A proposed Program based on the Next Generation Science Standards for the Development of Understanding of (NGSS) and Scientific Explanations among Electronic Diploma Students

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Abstract

The current research aimed to develop understanding of (NGSS) and Scientific Explanations among electronic diploma students by using a proposed program based on the Next Generation Science Standards (NGSS), The proposed Program was built, and to achieve the aims of the research, instruments of the research were built: content understanding of (NGSS) test, NGSS-aligned lesson plan analysis tool and scientific explanations test. The participants were (15 science students) from electronic diploma students in Faculty of Graduated Studies for Education, Cairo University. The researcher used experimental-quasi design, one experimental group only (pre and post). Results of the research showed the great effect and effectiveness of the proposed program based on "NGSS" in developing" understanding of (NGSS) and scientific explanations among electronic diploma students.

Keywords: Next Generation Science Standards "NGSS"- Understanding- Scientific Explanations- electronic diploma students

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Introduction

Educational practices in today's world vary in parallel to development of science and technology. Accordingly, countries embark on new quests to enhance quality of education, acting from the principle that scientific and technological development is possible only by means of education.

There is a major science education reform effort taking place in the United States with the development and adoption of the NGSS. The Next Generation Science Standards (NGSS) are intended to reflect a new vision for American science education. The NGSS were released in the United States (U.S.) on April 9, 2013. The NGSS are a set of science standards that are research based and were developed to improve science education for students in grades K-12. They were developed by the states along with several critical partners including National Research Council (NRC), the National Science Teachers Association (NSTA), and the American Association for the Advancement of Science (AAAS). (Christopher, 2017; Smith & Nadelson, 2017, 194).

The structural and conceptual vision for science education are outlined in the Next Generation Science Standards in the United States. Structurally, the *NGSS* outlines three-dimensions of science learning: science and engineering practices (S&EPs), crosscutting concepts (CCs) and disciplinary core ideas (DCIs). (S&EPs) are revealed as practices undertaken to develop explanations and arguments for explaining natural phenomena, or making informed decisions related to societal concerns. The CCs are ‘thinking tools’ that can be used across disciplines in sense making. DCIs are organized into four domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology and applications of science, and are ordered according to learning progressions that are grounded in the notion that learning is a developmental progression as students move from kindergarten through twelfth grade K-12. As CCs are also applicable across disciplines, they are seen as helpful in supporting the coherent development of students’ science-informed views of the world. Conceptually, the *NGSS* outlines a commitment to students’ engagement in the connection of three-dimensional learning. In this regard, students engage in S&EPs to use DCIs and CCs to explain phenomena or solve problems. (Campbell, 2015, 2).

The NGSS describe specific goals for science learning in the form of performance expectations "statements about what students should know and be able to do at each grade level, and thus what should be tested at each grade level". Each performance expectation incorporates all three dimensions: Practices, Crosscutting Concepts, and Core Ideas, and the NGSS emphasize the importance of the connections among scientific concepts. The NGSS's performance expectations place significant demands on science learning at every grade level. ((NRC, 2012, 218; NGSS, 2013 G, 1-2)

The goal of the Next Generation Science Standards is to improve K-12 science education for all students. These standards give local educators the flexibility to design classroom learning experiences that stimulates students' interests in science and prepares them for college, careers, and citizenship. Thus, the NGSS has been described as a shift from a focus on learning facts to discovering scientific principles, and from explaining isolated processes to answer larger questions for which those processes are part of the answer (Reiser, 2013).

Just as the Next Generation Science Standards (NGSSs) call for change in what students learn and how they are taught, science teacher education programs must reconsider courses and curriculum in order to prepare teacher to understand and implement new standards. There are plenty of implications of NGSS for the teaching of science, preparation of science teachers, in service professional development of science teachers, and for the knowledge and practices of university faculty who work with science teachers. (Lederman & Lederman, 2014, 141; Lee, et al., 2014, 224, Simpson, 2017, et al., 1; Spector, 2016, 87; Hanuscin & Zangori, 2016, 799).

It's not enough for science teachers to read through the *Next Generation Science Standards* (*NGSS*) and correlate their content to the established curriculum. Science teachers will need considerable support from professional development providers to become familiar with the new standards and to implement them effectively. Teachers should be prepared to make the vision of the *NGSS* come alive in their classrooms**.** The preparation will be most effective if it begins in undergraduate course work in universities that prepare teachers and is sustained by ongoing professional development designed to bring about real change. (Hanuscin, et al., 2016; Hoffenberg & Saxton, 2015; Rhoton, 2018)

Some studies confirmed the importance of preparing prospective science teachers such as (Acare, et al., 2015; Carpenter, et al., 2015; Ward, 2016; Windschitl & Stroupe, 2017; Wiyanto, et al., 2017). In view of the results of these studies, there is a great need for further researches to prepare science students- teachers in light of (NGSS).

