educational technologies, the organization of the learning environment, and students' abilities in research and inquiry. Furthermore, it examines how well students are able to construct and expand conceptual understanding and apply what they

have learned to real-life situations. This ongoing evaluation helps students internalize concepts and experiences, master essential skills, and broaden their overall understanding.
In light of the importance of students acquiring the dimensions of scientific sense and their continuous pursuit of understanding and exploration, this study seeks to examine the impact of designing an educational program based on the 5Es learning cycle on the development of scientific sense among tenth-grade female students in physics within the Directorate of Education in the Karak region.

2.6 Previous Studies

After reviewing a number of previous studies related to the current research topic, the researcher categorized them into two groups:
Studies that addressed the 5Es learning cycle model, and studies that examined the acquisition of scientific Sense.
The studies are presented in descending chronological order:

- **Studies on the 5Es Learning Cycle Model**

Al-Sowelmyeen (2020) conducted a study aimed at identifying the effectiveness of teaching using the 5Es learning strategy in developing thinking skills in science among eighth-grade students in Jordan. A thinking skills test consisting of 37 items was administered to a sample of 60 students, who were randomly divided into two groups of 30 students each. The experimental group was taught using the 5Es learning strategy, while the control group was taught using traditional methods. The results revealed statistically significant differences at the significance level ($\alpha = 0.05$) between the mean scores of the two groups in overall thinking skills and in each sub-skill, in favor of the experimental group. The study recommended the use of the 5Es learning cycle in science instruction and training teachers on how to apply it to foster thinking skills.

Al-Qawasmeh and Al-Qadri (2019) conducted a study to examine the impact of using a computerized version of the 5Es learning cycle strategy in developing scientific thinking skills among fourth-grade students in science at Islamic Scientific College Schools in the American SAT program in Jordan. The researchers used a quasi-experimental method with a sample of 48 students, divided into an experimental and a control group. The results showed that the performance of the experimental group exceeded that of the control group. No statistically significant differences were found due to the interaction between teaching strategy and gender (male or female). Based on these findings, the study recommended using computerized 5Es learning models in science instruction to develop scientific thinking skills among fourth-grade students.

Al-Shurab (2017) conducted a study to investigate the effect of teaching general science using the modified 5Es learning cycle strategy on the development of problem-solving ability and attitudes among female students in the basic education stage in Jordan. A quasi-experimental design was used, with both the control and experimental groups consisting of 40 eighth-grade female students from Mahis Secondary School. The results showed statistically significant differences between the mean scores of the two groups on the problem-solving test in favor of the experimental group. Significant differences were also found in students' responses on the attitude scale, again in favor of the experimental group. The study recommended that educational supervisors hold training workshops for teachers on the core elements of the 5Es learning strategy in science teaching.

Malik et al. (2017) conducted a study to examine the effect of applying the 5Es inquiry-based learning cycle model on academic achievement in the unit of fluid statics in physics. A quasi-experimental one-group design was employed with a purposive sample of 30 students from a secondary school in Indonesia. The cognitive domain was assessed using essay questions, the affective domain using a Likert-scale questionnaire, and the psychomotor domain through observation. The results indicated that the achievement rates for teachers and students were 91% and 87%, respectively—classified as "good." The improvement in students' cognitive achievement was 41% (moderate), affective achievement 76% (good), and psychomotor achievement 71% (also good). A t-test was used to compare the calculated t-value with the critical value ($t = 15.529 > 2.042$), confirming statistical significance. The study concluded that the 5Es inquiry-based learning model represents a promising alternative to enhance student achievement in the unit on fluid statics in physics.

- **Studies on Scientific sense**

Younis and Jardo (2021) conducted a study aimed at exploring the effect of the "Snowball Strategy" on scientific sense and future thinking among sixth-grade primary students in science. The researchers used a quasi-experimental design with a sample of 78 students from Al-Kufa Model School in Mosul, Iraq. After excluding students who had failed the previous year, the final sample consisted of 68 students—36 in Class A and 32 in Class B. Class A was assigned as the control group, while Class B served as the experimental group.

