Port Said Journal of Educational Research (PSJER)
2023, VOL. 2, Issue no. 2, 29-78.
DOI: 10.21608/PSJER.2023.181389.1011

Utilizing Earth and Space Sciences in The Light of the Next Generation Science Standards (NGSS) for Improving Scientific and Engineering Practices among preparatory stage pupils

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Abstract
The current research aimed to use earth and space sciences in light of the next-generation science standards (NGSS) to improve scientific and engineering practices among middle school students. The research followed the quasi-experimental design, a pre-post one-group design for experimenting with the developed Earth-Universe Unit. The participants consisted of 30 female students. The materials for the research tools were a student's book, a teacher's guide, and a learner's activity booklet. The tool of the study was a scientific and engineering practices test. The results revealed that there is a statistically significant difference between the mean scores of the participants in the pre and post-administration of the scientific and engineering practices test at the level (0.05) in favor of the post-application. This means the effectiveness of the developed curriculum (Unit of the Earth and the Universe) in the light of NGSS in science for the first grade of middle school. The research also recommended the necessity of paying attention to the Next Generation Science Standards in developing science curricula in the preparatory stage, especially in the field of the universe and earth sciences.

Keywords
NGSS Standards, Science Curriculum, Scientific and Engineering Practices.

Introduction

The current era is witnessing technological and informational developments and rapid knowledge growth. Therefore, this requires the need to develop general education curricula including science curricula in various educational stages to keep pace with their counterparts in developed countries. Additionally, to prepare individuals to meet these developments, and contribute to the production of knowledge and its use in different scientific fields. Moreover, science curricula are currently witnessing many efforts to develop them because the problems of educational systems cannot be solved in isolation from the curricula. As they are considered an important indicator of the progress and prosperity of countries. Indeed, teaching science curricula is of great importance in the progress of societies, as it is the center of the life of societies, because it is necessary for understanding natural phenomena, solving problems, making decisions, and leading the world. As science curricula are not just presenting facts and concepts included in the academic content, but are concerned with refining the cognitive side and developing the ability to create and innovate.

Actually, the textbook is also considered the actual translation and the official document of the educational curricula and the most important educational source for the learner and the teacher because of its educational value (Al-Rubaiaan, 2017). Thus, it was necessary to choose its components carefully to achieve the educational goals hoped for from it in light of the many developments in the science curricula recently, however, there are still loud shouts and criticisms of these curricula, whether by specialists or non-specialists from among the Egyptian society. Therefore, this led to the emergence of the need to evaluate these curricula in light of the international quality standards that resulted from movements to reform science curricula in developed countries. As an attempt to reduce the gap between scientific and technological progress and science education and the most recent of these criteria is NGSS (Omar, 2017).

The NGSS is the result of several movements to reform science education in the United States of America, which began in 1983 AD with the issuance of the “Nation at Risk” report, as well as carrying out several projects to reform science STS Such as Science, Technology and Society (STS) approach, which focuses on teaching and learning science in the context of human experience or society. In addition to the entrance to Science, Technology, Society & Environment (STSE Science & Technology & Society & Environment), which adds the environment dimension to the entrance. This was followed by the "2061" project published by the American Association for the Advancement of Science (AAAS) in 1985 (Al-Subaie, 2018).

As an extension of previous reform movements, the Achieve Organization began in 2010 in collaboration with the American Association for the Advancement of Science (AAAS) and the National Science Teachers Association (NSTA) in setting the (NGSS). This was in response to concerns about the need for a scientifically literate workforce, increased interest in STEM innovations, and legacy science standards documents, as well as the need for citizens who can compete in the global economy, and participate freely in Democracy, making personal decisions, understanding current events, and making judgments based on scientific evidence. (Achieve Report, 2010). The main documents of the NGSS provide a new vision and a qualitative transfer in teaching and learning science and a radical departure from what is happening in most classrooms from a place where students learn about science to a place where students do science” (Housel, 2016).

The NGSS is new performance expectations (standards) for effective science education in the 21st century, which focus on engineering and technology, and include K 12 science content standards. It is intended as a "set of performance expectations that describe what students should know and be able to do in the fields of physical sciences, space and earth sciences, life sciences, technology and science applications, in each grade from kindergarten to twelfth grade." These standards are designed to improve science education for all learners and prepare them for college, careers, and citizenship (Hassanein, 2016).

The NGSS consists of three dimensions found in a framework for K-12 Science Education prepared by the National Research Council (NRC, 2013). These three dimensions are (a) scientific and engineering practices, (b) crosscutting concepts, and (c) core ideas. Practices describe the behaviors that scientists follow to engage in research and build models and theories about the natural world. The National Research Council used the term practices instead of the similar term skills to emphasize that engaging in scientific research requires not only skills, but also information related to these skills, and the aim of the practices is not only to know and understand the scientific and engineering content, but also to understand the methods used by scientists and engineers in research. Science teaching research has proven that the central ideas (content) and practices are important, but they are taught separately, as science and engineering always unite together in content and practice, because the combination between content and practice gives a context for learning. The teaching of content and practice separately results in memorization, but through integration between them, the emotional aspect associated with science begins in the learners, as it allows them to apply science in the contexts of their lives. So, it will show learners the relationship between science, technology, engineering, and mathematics (the four fields in STEM) in everyday life. Engagement in scientific practices helps students understand how scientific knowledge develops, while engagement in engineering practices helps them understand the work and methods of engineers (NSES, 2013; NRC, 2012, Hassanein, 2016).

Comprehensive concepts are the topics of science that provide an organizational scheme for concepts through which the fields of knowledge are linked together, and the relationships between different scientific concepts are shown and presented coherently and logically based on global scientific foundations. Cross-cutting concepts have applications in all areas of science. Likewise, it is a way of connecting different fields of science, helping students to explore interconnections and relationships across the four fields of science: physical sciences, life sciences, earth and space sciences, and engineering design.

As for the core ideas, they enable the learner to expand the study of these four fields of science and highlight the relationships between science, engineering, and technology. The core ideas should be central, and they must combine at least two of the following criteria (Hassanein, 2016):

- It has wide importance across multiple scientific and engineering disciplines, or it is a major concept around which several disciplines are organized.
- It has an explanatory power that can be used to explain many phenomena.
- Generative, providing an essential tool for understanding or researching more complex ideas and problem-solving.

Several studies were conducted on NGSS (Abdel-Al, 2021; Al-Toura, 2018; Al-Subaie, 2018; Omar, 2017; Al-Ahmad, 2017; Al-Baz, 2017; Al-Otaibi & Al-Jabr, 2017; Al-Abdalia, 2017; Saeed, 2011; Al-Zuwaid,2009; Al-Khoury, 2006) and these studies aimed at evaluating or developing science curricula, or suggesting general objectives for science education in the light of NGSS in the various educational stages.

In light of the foregoing, it is clear that the standards of science for the next generation differ from all the standards that preceded them, and the need for them has emerged. Since more than fifteen years have passed since that time there have been many advances in the fields of science and scientific education, as well as the economy based on innovation. They came in the form of expectations for the performance of female students, which are translated into three basic pillars: comprehensive concepts, core ideas, and science and engineering practices. Many studies - mentioned above - have been conducted on the development of science curricula in various Arab and foreign countries in the light of NGSS to develop comprehensive concepts, main (Core) ideas, and scientific and engineering practices in multiple educational stages. However, there is no study so far exposed to the development of the field of earth and space sciences in the light of NGSS in the Arab Republic of Egypt to develop scientific and engineering practices among middle school students, which is what the current research is concerned with.