A continual goal of science education is to develop student understanding of core scientific concepts by exposing them to well-designed curricular experiences. More recently, scholars have engaged in efforts to develop curriculum materials and other supports to help teachers teach for understanding. The central premise behind this recent movement is that teachers should plan and enact instruction in which students have opportunities to learn about, experience, relate, and apply core disciplinary ideas (Penuel, et al., 2009, 2; Wiggins & Mc Tighe 1998).

A deep understanding of content is important to successful implementation of the NGSS; however, there is a traditional divide between content and pedagogical coursework in teacher preparation; So it is very important to develop the understanding of core principles of (NGSS), Therefore, there are only few studies interested in developing the understanding of (NGSS) such as (Hanuscin & Zangori, 2016; AbdulKarim, 2017; Shernoff, et al., 2017), so there is great need for more researches to improve science teachers understanding of (NGSS).

The study of science in essence involves the explanation of phenomena by inferring the reasons for occurrences and justifying the significance of the observed event. On almost a daily basis, there are articles in the news that seek to provide a scientific explanation for how or why a given natural phenomenon occurred. The topic may be climate change, nuclear energy, genetically modified food or something else that impacts the everyday lives of school students. Students need to be able to evaluate the evidence and reasoning presented in the article. In addition, they also need to grow in the ability to develop well-reasoned scientific explanations of their own. This raises a challenge for the science educators: How can they equip students with the requisite knowledge and skills for answering science questions about natural phenomena? Critical skill that all students should develop through their study of science are the ability to develop and critique a scientific explanation. One of the practices identified as essential for all students in the Next Generation Science Standards (NGSS) is: Constructing explanations (for science) (McNeill & Krajcik, 2012, 1; NRC, 2012, 67-71).

Engaging students with standard scientific explanations of the world helping them to gain an understanding of the major ideas that science has developed is a central aspect and goal of science education. Science teacher education and professional development will play a big role in whether students achieve the goals embraced by the Next Generation Science Standards. Teachers' understanding of the scientific practice of explanation is linked to students' successful demonstration of that practice. Therefore, science teachers and students- future teachers need explicit and professional development and preparation experiences that help them build a deep understanding of what is meant by terms like "scientific explanation" and examples of what proficient student explanations should look like in various contexts. (Hoffenberg & Saxton, 2015; NRC, 2012, 67).

Some studies Interested in developing scientific explanations among students in elementary, middle and secondary such as (Gilmanshina, et al., 2016**;** Hoffenberg & Saxton, 2015; Hsu, et al., 2015; Ibrahim, 2014) However, there is a scarcity of studies that have focused on the development of scientific explanations among the science students- teachers.

Sense of the research problem

It is clear from the above that the importance and the need of preparing and developing science teachers professionally in the light of (NGSS), and the development of understanding of (NGSS) and scientific explanations among them.

This is confirmed by the latest conferences of education in Egypt Such as" the 18th Scientific Conference of the Egyptian Association for Science Education, 24-25/7/2016; the 25th Scientific Conference of the Egyptian Association for Curricula and Teaching Methods, 3-4/8/2016; and the third International conference of the Faculty of Education of October 6 university 2017 University, entitled "The Future of Teacher Preparation and

Development in the Arab World", 23-24/4/2017".

This is also confirmed by some studies as (Abdul Karim, 2017; Ahmed & Almokbel, 2016; Rawashdah, et al., 2018).

As a pilot study, the researcher conducted an initial questionnaire on 15 science students- teachers in electronic diploma at the end of the first semester of the academic year (2017-2018). The questionnaire consisted of three questions: (1) what do you know about NGSS?, (2) what do you know about scientific explanations? and (3) how can you develop students' scientific explanations?, The initial questionnaire revealed that 100% of the students have no information about what NGSS is, and 60% of them have a little information about scientific explanations and how to develop it. In additional the administration of initial scientific explanations test was done, The results of the administration resulted in shortage and weakness among them in scientific explanations formation. These results of the pilot study indicate that there is a real problem.

Problem of the research

Based on the recommendations of previous conferences and studies and the results of the pilot study, there is a need for a proposed program based on (NGSS) to develop science students-teachers' understanding of (NGSS) and scientific explanations among them Accordingly, this research attempted to answer the following questions:

1. What is a proposed program based on the Next Generation Science Standards for the development of the understanding of (NGSS) and scientific explanation among electronic diploma science students?
2. What is the effectiveness of the proposed program in developing content understanding of (NGSS) among electronic diploma science students?
3. To what extent were science students- teachers' curricular shifts in understanding NGSS reflected in the lesson plans that they developed?
4. What is the effectiveness of the proposed program in developing scientific explanation among electronic diploma science students?