The results showed that the experimental group, which was taught using the snowball strategy, outperformed the control group, which was taught using traditional methods.

Hassanein et al. (2020) conducted a study to develop a proposed program based on constructivism for teaching science to enhance scientific sense among hearing-impaired students at the preparatory stage. To achieve this, the researchers designed the proposed program and a teacher's guide, in addition to preparing a scientific sense scale. The sample consisted of 31 first-year preparatory students from Al-Amal School for the Deaf and Hard of Hearing in Tahta. Statistical analysis was carried out using the t-test and Blake's equation. The study concluded that the constructivist-based program was effective in developing scientific sense and recommended the need to support hearing-impaired students through tailored educational programs.

Abu Hasel (2019) conducted a study to investigate the impact of the whole-brain teaching strategy in science instruction on academic achievement, the development of scientific sense, and certain habits of mind among first-grade intermediate students. The sample consisted of 29 students in the experimental group and 29 in the control group. The findings revealed statistically significant differences at the (0.005) level between the two groups in favor of the experimental group in the scientific sense test. The effect size was reported at 0.5, indicating a moderate effect of the whole-brain teaching strategy on overall scientific sense development.

Qushta (2018) carried out a study to examine the effect of using two augmented reality (AR) formats in developing scientific concepts and scientific sense in science among seventh-grade female students in Gaza. The researcher developed a test for the acquisition of scientific concepts and another for assessing the cognitive dimension of scientific sense. The study sample included 58 seventh-grade students from Dar Al-Arqam Secondary School, randomly assigned to an experimental group (29 students) taught using two AR formats, and a control group (29 students) taught using traditional methods. The results showed statistically significant differences in favor of the experimental group in both post-tests: one measuring the acquisition of scientific concepts and the other measuring cognitive scientific sense.

Al-Salamat (2018) aimed to investigate the effect of using the jigsaw strategy in teaching physics on the development of scientific sense and perceived self-efficacy among first-year secondary students. The study employed a quasi-experimental method with a sample of 58 students, randomly divided into experimental and control groups. The results revealed statistically significant differences at the (0.05) level between the mean scores of the two groups on the scientific sense and self-efficacy scales, in favor of the experimental group that was taught using the jigsaw strategy.

2.7 Commentary on the Reviewed Literature

The review of previous studies reveals the following:

First, the studies addressing the 5Es learning cycle model examined its impact on various educational outcomes such as problem-solving and attitudes (Al-Shurab, 2017), the application of the model to a specific unit in physics (Malik et al., 2017), the development of scientific thinking skills (Al-Qawasmeh & Al-Qadri, 2019), and the enhancement of thinking skills in science (Al-Sweilmien, 2020).

Second, the studies focusing on scientific sense explored different instructional strategies. Some investigated the effect of the snowball strategy on scientific sense and future thinking (Younes & Jirdu, 2021), while others aimed to develop a constructivist-based program to enhance scientific sense (Hassanein et al., 2020), examined the impact of the whole-brain teaching strategy on academic achievement, scientific sense, and certain habits of mind (Abu Hasel, 2019), assessed the use of two augmented reality approaches to improve scientific concepts and scientific sense (Qushta, 2018), or studied the effect of using the jigsaw strategy in teaching physics on the development of scientific sense and perceived self-efficacy (Al-Salamat, 2018).

Accordingly, most of the reviewed studies to the best of the researcher's knowledge examined the 5Es learning cycle model as an isolated instructional strategy, without investigating its relationship with scientific sense. Moreover, these studies generally approached the 5Es model simply as a strategy rather than as a full-fledged educational program.

Viewing the 5Es as a strategy involves using it as one of several teaching methods—for instance, flexibly incorporating its phases (Engage, Explore, Explain, Elaborate, and Evaluate) within lessons. In contrast, treating the 5Es as a program entails designing a comprehensive educational package centered around the 5Es, which includes detailed lesson plans, teacher training, instructional materials, assessments, and potentially a complete curriculum aligned with the model. In contrast, the present study distinguishes itself by conceptualizing the 5Es learning cycle model as an integrated instructional program within the context of physics teaching, aligning with the objectives of the teaching–learning process and targeting the achievement of the intended learning outcomes.The researcher also notes that, despite the diversity of studies addressing the 5Es model, few—within the limits of her knowledge—have applied the model within a complete instructional program grounded in constructivist theory and encompassing the five stages of the lesson: engagement, exploration, explanation, elaboration, and evaluation, in addition to incorporating modern teaching and assessment strategies.