Research problem

In light of the recommendations of Ghanem's study (2016), there is a need to develop Egyptian science curricula in light of global future trends by creating curricula in accordance with NGSS to encourage students to complete their studies of science at the university level. Moreover, the interest of organizations concerned with issues of teaching science to conduct their research in a way that reflects the real reality of the field using a set of indicators, the most important of which are: the results of international tests for science and mathematics, such as the TIMSS and PISA tests. Additionally, the results of the ability of secondary school graduates to pass the tests of science faculties to enroll in university education and the results of field research attributed this decline in the understanding of science and mathematics mainly to the fact that the National Science Education Standards (NSES) alone are no longer sufficient and able to teach science to prepare children of this generation into the third millennium (NSES, 2013; NRC, 2012).

There has been a need for science standards for the next generation to develop science curricula in the various educational stages, given that more than fifteen years have passed since the standards of scientific education. Since that time, there have been many advances in the fields of science and scientific education, as well as an economy based on innovation and knowledge, in addition to the lack of female students who enter science, technology, engineering, and mathematics (STEM) disciplines despite the need for them (NGSS Lead State, 2012; National Research Council, 2012). Moreover, based on recommendations of the study of Elgendy et al. (2022) which aimed to determine the availability of the NGSS in the field of earth and space sciences in science books for the preparatory stage, in Egypt. It has explained the need to develop the field of earth and space sciences for the development of scientific and engineering practices, as it came with the least dimensions involved. Hence, there is a need to develop fields that least represent the next-generation science standards in the field of Earth and Space Sciences.

Therefore, this study sought to answer the following question: *What is the effectiveness of a unit developed in the light of NGSS in earth and space sciences in science books in developing scientific and engineering practices among first-grade female pupils?*

Research Hypothesis

There is a statistically significant difference between the mean scores of the research sample students in the pre and post-administration of the scientific and engineering practices test in science at the level of $(0.05 \leq \alpha)$ in favor of the post-administration.

Research aims

1. Preparing a list of NGSS in the field of earth and space sciences for the preparatory stage.
2. Developing the unit "Earth and the Universe" from the field of Earth and Space Sciences in light of the NGSS to develop scientific and engineering practices among the research sample.
3. Investigating the effectiveness of teaching the unit "Earth and the Universe" in the field of Earth and Space Sciences in the light of the Next Generation Science Standards (NGSS)

for the development of scientific and engineering practices in science among female students of the first preparatory stage, the research sample.

Research Significance

The importance of the current research was as follows:

1. Developing the scientific and engineering practices of first-grade preparatory female students, which contributes to preparing them according to the latest international standards of science.
2. Helping first preparatory grade teachers to understand the extent to which the current science curriculum (the field of earth and space sciences) agrees with the scientific standards for the NGSS.
3. Providing teachers with a teacher's guide that explains how to teach science according to the NGSS of first-grade preparatory students.
4. Providing a list of the NGSS that must be available in the field of earth and space sciences in the science curriculum in the first year of middle school. As it helps researchers to build other units accordingly, and investigate their impact on the development of other variables related to science standards.
5. Preparing learners in accordance with international standards. As it provides graduates who can deal with technological innovations, who also think in a sound scientific way, and preparing in schools and universities to match the requirements of the labor market.

Definition of terms

Curriculum Development

It is the process of redesigning the curriculum by introducing a set of innovations and innovations on all elements and components of the curriculum (first-grade science curriculum) to reform the curriculum in accordance with the NGSS and improve the educational process and raise its level to achieve the desired educational goals.

Next Generation Science Standards (NGSS):

A set of global performance expectations that determine what learners (first –grade preparatory schoolgirls) should know and be able to perform in various fields of science. These standards have been set to improve science curricula (first-grade preparatory science curriculum) to prepare a new generation qualified for the labor market and its professional requirements.

Scientific and Engineering Practices

It is about the mental and performance practices that female students must be able to use, to link the field of earth and space sciences in their real lives, to make them able to provide innovative solutions to real-world problems in the future by engaging in the practice of scientific investigation and engineering design among first-grade middle school students in science, and it can be measured through a test prepared for this purpose.

Literature Review

Scientific and Engineering Practices (SEP)

There is a close relationship between next-generation science standards and scientific and engineering practices. It is one of the basic dimensions of NGSS. It is not a teaching strategy, but rather an outcome of learning. Its importance is due to the fact that it focuses on the integration of scientific knowledge and its applications in engineering designs.

The nature of SEP

Scientific practices differ from engineering practices, where scientific practices refer to those practices that scientists follow in building theories and models around the world, while engineering practices refer to those practices that engineers practice in building and designing systems, and describe the practices of scientists while engaging in research and building models and theories around the world. The term practices was used instead of the term skills by the National Research Council; To emphasize that scientific research requires not only a set of skills, but also information or knowledge related to those practices, as the main goal of the practices is not only to know and understand the scientific and engineering content, but also to understand the methods used by scientists and engineers during the research process (Hassanein, 2016).

Scientific and engineering practices are of great importance in light of scientific and technological developments, and the increase in the need for scientific knowledge. Hence, the design of the educational system must prepare students to develop not only engineering literacy, but also scientific literacy, and therefore the use of teaching methods that focus on designs Engineering and scientific is the cornerstone of scientific and engineering literacy, which helps students to make decisions about their scientific and professional lives and solve problems that they face in their real life. Participation in these practices develops students' curiosity, arouses their interests, and urges them to continue their studies, and also makes students' knowledge clearer, and affects their view of the world in which they live In addition, knowledge of science and engineering may help students to address many of the challenges they face in our society today, such as prevention of widespread and epidemic diseases, preservation of sources of fresh water and food. (National Research Council, 2012).

Engineering requires students to display their knowledge and present it in a valuable and meaningful way, as well as to engage in practices; to develop creativity, critical thinking, and collaborative work with peers to reach the final design. Engineering design also provides meaningful and engaging ways to put scientific principles and practices into practice and gain scientific knowledge as students engage in prototyping, testing the success or failure of models, and making connections between what they observe and how they diagnose problems through troubleshooting (Crismond & Peterie, 2017).

The importance of engaging in scientific and engineering practices is evident in helping students to work actively and effectively in three directions of activities (Hassanein, 2016):

- The first: investigation and empirical inquiry, which includes asking questions, observation, experimentation, data collection, and measuring test results.
- The second: constructing interpretations or designs using models, theories, and creative thinking, which includes imagining models and theories, interpreting them, and predicting the formation of hypotheses and solutions.
- The third: analyzing, discussing, evaluating, and criticizing ideas such as the fit of models and explanations to evidence or the appropriateness of product designs.

Scientific and engineering practices have been identified in eight basic practices necessary for student learning. The following is an explanation for each of these practices:

First practice: Asking Questions and Defining Problems

Asking questions is a skill that students must be able to use at any level of study, whether it is between students and each other or between students and teachers about the phenomenon they observe or study, as well as about the conclusions or interpretations they draw from the models and experiments they perform. As for geometry, students practice asking questions to determine the problem for which constraints and specifications should be reached

(National Research Council, 2012). The skill of asking questions is necessary for the development of scientific habits of the mind, and an important element in scientific enlightenment, which makes students not only consumers of knowledge but also producers of it. Science always begins by asking questions about the studied phenomenon, while engineering often begins with defining a problem to be solved or asking questions to define a problem, such as: What is the benefit behind this problem? What are the challenges that face this problem and impede its solution? Often, other questions come to the student's mind when generating possible solutions: can two or more ideas be combined to produce the best and most appropriate solution? Can possible solutions be tested? What evidence is needed? To determine the best solutions? Science and engineering learning should therefore develop not only the ability of students to ask questions but also prompt them to ask more well-formulated questions that can be studied. (National Research Council, 2012; NGSS Lead States, 2013a).