3 Research Procedures

3.1 Research Methodology

A quasi-experimental approach was employed to investigate the effectiveness of an educational program based on the 5Es instructional model and to assess its impact on students' scientific sense among tenth-grade female students. To achieve this purpose, the researcher adopted a design involving two groups: an experimental group and a control group. The dependent variable in the study was the student's level of scientific sense, as measured by a researcher-developed test. The independent variable was the instructional method, where the educational program was implemented with the experimental group, while traditional methods with the same instructional units (Motion and Force) were taught to the control group using traditional teaching methods. The traditional methods included lecture-based instruction and textbook-centered teaching to ensure clarity and ease of replication.

3.2 Research Population and Sample

A purposive sample of one school was selected from Noor Al-Hussein Secondary School, affiliated with the Directorate of Education in the Karak region. This school was chosen due to the feasibility of conducting the study, including the availability of multiple class sections within the targeted grade level, and the school's administrative and technical support provided to the researcher. The school administration facilitated all necessary resources, including educational tools and access to the physics laboratory. Additionally, the physics teacher cooperated in implementing the study procedures. after which two intact classes were randomly assigned to experimental and control groups and consisted of 52 tenth-grade female students One of the sections was randomly assigned as the experimental group (n = 26), while the other section served as the control group (n = 26).

3.3 Research Tools

To achieve the objectives of this study and to answer its research question, the researcher developed two instruments:
Scientific Sense Test and an educational program based on the 5Es learning cycle model. And as follows:
First: Scientific Sense Test
To develop the scientific sense test, the following steps were taken:
a. Determining the purpose of the test (Scientific sense):
The test aimed to measure the level of scientific sense acquisition among tenth-grade female students in the subject of physics, specifically within the prescribed topics of the two instructional units: *Motion* and *Force*, from the first semester. The content of both units was analyzed, the relevant sub-concepts were identified, and a **table of specifications** was developed in alignment with the cognitive dimensions of scientific sense and their corresponding weightings. (See Table 1.)

Table 1: Specifications Table for the Scientific Literacy Test

Cognitive Dimension	Number of Questions	Question Numbers	Relative Weight
Recalling Experiences and Connecting Them to the Present	7	1-7	28%
Numerical sense	6	8-13	24%
Activating Most Senses	6	14-19	24%
Thinking About Thinking	6	20-25	24%
TOTAL	**25**		**100%**

b. Preliminary version of the test (Scientific sense):
The initial version of the test consisted of 25 multiple-choice items, with each item followed by four response options. The maximum possible score on the test was 25, and the minimum score was 0. The first page of the test included clear instructions directed to the students, explaining the purpose of the test and emphasizing the importance of carefully reading each question, answering all items, adhering to the allotted time, and responding directly on the question paper.

c. Validity of the test (Scientific sense):

To ensure the test's validity and its appropriateness for meeting the objectives of the current study, the initial draft was submitted to 15 panel members of specialists in curricula, teaching methods, and educational measurement and evaluation. The panel included 7 university professors, 2 educational supervisors, and 6 physics teachers for the tenth grade. They were asked to evaluate the test items in terms of content alignment, clarity of language, appropriateness of instructions, and to provide suggestions for additions, modifications, or deletions as necessary. An agreement criterion of 80% or higher was set for retaining an item, while items with less than 80% agreement were subject to modification or removal. Based on the experts' feedback, the test was revised accordingly. A total of six (6) questions—numbers (2), (3), (4), (5), (6), and (19)—were deleted. The wording of question (7) was modified, an illustrative figure was added to question (12), and the answer choices for questions (21) and (24) were revised. The researcher considers these revisions as evidence supporting the test's content validity and as a contributing factor to enhancing the reliability of its results.

d. Applying the Scientific Sense Test to the Pilot Sample

After incorporating the necessary modifications based on the feedback of the expert reviewers, the test was administered to a pilot sample of 30 tenth-grade female students from the study population but not part of the main sample. Through this pilot application, the duration of the Scientific sense Test was determined by calculating the total time taken by all students to complete the test and dividing it by the number of students. The appropriate time for completing the theoretical section of the test was estimated to be 40 minutes.