The second practice: Developing and using Models

The study of science and engineering is based on the construction and use of models as useful tools for representing ideas and interpretations. Examples of these tools include drawings, diagrams, mathematical representations, analogies, and computer simulations, building diagrams or physical models to clarify relationships between phenomena or clarify a vital process (LaDue et al., 2015).

Models are used in science to represent a system under study, help students ask and develop questions and interpretations, and generate the information necessary for making predictions and continuous communication of ideas between students. It also helps students evaluate models by comparing their expectations with the real world, and then modifying them to gain an accurate insight into the phenomenon being studied. Conceptual models are an external expression of the mental models that scientists have. The better the mental models, the more they lead to a deeper understanding of science and the promotion of scientific thinking. (National Research Council, 2012; NGSS Lead States, 2013).

Third Practice: Planning and Carrying out Investigations

Scientific and engineering investigations that can be conducted to describe a phenomenon, or to test a theory of how scientists work to help students know how to repair and develop the performance of the technological system, as well as compare the different solutions that have been reached to find out the best solution to the problem. It is also important for students to be aware of the purpose of the investigation, to predict the results and then provide evidence to support their conclusions and to use logic, ideas, and scientific theories to give a reason for considering the data as evidence. In laboratory experiments, students are expected to determine which variables should be treated as inputs, and which variables should be treated as outcomes or outputs, and to control or maintain these variables across various experiments. In the case of field observations, planning includes determining how to collect various samples of data under different conditions, even if not all conditions are under the full control of the verifier. (NGSS Lead States, 2013a)

Fourth practice: Analyzing and Interpreting data

Data analysis and interpretation are used to detect patterns that indicate relationships. It includes data analysis and representation in tables, graphs, maps, and charts. Where data representation contributes to identifying linear and non-linear relationships and understanding temporal and spatial relationships between variables easily (LaDue et al., 2015). It is also expected that students, after their progress from one class to another, will be able to employ a larger set of tools for tabulating data, in addition to improving their abilities to interpret data, use mathematics to represent relationships between variables, and reduce sources of error if possible data as supportive evidence for their conclusions (NGSS Lead States, 2013a).

Fifth Practice: Using Mathematics and Computational Thinking

Although there are many questions about how to apply mathematics and computational thinking in science and engineering, mathematics combines science and engineering by helping engineers apply the mathematical form of scientific theories and enabling scientists to use information technologies designed by engineers. For scientists and engineers to perform investigations and build complex models. Pupils can use mathematics to represent physical variables and make quantitative predictions and use computer-related laboratory tools to observe, measure, and manipulate big data to identify meaningful patterns. Students are also expected to participate in computational thinking and its strategies for organizing data, developing and using it, or simulation models of natural systems. From the above, it can be concluded that mathematics is an essential tool for understanding science, so the NGSS standards focus on including basic skills of mathematics in the classroom, in addition to promoting the education of all sciences using good mathematical and computational thinking. (NGSS Lead States, 2013, b).

Sixth Practice: Constructing Explanation and Designing Solutions

Science aims to build theories about the world in which we live, as well as build explanations about phenomena. The theory is considered acceptable when it has many empirical evidence and logical explanations derived from previous theories. The explanation includes explaining how one variable relates to another variable and the effect of each variable on the other. Explanations are provided in response to a question, and scientists often use interpretations and investigations to construct data. As for engineering, it aims at design rather than interpretation, so the activities of engineers include elements that differ from those used by scientists, and these elements include the constraints and specifications necessary to reach a solution, develop models and test them, and improve design ideas in light of the prototype. (NGSS Lead States, 2013b).

Seventh practice: Engaging in argument from evidence

In the study of science and engineering, there should be opportunities to provide the necessary evidence and proof to explain a phenomenon, defend a new idea, or support a hypothesis that is likely to be a solution to a problem (phenomenon). Therefore, students should discuss the explanations that have been built, defend these statements with arguments and evidence, and participate in scientific discussions and debates; Arguments are discussions in order to reach agreements about the explanations and solutions they propose, so arguments and arguments based on evidence are among the most appropriate procedures that students use to explain a phenomenon or reach a solution to a problem, as well as understanding the culture and thought in which scientists live. (NGSS Lead States, 2013a).

Eighth Practice: Obtaining, Evaluating, and Communicating Information

This practice is essential in science and engineering, including reading, interpreting, and producing a scientific and technical text, and presenting reports of scientific applications or technological developments to identify basic ideas and identify sources of errors, distinguish observations from inferences, and evidence from interpretations. In order to obtain reliable information to evaluate the merit and validity of designs, scientists and engineers use multiple sources to obtain information. There are many ways to communicate information and ideas such as: using tables, schematics, graphs, model models, and equations, as well as writing and oral through productive discussions (NGSS Lead States, 2013b).

The previous studies that examined scientific and engineering practices

The study by Rowland (2014) aimed to determine the impact of students’ involvement in some scientific practices included in the NGSS standards, including the use and development of models and the use of mathematical thinking, students' understanding of biological concepts, and increasing their motivation. It has been shown that students' involvement in scientific practices increased students' understanding and motivation. AL-Baz (2017) aimed to develop the chemistry curriculum for the first secondary grade in the light of the field of engineering design presented by the NGSS standards and measure its impact on the development of scientific and engineering achievement and practices that should be developed among first-grade secondary students through teaching chemistry. Its results have explained that involvement in activities based on NGSS helped the participants gain scientific and engineering practices. Moreover, the study by Ali (2020), aimed to identify the effectiveness of using recreational activities in developing scientific and engineering concepts and practices for the standards of the next generation in science for people with special needs at the primary stage, and the results showed that all the skills of the NGSS standards were available to a moderate degree in the content of the science curriculum, and also The existence of a strong correlation between scientific concepts and scientific and engineering practices as a result of the use of recreational activities.

Other studies dealt with the importance of scientific and engineering practices for teachers, including the Kawasaki's study (2015), which aimed to examine teachers' goals and classroom instructions on scientific and engineering practices in the standards (NGSS). The study recommended the professional development of teachers to improve their understanding and objectives and training for a deeper understanding of the standards. The study by Haag and McGowan (2015) examined the degree of motivation of teachers to adopt scientific and engineering practices from the standards (NGSS) and their willingness to implement these practices in their classrooms. The study revealed that the degree of motivation among secondary school teachers to use scientific practices and engineering was higher than that of middle school teachers, and science teachers at the secondary stage are more willing to implement these practices than middle school teachers and that some obstacles impede the implementation of (NGSS) standards, including lack of teacher training, professional development, limited teaching time, and the lack of resources.

In addition, Ahmed (2018) investigated the effectiveness of a training program for science teachers based on NGSS standards in developing scientific and engineering practices and their self-efficacy in Jordan. As the study by Bin Qasim (2019) aimed to determine the level of possession of science teachers at the secondary level in the Kingdom of Saudi Arabia for scientific and engineering practices in the light of the next generation of science standards. What have been mastered to a lesser extent by science educators are: planning and carrying out investigations, developing and using models, constructing explanations and designing solutions, engaging in arguments from evidence, and using mathematics and computational reasoning. The study by Afifi (2019) aimed to build a proposed training program for science teachers in Egypt based on science standards for the next generation to develop their ability to use science and engineering practices (SEPs) while teaching science. The results of the research showed that science teachers use science and engineering practices with a degree of " Medium", and their use of some practices was "low" in light of their self-report.