Internal Consistency Validity of the Scientific sense Test:

Item-dimension and Item-total Pearson correlation coefficients were calculated to examine how well each item correlated with the dimension and with the overall test score, which is one of the approaches for establishing construct validity. Pearson correlation coefficients were calculated for each item on the scale in relation to the total score. Table (2) presents the results.

Table 2: Correlation Coefficient of Each Item in the Scientific Sense Test with Dimensions and Correlation of Items with Total Score

Item Number	Correlation		Item Number	Correlation	
	Dimension	Total Score		Dimension	Total Score
1	0.758**	0.803**	14	0.473**	0.423*
2	0.830**	0.675**	15	0.473**	0.439*
3	0.636**	0.470**	16	0.824**	0.793**
4	0.758**	0.803**	17	0.734**	0.588**
5	0.522**	0.464**	18	0.709**	0.575**
6	0.706**	0.525**	19	0.770**	0.662**
7	0.830**	0.675**	20	0.874**	0.643**
8	0.702**	0.467**	21	0.632**	0.626**
9	0.621**	0.470**	22	0.529**	0.405*
10	0.742**	0.610**	23	0.744**	0.382*
11	0.797**	0.633**	24	0.751**	0.439*
12	0.411*	0.504**	25	0.921**	0.842**
13	0.620**	0.662**			

** Statistically significant at the 0.01 level ($\alpha < 0.01$).

*Statistically significant at the 0.05 level ($\alpha < 0.05$).

Table 2 shows that all correlation coefficients between each item of the scientific sense test and the overall test score were statistically significant at the ($\alpha < 0.01$) level in most cases. These results indicate that the test validly measures the construct it was designed to assess, which enhances confidence in its use for the purposes of the present study.

Reliability of the Scientific sense Test:

To verify the reliability of the test, it was administered to a pilot sample consisting of 30 tenth-grade female students from the study population but not included in the main sample. The sample was drawn from Zahoum Mixed Secondary School and Adir Mixed Secondary School. Using the Kuder-Richardson Formula 20 (KR-20), the reliability coefficient was calculated and found to be 0.86, indicating a relatively high degree of reliability and the test's suitability for application to the main sample. Table 3 presents these findings.

Table 3: Reliability Coefficients of the Scientific Sense Test

Dimension	Number of Items	Reliability Coefficient
Recalling Experiences and Connecting to the Present	7	0.81
Numerical Sense	6	0.80
Activating Most Senses	6	0.79
Thinking About Thinking (Metacognition)	6	0.87
Total	**25**	**0.86**

Table 3 shows that the reliability coefficients for each dimension of the scientific sense test ranged from 0.79 to 0.87, which are considered acceptable values that reflect good reliability, further supporting the test's appropriateness for use with the main study sample.

The difficulty index for each test item was calculated by determining the percentage of incorrect responses relative to the total responses per item. Since the test was of the multiple-choice objective type, each item was scored dichotomously (1 for a correct answer, 0 for an incorrect or unanswered item). The discrimination index was calculated by ranking students' total scores in descending order, then dividing them into upper (top 50%) and lower (bottom 50%) groups, since the pilot sample consisted of only 30 students. The discrimination index was computed using the following formula: **Discrimination Index = (Number of correct responses in the upper group – Number of correct responses in the lower group) ÷ Number of students in either group.** Table (4) presents the results of the analysis.

Table 4: Difficulty and Discrimination Indices for the Scientific Sense Test Items

Item	Difficulty Index	Discrimination Index	Item	Difficulty Index	Discrimination Index	Item	Difficulty Index	Discrimination Index
1	0.57	0.73	11	0.30	0.47	21	0.43	0.47
2	0.30	0.60	12	0.27	0.27	22	0.80	0.27
3	0.67	0.40	13	0.53	0.53	23	0.33	0.27
4	0.57	0.73	14	0.33	0.27	24	0.20	0.27
5	0.37	0.47	15	0.27	0.27	25	0.30	0.60
6	0.40	0.53	16	0.57	0.73			
7	0.30	0.60	17	0.43	0.60			
8	0.40	0.40	18	0.47	0.53			
9	0.67	0.40	19	0.53	0.53			
10	0.57	0.60	20	0.37	0.47			

Table 4 indicates that item difficulty indices ranged from 0.20 to 0.80, reflecting a broad gradient of difficulty levels across the test items. This is an indicator of good item quality and alignment with the test's intended purpose in the current study. The discrimination indices ranged from 0.27 to 0.73, all of which were positive values, indicating good discriminatory power. These indices further support the validity of the test, as a test item's ability to discriminate between high- and low-performing students is a strong indicator of its validity.
Based on the experts' feedback and the pilot application, the final version of the test was established. Each item was scored as follows: 1 point for a correct answer, and 0 points for an incorrect or unanswered question. Therefore, the maximum score on the test was 25, while the minimum score was 0.

Second: The Educational Program

The educational program was designed and implemented in coordination with the physics teacher during the instruction of the designated units to the experimental group. The program aims to enhance knowledge acquisition and promote self-construction of understanding within the learners' cognitive structures. It also seeks to encourage the application of knowledge through perception, comprehension, reasoning, and the improvement of students' thinking skills. The program is aligned with the content and learning objectives of the two selected physics units for the tenth grade (Motion and Force), in addition to the research objectives. It is designed to enable students to acquire scientific knowledge through personal experience and individual cognitive processing and organization, with a particular focus on physics concepts.

The instructional material was developed according to the 5Es learning cycle model and centered around the two selected units (*Motion* and *Force*). The teacher's guide included the following components:

- **Program Title:**

An Educational Program for Teaching the Units of Motion and Force Based on the 5Es Learning Cycle Model.

- **Program Objectives:**

objective to be related to developing an instructional program based on 5 Es instructional model.

- **Tools and Methods Used:**

The teacher makes use of instructional aids, materials, classroom activities, and worksheets necessary for the teaching and learning process.

3.6 Steps for Implementing the Educational Program

- **Classroom Environment:**

Learning is implemented through various activities and tasks either in the physics lab or the classroom, while ensuring a proper classroom environment in terms of ventilation, lighting, and furniture suitable for group work. Each group is provided with the required tools to carry out experiments, activities, and complete worksheets. Students are also guided through task instructions and self-assessment criteria. Additionally, collaboration is established with the computer science teacher to support the implementation of digital and technical activities, as well as with the school librarian to provide students with appropriate references for research and report writing.

- **Learning Resources and Materials Used:**

Human Resources: The physics teacher, students, laboratory assistant, computer science teacher, school librarian, school principal, subject supervisor, and educational counselor.

Material Resources: The official textbook, the teacher's guide tailored to the educational program, the physics lab and related tools, stationery, colored papers, environmental materials, computers, data show projector, school library, computer lab, and internet access.

- **Teaching Methods and Strategies:**

All instructional methods and teaching strategies that support the development of reflective thinking skills—integrated into the phases of the 5Es learning cycle—were applied. These include active learning, cooperative learning, brainstorming, critical thinking, and problem-solving.

- **Tools, Strategies, and Activities:**

Students used graphing notebooks, pencils, calculators, and lab tools for inquiry-based activities such as: balls, toy cars, measuring tapes, stopwatches, string, projectile launchers, smartphones, and more. Worksheets were also an essential part of the activities.

- **Assessment Tools:**

The program, built on the 5Es model, aims to enhance reflective thinking skills. Therefore, a variety of assessment methods and tools were employed, including:

KWL charts, Quizzes, Evaluation of communication and collaboration among group members, Performance-based task assessment, Presentation of results, Report writing, Portfolios, and Performance-based assessment.