Based on the foregoing, it is clear that the female students' mastery of the eight practices mentioned above facilitates their discovery of the world around them in all its details. In order to qualify them to confront it and solve its problems, and also that there is a great need to train science teachers to use science and engineering practices. The researchers benefited from these dimensions in how to prepare the test of scientific and engineering practices, as well as the design of preliminary, investigative, and applied activities included in the students' activity booklet.

Research procedures

In this part, the steps followed by the researchers in developing the earth and the universe unit in the first –grade of middle school were addressed in the light of the Next Generation Science Standards (NGSS), to answer the research questions and verify the validity of its hypotheses. The following is a detailed presentation of these procedures:

Procedures for developing the "Earth and Universe" unit

First: Determining the percentage of availability of scientific and engineering practices in the field of earth and space sciences.

To determine the extent to which the field of earth and space sciences includes these practices, reference was made to previous studies. As a result, Figure (1) shows the results of the study of Elgendy et al. (2022) which aimed to determine the percentage of availability of NGSS in the middle school science textbooks as a whole.

Figure 1

Percentage of availability of the three dimensions of NGSS (core ideas, scientific and engineering practices, and comprehensive concepts) for the field of earth and space sciences in the preparatory school science textbooks.

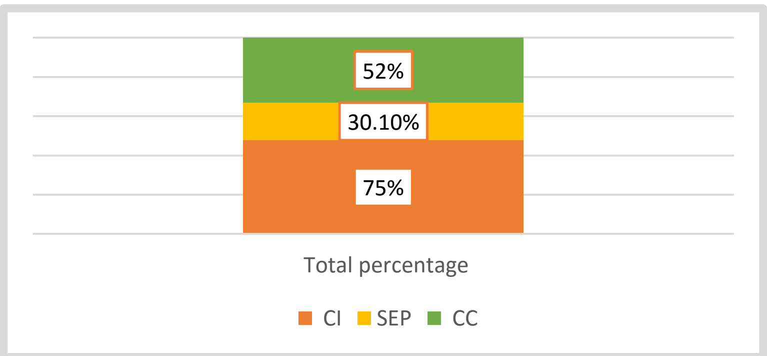
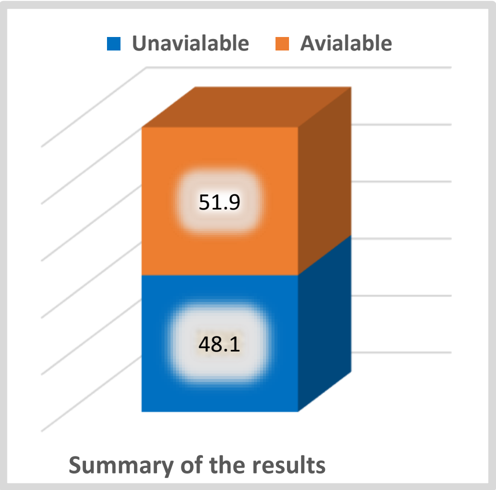


Figure (1): shows that the availability of core ideas in the field of earth and space sciences in preparatory school science books amounted to 75% of the number of indicators that must be available, and thus it is in the first place, and comprehensive concepts came in the second place with 52% of the indicators that must be available. In third and last place, scientific and engineering practices, with a rate of 30.1%, which is a weak percentage. The following graph shows the percentage of availability of science standards for the next generation in the field of earth and space sciences in the science books of the preparatory stage.

Figure 2

Graphic representation of the percentage of availability and non-availability of NGSS in the field of earth and space sciences in science books for the preparatory stage.



According to the above, there has become a necessary need to develop the field of earth and space sciences in middle school science books, given that the inclusion of science standards for the next generation is generally average, and the extreme weakness of scientific and engineering practices in the curriculum as a whole in its four dimensions (goals, content, activities, and evaluation methods).

Second: Preparing the earth and universe unit developed in the first year of middle school (the student's book) in the field of earth and space sciences in the light of NGSS.

1. Determine the foundations for building the developed unit

The developed unit was built in light of the model designed by Krajcik et al. (2014), which is based on (15) pillars. Considering the following:

- Commitment to the subjects of the field of earth and space sciences in the current science curriculum in the preparatory stage, with the inclusion of all its elements (goals, content, activities, evaluation) with the dimensions of science standards for the next generation identified in the current research.
- Diversifying teaching methods that take into account individual differences among students and encourage them to interact positively to achieve the goals of the developed curriculum.
- Taking into account the characteristics of students in the preparatory stage and the individual differences between them.
- The possibility of implementing the developed curriculum in terms of the required time, educational activities, and material and human capabilities.
- Taking into account sufficient flexibility when preparing the developed curriculum. So, the necessary modifications can be made to keep pace with the continuous developments and changes in the surrounding society.

2. Developing the field of earth and space sciences in the science curriculum for the first year of middle school in the light of NGSS

The general objectives of the developed unit of the field of earth and space sciences were derived from the developed science curriculum for the first year of middle school in the light of the following:

- Next Generation Science Standards List.
- The nature of the field of earth and space sciences in the science curriculum for the first year of middle school, and how to use it to develop scientific and engineering practices in science.
- Previous Arabic and foreign literature and studies.
- The general framework of the developed science unit.
- Reconstructing the "Earth and the Universe" unit from the science curriculum for the first year of middle school in the light of NGSS including innovations and investigative activities, and taking into account the development of scientific and engineering practices, according to what is permitted by the nature of the developed unit's topics. The following has been taken into account:
- What the result of the analysis of the field of earth and space sciences showed in the science curriculum in the preparatory stage is the weakness in its handling of science standards for the next generation.
- The nature of science in general, including the important topics it contains related to students and the environment in which they live.
- The importance of the science curriculum in preparing future scientists by instilling in students a love for science, and learning about its latest exciting developments.
- The challenges and transformations facing the contemporary global community, the most important of which are the scientific revolution and technological innovations.

3. Determine the strategies and teaching methods for the developed unit

Diversity has been taken into account in active learning strategies to teach the content of the field of earth and space sciences in science curricula so that the main objective of conducting the research is achieved. Diversity has been made according to the objectives and nature of the content of the unit including the topics it includes, as well as depending on the available capabilities. Among the proposed teaching strategies and methods are the following:

- Integration of the five steps of the learning and investigation cycle, which are: the preliminary stage, the investigation stage, the interpretation stage, the integration stage between engineering, science and technology, the application stage, and the evaluation stage.
- In addition to a set of various teaching strategies: cooperative learning, dialogue and discussion, experimentation, practical presentation, self-questioning, problem-solving, and concept mapping.

4. Determine the technological means and educational activities necessary to teach the developed curriculum:

When determining educational activities, the following must be taken into account:

- A variety of educational aids, including models, samples, models, paintings, educational films, educational CDs, and education using the Internet.
- Educational activities include classroom and extra-curricular activities, whether individual or group.
- Designing scientific activities that allow students to practice the greatest amount of scientific and engineering practices.
- Designing some investigative activities to ensure the accuracy of the conclusions reached by students with the teacher.
- Designing different shapes and models and drawing diagrams for the content of the developed curriculum topics.
- Designing topics for the content of the developed curriculum, using the World Wide Web.