3.7 Implementing the Phases of the 5Es Learning Cycle in the Classroom

The educational program based on the 5Es learning cycle model is implemented through five sequential and interrelated phases, as follows:

- **Engagement Phase:**

In this phase, aspects of the problem are presented, its components are identified, and any misconceptions are addressed. Students' curiosity and interest in the learning topic or concept are stimulated, and their prior knowledge is elicited. For example, in the lesson *Motion in One Dimension*, students are shown a picture and asked to reflect and generate questions such as "Why did this happen?", "What do I know?", and "What can I find out about this topic?"

Specifically, they are shown an image of billiard balls and asked to think: if a rolling ball slows down on a straight horizontal path, is its acceleration positive or negative? Students are encouraged to identify aspects of the problem and misconceptions, and record what they want to know in a **KWL chart**.

- **Exploration Phase:**

In this phase, students are encouraged to explore the content and derive logical relationships through observation and investigation. Curiosity is further stimulated by providing hands-on experiences and opportunities for collaboration, conceptual understanding, and hypothesis generation. For example, in the lesson on *Motion in One Dimension*, an inquiry-based question might be posed: *When is acceleration constant? Can kinematic equations be used if the car's speed changes irregularly?*

Students conduct a hands-on experiment to calculate acceleration. The teacher's role is to encourage student participation, facilitate collaboration with minimal intervention, and observe student interactions while posing thoughtful, guiding questions.

- **Explanation Phase:**

This phase focuses on providing explanations and solutions to the posed problem, as well as introducing and clarifying the target concept and related terminology. Students are expected to refer to knowledge sources, engage in group discussions, and interact with the teacher to construct accurate definitions and explanations. In the *Motion in One Dimension* lesson, students are asked whether kinematic equations can be used if a car's speed changes irregularly, and to provide evidence supporting the idea that these equations are not valid in that context. During this stage, the teacher facilitates the process by encouraging clarification, posing follow-up questions, and using various strategies such as poster sessions, raised-hand discussions and etc.

- **Elaboration Phase:**

In this phase, students explore new applications of the concept and relate it to other learned concepts. They are asked to use newly acquired terms in forming logical conclusions and real-world inferences. For example, students are encouraged to connect physics to everyday life by researching motion-measuring devices. They are asked to choose one such device, explain its principle of operation in their own words, and present it to the class. The teacher's role is to support students in applying and expanding the concepts and skills in new contexts, guiding them to justify their reasoning and ask informed questions.

- **Evaluation Phase:**

This phase focuses on continuous assessment of what has been achieved, the extent to which learning objectives have been met, the availability of technologies, the organization of the learning environment, and students' abilities in research, inquiry, conceptual construction, and application of knowledge to real-life situations. Ongoing evaluation supports the assimilation of concepts, mastery of skills, and deepening of understanding.

3.8 Validity of the Educational Program

To verify the validity of the instructional material, it was reviewed by a panel of specialists in the subject matter of the study using a set of established criteria for evaluating educational programs. The content was aligned with the two developed units based on the 5Es learning cycle model. The reviewers' feedback was taken into consideration, particularly regarding the refinement of certain linguistic formulations, and the teacher's guide was finalized accordingly.

3.9 Procedures for Conducting the Study

To implement the study and achieve its objectives, the following procedures were followed:

- Reviewing the theoretical literature relevant to the study, including books, periodicals, journals, and previous research addressing the study variables (the 5Es learning cycle model and physics concepts).
- Purposefully selecting a sample of tenth-grade female students from the study population.
- Randomly assigning the sample into two groups: an experimental group (n = 26) and a control group (n = 26).
- Selecting and analyzing the content of the two instructional units (*Motion* and *Force*) from the first semester of the tenth-grade physics curriculum.
- Developing the study instrument (Physics Concepts Acquisition Test) and verifying its validity and reliability indicators.
- Designing the educational program based on the 5Es learning cycle model.
- Verifying the validity of the educational program.
- Obtaining the necessary formal approvals from Mutah University and the Directorate of Education in the Karak region.
- Administering the pre-test (Physics Concepts Acquisition Test) to both the experimental and control groups, and collecting and recording the results.
- Beginning instruction for both groups during the first semester of the 2021/2022 academic year. The educational program was implemented with the experimental group, with two sessions per week in accordance with the official timetable for physics classes, in coordination with school administration and the physics teacher. The duration of the program was eight weeks.
- Implementing the instructional content for the experimental group using the educational program, while the control group received instruction on the same content using traditional methods. Both groups shared the same general learning objectives for the selected units.
- Administering the post-test (Physics Concepts Acquisition Test) to both the experimental and control groups.
- Entering and analyzing the collected data using the Statistical Package for the Social Sciences (SPSS) to determine the effectiveness of the educational program in developing students' acquisition of physics concepts.

3.10 Statistical Analysis

To answer the research question, descriptive and inferential statistical methods were applied using **SPSS version 16** as follows:

- Pearson correlation coefficient to verify the internal consistency validity of the Scientific Sense Test and calculate its reliability based on the pilot sample.
- **Kuder-Richardson Formula 20 (KR-20)** for measuring test reliability.
- Item difficulty and discrimination indices for the Physics Concepts Acquisition Test.
- Descriptive statistical measures to describe the performance levels of the control and experimental groups on the pre- and post-tests.
- **One-Way ANCOVA (Analysis of Covariance)** to examine the significance of differences between the groups' mean scores on the pre- and post-tests, while controlling for pre-test performance (as a covariate).
- **Eta-squared (η^2)** effect size indicator.

4 Results & Discussion

4.1 Results Related to the Research Question: *What is the effectiveness of an educational program based on the 5Es learning cycle in developing scientific sense among tenth-grade female students in physics in the Karak region?*

To answer this question, means and standard deviations were calculated for the performance of the two groups (control and experimental) on the Scientific sense Test in both the pre-test and post-test. Adjusted means were also calculated according to the group variable (control vs. experimental), as presented in Table 5.

Table 5: The Means and Standard Deviations of the Performance of the Control and Experimental Groups on the Pre- and Post-Scientific Sensibility Scale

Dimension	Group	Pre-Test Mean	Pre-Test SD	Post-Test Mean	Post-Test SD	Adjusted Mean	Std. Error
Recalling Experiences and Connecting with the Present	Control	2.54	1.30	2.88	0.766	2.886	0.153
	Experimental	2.57	1.13	5.65	0.797	5.652	0.153
Numerical Sense	Control	2.57	1.36	2.85	0.675	2.846	0.144
	Experimental	2.57	1.30	4.88	0.816	4.885	0.144
Activating Most Senses	Control	2.38	1.17	2.77	0.765	2.766	0.138
	Experimental	2.35	1.16	5.31	0.679	5.311	0.138
Thinking about Thinking	Control	2.19	1.52	3.15	0.834	3.154	0.152
	Experimental	2.19	1.52	5.00	0.693	5.000	0.152
Total	Control	9.69	3.37	11.65	1.696	11.654	0.308
	Experimental	9.69	3.27	20.85	1.461	20.846	0.308

The data in Table 5 indicate observable differences between the two groups in their performance on the pre- and post-tests of the Scientific sense Scale, both at the level of individual dimensions and the overall scale. Adjusted means also show notable differences. To test the statistical significance of these differences, a One-Way Analysis of Covariance (ANCOVA) was conducted to compare the groups' post-test scores while controlling for pre-test performance (used as a covariate). The results are shown in Table 6.

Table 6: One-Way ANCOVA Analysis for Pre/Post Differences in the Scientific Sense Scale

Dimension	Source	Sum of Squares	df	Mean Square	F Value	Sig.	Eta Squared
Recalling Experiences and Connecting with the Present	Group	99.415	1	99.415	162.818	0.000*	0.769
	error	29.919	49	0.611			
	Total	1078.00	52				
	Corrected total	130.231	51				
Numerical Sense	Group	54.019	1	54.019	100.246	0.000*	0.672
	error	26.404	49	0.539			
	Total	859.00	52				
	Corrected total	82.058	51				
Activating Most Senses	Group	84.176	1	84.176	170.461	0.000*	0.777
	Error	24.197	49	0.494			

	Total	958.000	52				
	Corrected total	109.923	51				
Thinking about Thinking	Group	44.308	1	44.308	74.194	0.000*	0.602
	error	29.262	49	0.597			
	Total	938.00	52				
	Corrected total	73.692	51				
Total	Group	1098.481	1	1098.481	445.162	0.000*	0.901
	Error	120.912	49	2.468			
	Total	14955.00	52				
	Corrected total	1223.750	51				

The data in Table 6 show that the F-values and their associated significance levels ($p = 0.000$) are less than the alpha level of 0.05, indicating statistically significant differences in the post-test scores of the Scientific sense Scale across all dimensions and the overall score, after controlling for pre-test performance. Referring to the adjusted means in Table 5, the differences favor the experimental group, indicating that the students in this group developed significantly higher levels of scientific sense compared to those in the control group.

According to Cohen's classification (Blant, 2015), these values represent large effect sizes, thus confirming the effectiveness of the 5Es-based educational program in developing scientific sense in physics among tenth-grade female students in the Karak Directorate of Education.

5 Conclusions

The findings of the study demonstrated the effectiveness of the educational program based on the 5Es learning cycle in developing scientific sense among tenth-grade female students. Statistical analyses of the pre- and post-test results on the Scientific Sense Scale, across both individual dimensions and the overall score, indicated significant differences in favor of the experimental group. This was further confirmed by the large effect size (0.901) according to Cohen's classification (Blant, 2015).

Based on the researcher's interpretation, the following factors may account for this result:

- The program contributed to creating an interactive and stimulating classroom environment for learning and teaching. Students engaged actively in instructional activities—whether by connecting prior knowledge to new content, conducting experiments, formulating explanations, expanding their understanding, or participating in evaluation processes.
- The nature of the 5Es model and its emphasis on hands-on activities played a key role in enhancing scientific sense among students. From a constructivist perspective, knowledge acquisition is an active and continuous process that involves restructuring one's cognitive framework. It extends beyond simply storing and retrieving information, emphasizing the activation of multiple senses during the learning experience.
- The program succeeded in achieving the goals of science education by fostering positive attitudes toward science and empowering learners to construct their own understanding. It also enhanced various dimensions of scientific sense, including recalling and applying prior knowledge, using numerical reasoning, engaging multiple senses, and developing metacognitive awareness.
- The program helped students improve their task processing, problem-solving abilities, scientific communication, thinking skills, and intellectual habits. It also promoted specialized scientific awareness and reasoning.
- The 5Es learning cycle enabled students to make informed judgments, select appropriate problem-solving strategies, and develop causal reasoning skills. It also enhanced their cognitive flexibility and mental performance toward achieving educational goals.

Accordingly, the current findings align with prior research (e.g., Al-Salamat, 2018; Qushta, 2018), which also highlighted the positive impact of active or constructivist instructional strategies on students' scientific understanding and attitudes toward science, (Abu Hasel ,2019), which found improvements in scientific sense through whole-brain teaching strategies, (Hassanein ,2020), which confirmed the effectiveness of a constructivist-based program, and (Younes and Jardu, 2021), which showed that the Snowball strategy was effective in developing scientific sense.

5.1 Recommendations and Suggestions

In light of the study's findings, the following recommendations are proposed:

- It is essential to develop effective educational programs for teaching physics that are grounded in constructivist-based models and strategies, in order to achieve the intended scientific and educational objectives across different educational levels.
- There is a need to adopt modern instructional approaches that integrate effective strategies —such as the 5Es learning cycle model —with teachers' active involvement and engagement in the classroom.
- Curriculum developers and instructional designers should be encouraged to incorporate the 5Es learning cycle model into educational materials, with a particular focus on its effectiveness in fostering student engagement and learning.
- Further research is recommended to apply similar programs to other age groups and student categories, as well as to develop additional effective and engaging instructional programs.

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