5. Determine the methods of evaluating the developed curriculum:

In this research, the researchers used some tools to assess the extent to which the objectives of the developed curriculum were achieved, such as lesson evaluation questions. An examination of scientific and engineering practices in science.

6. The field of earth and space sciences developed in the science curriculum in the classroom in light of the list of NGSS

After reviewing the books of the science course for the first, second, and third grades of preparatory school, the third unit of the science course for the first grade of preparatory school was chosen, “The Unity of the Earth and the Universe,” the second semester, to develop it in the light of science standards for the next generation, and to prepare the student’s book, the student’s activity brochure, and the teacher’s guide for experimentation Measuring its effectiveness in developing scientific and engineering practices.

7. Determining the relative weight of the unit (Earth and Space) and justifications for its selection:

The "Earth and the Universe" unit represents a third of the science curriculum prescribed for the second semester of the first year of middle school students, as the number of classes prescribed for it reached (10) periods, and it was chosen for the following reasons:

- The results of the analysis which has proved the poor representation for NGSS in the field of earth and space sciences in the science curricula at the preparatory stage. (Elgendy et al., 2022).
- The unit includes topics that can be included in NGSS, commensurate with the research objectives.

- It has scientific applications in the daily lives of students, due to its connection to the environment, as well as its interesting topics, and helps them explain many cosmic phenomena that occur around them.
- It contains many topics that raise many questions and curiosity among students, which encourages them to carefully observe cosmic phenomena, as well as helps them develop many scientific and engineering practices.
- It contains many activities and applications, which provide an opportunity for the possibility of developing teamwork and the ability to think investigative.
- The necessity of teaching it to students to provide them with concepts and information related to the planet Earth, and its inclusion in the geological phenomena that occur around us in nature, which answer most of the questions that revolve in their minds about these phenomena and geological processes associated with them, that is, the topics of this unit work to provide students with concepts and geological information in a functional way which makes it more important to them.

The materials and tools used in the experimental study

The following is a detailed presentation of each procedure, as follows:

1. *Preparing the student's book on the unity of the earth and the universe for first-grade middle school students:*

A book has been prepared for the student in the "Earth and the Universe" unit of the science curriculum for the first year of middle school, which was developed in the light of the Next Generation Science Standards (NGSS). To continuously learn, research, and rely on evidence in explaining similar phenomena, developing their scientific and engineering practices, and identifying their direction toward the developed unit. The following table (1) shows the lessons included in the unit.

Table 1

The lessons included in the upgraded unit.

The lessons	Periods
Celestial bodies	3
Planet Earth	3
Rocks and minerals	3
Total	9

The process of preparing the student's book for the earth and the universe unit went through the following steps:

- Determine the general objectives of the unit to be developed: in the light of performance expectations, Next Generation Science Standards (NGSS), and the main topics of the Earth and Space Unit; the general objectives of the unit to be developed have been formulated.
- Formulating the content of the student's book (experimental unit): The content of the "Earth and the Universe" unit was developed and reformulated in light of the dimensions of the Next Generation Science Standards (NGSS), taking into account the following:
    - The unit lessons seek to help the student build his knowledge of himself by searching for information from various sources of knowledge, and in cooperation with his colleagues in the implementation of scientific and engineering practices.
    - Refer to many different sources related to the main topics in the textbook to enrich the content.

- Arouse the attention and thinking of the student, by including the questions in the content.
- The content of the unit topics includes introductory and investigative activities that help the student to understand the main ideas in each topic, which leads to deepening understanding.
- Directing students to carry out investigative activities that contribute to the development of their scientific and engineering practices, such as participating in the survey, analyzing and interpreting data, using models, participating in discussions based on evidence, and identifying problems.
- Selecting a number of geological innovations that suit the topics of the unit, and are in line with the requirements of the era of the scientific revolution, and include them in the content.
- Enriching the content with pictures and illustrations of concepts, conceptual diagrams, and comparisons between different concepts to deepen and confirm the knowledge.
- Linking the topics mentioned in the student's book with the activities mentioned in the activity brochure.
- At the end of each lesson, a number of questions were set as a final evaluation to ensure that each student understood the lesson.

- Academic control of the student's book: after completing the preparation of the student's book in its initial form; It was presented to a group of arbitrators from professors specialized in the field of curricula and methods of teaching science in the faculties of education, to add or delete what they see fit and to make any observations about the extent of:

- Presentation of the scientific material in light of the Next Generation Science Standards (NGSS).
- Relevance of content to general objectives and formulation in an appropriate manner.
- Adaptation of educational activities to the content of lessons.
- Suitability of evaluation questions to objectives and content.
- Contribution of activities to the development of scientific and engineering practices.
- The safety and scientific accuracy of the scientific content of the book.
- Availability of a logical sequence in presenting the scientific content of the book.
- The expression of pictures, graphs, and tables on scientific concepts and phenomena associated with them.
- Relevancy of geological innovations to the content of lessons and real life.
- The appropriateness and correctness of formulating the structural and closing evaluation questions for each lesson.

In light of the opinions of the arbitrators, the student's book was amended after referring to the supervisors, and thus the student's book is ready in its final form.

2. *Preparing a teacher's guide for the (Earth and the Universe) unit for first-year middle school students:*

The teacher's guide was prepared in the light of the Next Generation Science Standards (NGSS), and it is considered one of the main requirements in preparing for the implementation of the experimental phase of the research, to guide the teacher when teaching the developed "Earth and Universe" unit, and it does not restrict the teacher or oblige him to follow the steps contained in it, but It is an expression of what the researcher imagines to organize and manage the classroom to achieve the desired goals of curriculum development. The researchers took into account that the teacher's guide should include the following elements when preparing it:

- An introduction through which the philosophy on which the evidence is based is clarified, in order to introduce the teacher to the Next Generation Science Standards (NGSS), as one of the modern educational trends, and to shed light on the dependent variables aimed at developing students through experimental treatment.
- A set of directives should be taken into account during the course of the learning process.
- Clarifying the procedural steps used in teaching the “Earth and the Universe” unit, which is done by merging the steps of the five-year learning cycle and teaching by inquiry (the introductory stage - the investigation stage - the interpretation stage - the application stage - the evaluation stage), in order to develop scientific and engineering practices.
- The time plan for teaching the developed "Earth and Universe" unit.
- Sources of knowledge and references that can be used.
- Formulating the guide lessons in the light of the following elements:
- Lesson title.
- The procedural objectives to be achieved from the lesson.
- Technological teaching aids and tools used.
- Procedural steps to implement the lesson.
- The assessment.

After completing the preparation of the teacher's guide in its initial form, it was presented to a group of arbitrators specialized in the field of curricula and methods of teaching science in the faculties of education. In order to ensure:

- The validity of the information contained in the content of the guide.
- The linguistic and verbal validity of the information included in the guide.
- The extent to which the objectives relate to the content of the lesson.
- The appropriateness of evaluation questions to ensure that the objectives of the lesson are achieved.
- The appropriateness of the proposed teaching strategies and methods for teaching the developed unit and the students of the first preparatory grade on the one hand, and the nature of scientific and engineering practices, and the development and trend towards the content of the developed unit on the other hand.
- The extent to which the dimensions of scientific and engineering practices are represented in the activities of the directory.

Adding suggestions for the guide or amendment as they see fit. In light of the opinions and instructions of the arbitrators, and concerning the supervising professors, the guide is in its final form.

3. *Preparing a student activity guide (Pamphlet) for the unity of the earth and the universe for first-grade middle school students:*

The student’s activity brochure was prepared for the unit of the earth and the universe developed in the science subject, the second semester, in the light of the NGSS, as the activities aim to spread the spirit of investigative learning and the development of scientific practices to build the student's knowledge of himself through scientific and engineering practices that he implements, and in cooperation and discussions with his classmates.

To prepare the activity booklet, the following were taken into account:

- Assigning students extra-curricular tasks that they accomplish, such as: reading scientific books and magazines, dealing with scientific websites on the Internet and the

Knowledge Bank, and benefiting from the capabilities of the surrounding local environment, as these tasks aim to encourage students to scientific exploration and self-knowledge.

- Prepare activities according to the basic steps of inquiry teaching.
- Preparing for the main ideas of the lesson by developing introductory activities.
- Allow students to record conclusions and questions in each investigative activity.
- Determine the title of the activity to clarify whether the activity is introductory, investigative, or practical.
- arbitrating of the student's activity booklet:
    - After completing the preparation of the activity brochure, it was presented to the specialized arbitrators to add or delete what they deem appropriate, and to make any observations about the extent of:
    - The scientific and linguistic integrity of the information included in the activity brochure.
    - Consistency and coherence of the method and steps of presenting activities.
    - The validity of the scientific information contained therein.
    - The suitability of the questions and activities for the level of the first preparatory grade students.
    - The accuracy of the scientific drawings and models included in the student's activity booklet.

The modifications were made in the light of the opinions of the arbitrators, and thus the activity brochure is ready in its final form.

Research tool setting

Preparation of scientific and engineering practices test in science

The researchers prepared a test of scientific and engineering practices in the field of earth and space sciences, and the preparation process went through the following steps:

1. *Determine the objective of the test*

It is a measure of the extent to which the first preparatory grade students acquire scientific and engineering practices, and to determine the extent of the effectiveness of the developed unit in developing scientific and engineering practices.

2. *Determine the type of test items*

In light of the objectives set for testing scientific and engineering practices in science, the researcher chose the pattern of multiple-choice questions, as the nature and characteristics of these questions are consistent with the objectives of the test, and participate in revealing the extent to which the objectives are achieved clearly, so the test was prepared in the form of paragraphs Multiple choice of 25 items.

3. *Formulation of test items*

The scientific and engineering practices test items (developing and using models, analyzing and interpreting data, building interpretations and designing solutions, obtaining information and evaluating it, asking questions and defining the problem, planning and conducting an investigation, engaging in evidence-based evidence, using mathematics) was formulated in a multiple-choice style.

4. *Test preparation*

Based on determining the type of test items, and how to formulate them; the researchers prepared the test to measure scientific and engineering practices in science. The vocabulary of each exercise has been formulated in light of its nature.

5. *Review the test items*

The researcher re-read and examined the test items 15 days after writing them, in order to eliminate as much as possible the effect of familiarity with the vocabulary in order to find out the appropriateness of grammar, integrity, and clarity of phrases. In the light of the review of the test items, some modifications were made to some of the test vocabulary, whether by deletion, addition, or improvement.

6. *Validity of the test*

The validity of the test of scientific and engineering practices in science was verified, as the researcher presented the test to a group of arbitrators, and this group included a number of specialists in curricula and methods of teaching science. The aim is to test scientific and engineering practices in science. The test was modified in light of the opinions and suggestions of the arbitrators, which guarantees the test the elements of honesty, to measure what was set to measure it.

7. *Exploratory Test Experimentation*

The objectives of Exploratory Test Experimentation are as follows:

- Checking the clarity of the verbal formulation of the test vocabulary.
- Determine the appropriate time for the test.
- Computing the coefficients of ease, difficulty, and discriminatory test items.
- Computing the reliability of the test.

- Computing the validity of the test.

To achieve the previous objectives, the researcher applied the test of scientific and engineering practices, after arbitration by specialists, on an exploratory sample consisting of 30 female students from the first preparatory grade at Al-Zahraa Preparatory School for Girls, Gharbia Governorate, after studying the unit (Earth and the Universe).

The linguistic wording of some of the test vocabulary was modified, which contained concepts and terms that aroused the attention of the students of the survey sample. After correcting the students' answers, the results were monitored and processed statistically to determine the time of the test and calculate the stability and validity of the test of scientific and engineering practices in science as follows:

- Determine the test time: The researchers found that the appropriate time to answer the test questions in its final form is approximately (35 minutes).
- Test reliability: The stability of the test was calculated using Cronbach's alpha coefficient using SPSS, Ver. 22, and the value of the alpha coefficient was 0.91, which is an acceptable stability coefficient indicating the stability of the test.
- Self-validity: The self-validity of the test value was 0.95, which is a high self-validity coefficient, and this indicates the validity of the test in measuring scientific and engineering practices in science.

8. Determine the test scores:

The researchers assigned one mark for the correct answer and zero for the wrong answer for each question of the test. Thus, the total score for the test of scientific and engineering practices in the field of earth and space sciences is (25) degrees.

9. Table of test specifications:

Based on the modifications made to the test in the light of the opinions and suggestions of the arbitrators in terms of adding, deleting, or improving some vocabulary.

The table of specifications for the test of scientific and engineering practices in the Earth and the Universe unit for the first grade of middle school was designed as follows:

Table 2

Specifications of the Test of Scientific and Engineering Practices in Science "The Unity of the Earth and the Universe" for the first grade of middle school.

N	SEP	Questions order	Number	Percentage
1	Using models	.24 ،20 ،13 ،12 ،11 ،7 ،1	7	**%28**
2	Construct the explanation	9 ،2	2	**%8**
3	Data exploration	.23 ،10 ،8	3	**%12**
4	Using mathematics	.25 ،14 ،6 ،4	4	**%16**
5	Problems solving	22 ،5	2	**%8**
6	Data analysis	16 ،15 ،3	3	**%12**
7	Participate in discussions based on evidence	21 ،19 ،18 ،17	4	**%16**
Total		**25**		**%100**

10. The final test copy

After verifying the appropriate time for the test, and the reliability and validity of the test, the test became applicable to the main sample of the research in the form of 25 multiple-choice questions that measure scientific and engineering practices. The question booklet included student data and test instructions, and the test included an answer sheet. It is a table with the number of the question and in front of it are four alternatives (a, b, c, d) from which the student determines the correct answer.

The procedures of the experimental study

These procedures included the step of selecting the research sample, the step of the quasi-experimental design of the research, and the step of field application.

The first step: selecting the research sample

- After obtaining the approval of the supervisors and administrative approvals, from the authorities concerned with applying the research tools to a sample of first-grade preparatory students at Al-Zahraa Preparatory School for Girls in Tanta, Gharbia Governorate.
- The researchers deliberately chose Al-Zahraa Preparatory School for Girls, due to the availability of a suitable number of first-grade female students to be the research sample, the cooperation of the school principal, and the provision of a classroom equipped with a screen and electronic devices to assist in the teaching process.
- The sample size of the experimental group in its final form was (30) students studying the "Earth and Universe" unit developed in the light of the Next Generation Science Standards (NGSS).

The second step: research methodology

The quasi-experimental design of the research included the following variables:

- Independent variable: the unit developed in light of the Next Generation Science Standards (NGSS).
- Dependent variables: scientific and engineering practices in science.

It is clear from the independent and dependent research variables that the design used is the semi-experimental design: a pre-post design for one group.

The third step: the application of the research which went through three phases

The first stage: before teaching the developed curriculum.

The researchers considered taking a set of procedures before teaching:

- Print the student's book, the student's activity guide (pamphlet), and the teacher's guide for teaching the topics of the "Earth and the Universe" unit assigned to first-grade middle school students in the second semester.
- Review the teacher's guide and re-read it several times for guidance during teaching.
- Ensuring the availability of technological educational materials and means necessary for teaching in the school.
- Preparing appropriate motivational rewards for students, and using reinforcement methods to ensure their continued attendance and effective participation during teaching.
- The researcher applied the pre-application of the research tools represented in a test of scientific and engineering practices in science on the students of the experimental group at the beginning of the second semester with two sessions, and after the end of the application of the test the researchers corrected and monitored the grades in preparation for the statistical treatment.

The second stage: Teaching the developed curriculum.

The first author taught the "Earth and the Universe" unit developed in the light of the Next Generation Science Standards (NGSS) for a research sample of first-year middle school students. And applying the test (6) weeks, the researchers took into account the following procedures when teaching:

- At the beginning, the researcher explained to the students the importance of the developed curriculum, and the main ideas that were built in light of it, and that the current teaching differs from what was previously studied, and asked for their cooperation while teaching the developed curriculum, as well as giving them an idea of how the lesson goes and their roles during the class.

- The researcher divided the students into groups, each group includes (4-6) students and left them the opportunity to divide the groups themselves, and distribute roles among them, to achieve better learning and increase their spirit of cooperation.
- The students handed over each class part of the activity brochure related to the subject of the lesson, and they were not handed over the complete activity brochure at the beginning of the application.
- After the students finished conducting the investigative activities recorded in the activity brochure for each lesson, they were handed their part of the student's book to refer back to and confirm the information they had reached, and so that they would not be distracted during the teaching procedure.
- The role of the researcher during teaching was limited to guiding and guiding the students, recording the mistakes they made in order to correct them, receiving their questions and discussing them, and identifying the groups that achieved the most appropriate answer and the best image of the investigative group work while carrying out the activities.
- Providing moral and material reinforcement to students and groups who presented unique ideas.
- Directing the students to read some books and search the Knowledge Bank website for topics related to the content of the lesson, while giving them the names of some books and websites on the Internet.
- Directing the students to answer the questions at the end of each lesson.

The third stage: after teaching the developed curriculum.

The researchers applied a test of scientific and engineering practices in science on the female students after completing the teaching of the developed curriculum, and the researcher corrected the tests and monitored the grades in preparation for the statistical treatments.

Results

The data obtained by the researchers were statistically processed using the statistical analysis package for social sciences, SPSS Ver.22, to test the validity of the research hypotheses. The results are related to the research question and its statistical hypothesis, which are related to the development of scientific and engineering practices in the sciences of female students in the first year of middle school, which stipulated:

1. What is the effectiveness of teaching a developed unit in light of NGSS from the field of earth and space sciences in science books in developing scientific and engineering practices in science for first-grade female students?
2. There is a statistically significant difference between the mean scores of the research sample students in the pre and post-applications at the level of ($0.05 \leq \alpha$) in the test of scientific and engineering practices in science in favor of the post-application.

The test of scientific and engineering practices in science was applied before and after (including seven scientific and engineering practices) on the female students of the research sample, in order to answer the research question, by testing the validity of the statistical hypothesis, as follows:

a. Presenting the results of the descriptive statistics of the scores of the students in the research sample in the test of scientific and engineering practices in science.

Table 3

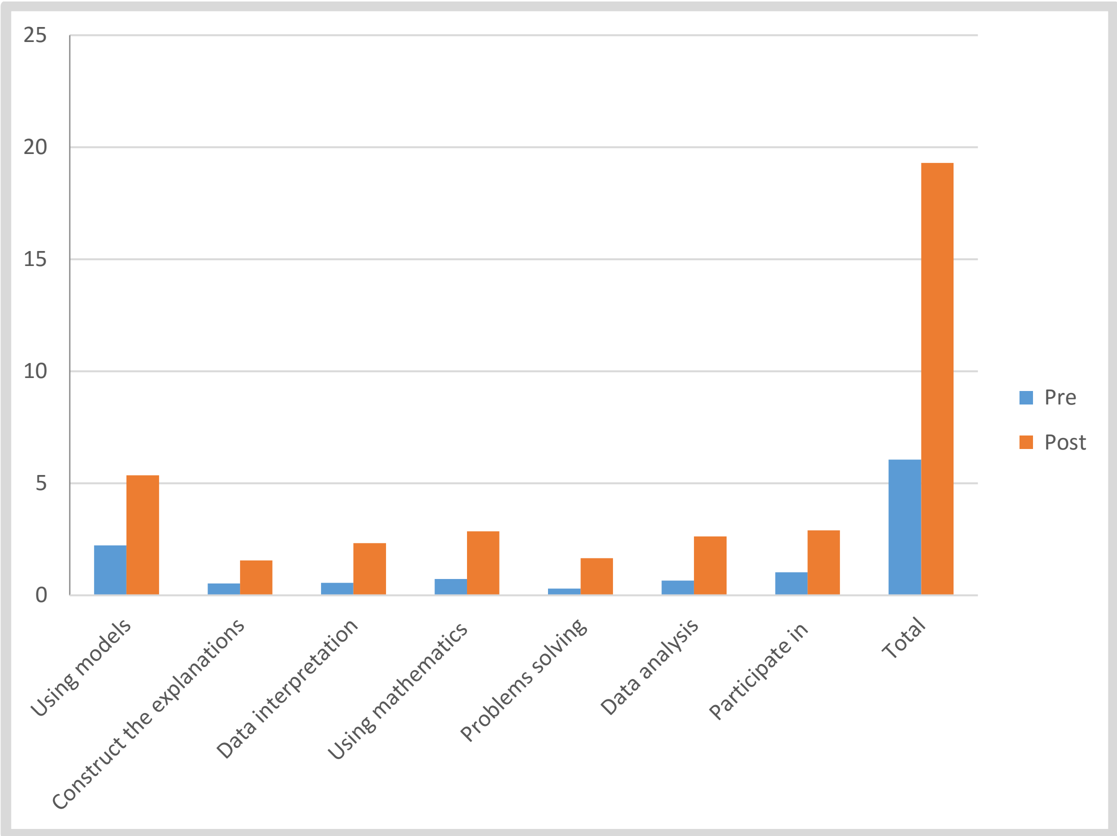
Means and standard deviations of the performance scores of the experimental group in the pre and post-applications of the test of scientific and engineering practices in science.

N	SEP	sample	Questions number	Means		Standard deviation		Percentage	
				pre	Post	pre	post	pre%	post%
1	Using models	30	7	2.23	5.36	1.13	1.18	31.8	76.57
2	Construct the explanations		2	0.53	1.56	0.50	0.56	25	78
3	Data interpretation		3	0.56	2.33	0.50	0.66	18.6	77.66
4	Using mathematics		4	0.73	2.86	0.73	0.73	18.25	71.5
5	Problems solving		2	0.3	1.66	0.46	0.47	15	83
6	Data analysis		3	0.66	2.63	0.47	0.61	22	87.66
7	Participate in discussions based on evidence		4	1.03	2.9	0.61	0.66	25.75	72.5
	Total		25	6.06	19.3	1.08	1.9	%24.2	%77.3

It is clear from table (3) that the performance levels of the students in the pre-application are lower than the post-application in the test as a whole, as well as in the sub-levels of scientific and engineering practices. Using models (2.23 pre - 5.36 post); construct explanation(0.53 pre - 1.56 post), data interpretation (0.56 pre - 2.33 post); Use of mathematics (0.73 pre - 2.86 post), problem-solving (0.3 before - 1.66 post), data analysis (0.66 pre - 2.63 post), participating in discussions based on evidence (1.03 pre - 2.9 post), testing as a whole (6.06 pre - 19.3 post), which means the development of the students' performance (the research sample) after studying the developed curriculum in the light of science standards for the next generation. The following figure (3) summarizes the differences between the mean scores of the (experimental) students of the research sample in the two applications (pre and post) to test scientific and engineering practices as a whole and in its sub-skills in science.

Figure 3

Graphical representation of the differences between the mean scores of the research sample students in the two applications (pre and post) to test practices in science.



By looking at Figure (3) above, it is clear that there are apparent differences between the averages of the students of the research sample in the pre and post-applications of the test of scientific and engineering practices in science as a whole, as well as in the sub-levels of the test.

To verify the significance of these differences, a paired sample t-test was calculated for the associated groups. To investigate the significance of the differences between the mean scores of each of the two applications (pre and post) for the research sample in the test of scientific and engineering practices in science.

b. Presenting the results of the inferential statistics of the scores of the students in the research sample in the test of scientific and engineering practices in science which is shown in table (4):

Table 4

Means, standard deviations, and "t" values for the performance scores of the experimental group students in the pre and post-applications of the scientific and engineering practices test in science.

N	SEP	Application	Sample	Questions	Mean	t-test value	df	Sig.(2-tailed)
1	Using models	Pre	30	7	2.23	13.14	29	.000
		Post		7	5.36			
2	Construct the explanations	Pre		2	0.53	7.87		.000
		Post		2	1.56			
3	Data interpretation	Pre		3	0.56	11.27		.000
		Post		3	2.33			
4	Using mathematics	Pre		4	0.73	10.87		.000
		Post		4	2.86			
5	Problems solving	Pre		2	0.3	12.17		.000
		Post		2	1.66			
6	Data analysis	Pre		3	0.66	14.99		.000
		Post		3	2.63			
7	Participate in	Pre		4	1.03	10.50		.000
		Post		4	2.9			
Total		Pre		25	6.06	37.67		.000
		Post		25	19.3			

It is clear from table (4) that there are statistically significant differences between the mean scores of the two applications (pre and post) for the research sample female students in the sub-levels of the test of scientific and engineering practices in science and the total score of the test; In favor of the post-application with the highest average, where all the values of "T" were greater than the tabular value, where the tabular "T" was at the level of (0.05) and degrees of freedom (29) = (2,045), which means that there has been a development of scientific and engineering practices in the test as a whole And in its sub-levels in the research sample. In the light of these results, it is possible to accept the first hypothesis directed from the research hypotheses, which states that there is a statistically significant difference between the mean scores of the research sample students in the pre and post-applications at the level of ($0.05 \leq \alpha$) in the test of scientific and engineering practices in science in favor of the post application.

To determine the effectiveness of experimental treatment in the development of scientific and engineering practices in science; The Eta-square equation ($\eta 2$), d, was used and calculated to determine the size of the effect of the treatment in the development of each sub-practice of the scientific and engineering practices test, as well as the total score depending on the calculated "T" value when determining the significance of the differences between the two applications (pre and post) of the research sample, This is illustrated by table (5):

Table 5

Eta-square values ($\eta 2$), d and the size of the effect of experimental treatment on the development of scientific and engineering practices in the two applications (pre and post).

SEP	t-value	$\eta 2$	Effect size
Using models	13.14	0.85	High
Construct the explanations	7.87	0.68	High
Data interpretation	11.27	0.81	High
Using mathematics	10.87	0.57	High
Problems solving	12.17	0.83	High
Data analysis	14.99	0.88	High
Participate in	10.50	0.79	High
Total	37.67	0.97	High

It is clear from table (5) that the values of η 2 eta square ranged between (0.57-0.88) for the sub-levels of the test. The value of Eta square η 2 for the test as a whole was (0.97); This means that the experimental treatment contributes significantly to the variance of the test as a whole by 97%, which indicates a significant impact of the experimental treatment and its effectiveness in developing scientific and engineering practices in science among the research sample.

Interpretation and discussion of research results

Search results can be traced back to:

- The developed unit contains a number of topics that affect the interests of the students, which helped to increase the students' motivation toward the learning process of earth and space topics.
- Teaching the developed unit using modern learning strategies that are based on the activity and engagement of the learner in the learning process. It helped the students to participate in discussions and dialogues about the topics included in the unit, and build knowledge by themselves by activating and recalling previous experiences, and integrating them with information, which helped in understanding and remembering information easily, and applying it in similar situations.
- In addition, the developed unit contains a large number of various activities and modern learning resources that helped the students activate their minds, and thus understand and acquire knowledge coherently, and the ability to analyze and classify them, and use them to solve the problems they face.
- This, in addition to being immersed in investigation and asking thought-provoking questions, helped stimulate the students' minds, and this led to a higher level of scientific and engineering practices among them.
- The students' sense of the importance of what they study, by linking the teaching to their reality and their lives, led to a high level of motivation, which led to engaging in

the completion of investigative activities, which had a great impact on the development of scientific and engineering practices among the research sample.

- The students benefited, through learning in cooperative groups, from the experiences of their classmates while practicing activities and solving thought-provoking questions, which led to a high level of scientific and engineering practices as a whole among the research sample.
- The evaluation methods included in the developed unit are varied and dealt with different levels of achievement.
- The use of feedback, whether material, such as prizes distributed to groups, or moral, such as expressions of encouragement and approval, would motivate students to focus and pay attention to the teacher.

These results are consistent with the findings of a number of previous studies, which presented a perception of the importance and how to develop science curricula in the light of science standards for the next generation, including: (Rowland, 2014; Hamed, 2015; Rashid, 2016; Al-Baz , 2017; Abdel Aziz, & Adel, 2017; Makiya, A. 2021).

Recommendations

Based on the research findings, the following recommendations can be made:

- The need for those in charge of planning curricula to adopt the NGSS in preparing science curricula at all educational levels.
- The need to pay attention to the NGSS in the development of science curricula at the preparatory stage.

- The need to reconsider the planning of science curricula in the preparatory stage so that it focuses on the development of scientific and engineering practices and is not limited to the collection of knowledge and information.
- Providing a supportive climate for discussion among students, with good management on the part of the teacher, is one of the factors that contribute to the development of cooperative learning among students.
- The need for the teacher to use evaluation methods that depend on surveying the answers from the students and not measuring the ability of the students to memorize and recall information.
- Emphasizing and encouraging science teachers to use age-appropriate strategies and subject content in the teaching process, which emphasize students' activity in the educational process and stimulate their love of learning.
- The importance of including pictures and charts in science books to reduce the abstraction of scientific concepts to facilitate their learning for students.
- Inclusion of many life problems related to the subjects of science books as scientific activities.

Suggestions for further research

In the light of the research findings and recommendations, the researcher suggests the following:

- A suggested training program to develop science teachers' awareness of the NGSS in the preparatory stage.
- Evaluating the field of life sciences (goals, content, activities, and evaluation methods). Preparatory stage in the light of the NGSS.

- Evaluating the field of natural sciences (goals, content, activities, and evaluation methods). Preparatory stage in the light of the NGSS.
- A training program to train science teachers on how to develop and teach the earth and universe unit developed according to the NGSS.

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