Aims of the research: The aims of the current research are developing the understanding of (NGSS) and scientific explanations among electronic diploma science students by using a proposed program based on Next Generation Science Standards.

Definition of Terms

After reviewing the educational literature, the procedural definitions of the research terms were defined

***Next Generation Science Standards**: The NGSS describe specific goals for science learning in the form of performance expectations-statements about what students should know and be able to do at each grade level-and thus what should be tested at each grade level. Each performance expectation incorporates all three dimensions: science and engineering practices "S&EPs", Crosscutting Concepts "CCs", and Disciplinary Core Ideas "DCIs".

***Understanding of (NGSS)**: It includes content and functional understanding.

***Content understanding:** Is a set of abilities associated together, which are includes the science student- teacher' use of core principles of (NGSS) which included in the proposed program to explain, interpret, apply what he/she learned in different situations, the student' Possession of critical and insightful views and the ability to analyze and derive results from divergent views. This understanding measured by the content understanding of (NGSS) test prepared by the researcher.

***Functional understanding**: It is science students- teachers' curricular shifts in understanding NGSS reflected in the lesson plans that they developed, and measured by NGSS-aligned lesson plan analysis tool.

Scientific Explanations: It is an attempt of science student-teacher to give the reason for or cause of a phenomena, it includes three components: a claim which makes a conclusion that addresses the problem about a phenomenon, an evidence that supports the student's claim using scientific data, and a reasoning that links the claim and evidence and shows why the data count as evidence to support the claim. And measured by the scientific explanations test prepared by the researcher.

Electronic Diploma: It is a general diploma for education in Faculty of Graduated Studies for Education, Cairo University. It works through the electronic learning management system "MOODLE", E. Diploma includes different courses, from these courses science teaching course, in this course students review the content of the course, and the system has synchronous and asynchronous interaction tools: the chat room, the virtual classroom, course forum and course activities. Important events are announced through latest news, upcoming events and recent activity in the course page. The LYNC program is used for direct meetings between the course teacher and students via virtual classes.

Delimitations of the research: The current research is delimited to:

- A group of (15) students who studied the science methods course in the electronic diploma at the faculty of Graduate Studies for Education, Cairo University, second semester of the academic year 2017/ 2018.
- Four Facets of content understanding: explanation, interpretation, application and prospective.
- Three components of the scientific explanation, these components are: claim, evidence and reasoning.

Significance of the research: The current research

* is a response to the global and Arab trends that call for reform and changes in science teacher education programs and professional development programs for the science teacher.
* can direct the attention of researchers and teaching staff in faculties of education by including "NGSS" in the courses of teaching science and training students during science education field on how to apply them.
* can direct the attention of curriculum and program designers to place emphasis on "NGSS" in designing science curricula and programs in all educational stages.
* provides the proposed program which can enhance the science student teacher in developing the conceptual understanding of the "NGSS", and scientific interpretations among them.

Review of Literature

First: The Next Generation Science Standards "NGSS"

The initial step in developing the NGSS was the development of A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (Framework). The intent of the Framework was to describe a coherent vision of science education by (1) viewing learning as a developmental progression; (2) focusing on a limited number of core ideas to allow for in-depth learning (both cross-disciplinary concepts with applicability across science and engineering and concepts central to each of the disciplines); and (3) emphasizing that learning about science and engineering involves integration of content knowledge and the practices needed to engage in scientific inquiry and engineering design. The NGSS kept the vision of the Framework intact by focusing on a rigorous set of core concepts that are articulated for each grade band (K-2, 3-5, 6-8, 9-12) and anchored to real-world science and engineering practices. (NRC, 2012, 10-11; NGSS, 2013A, 2)

Dimensions of the Next Generation Science Standards

Each standard of NGSS consists of three dimensions: science and engineering practices (S&EPs), crosscutting concepts (CCs) and disciplinary core ideas (DCIs), as identified in Framework for K-12 Science Education (NRC, 2011, ES-3; NRC, 2012, 3; Campbell & McKenna, 2016, 93-94; Best& Dunlap, 2014, 2).

➢ **Scientific and Engineering Practices: 1. Asking questions (for science) and defining problems (for engineering). 2. Developing and using models. 3. Planning and carrying out investigations. 4. Analyzing and interpreting data. 5. Using mathematics and computational thinking. 6. Constructing explanations (for science) and designing solutions (for engineering). 7. Engaging in argument from evidence. 8. Obtaining, evaluating, and communicating information.**
➢ **Crosscutting Concepts: 1. Patterns 2. Cause and effect: Mechanism and explanation. 3. Scale, proportion, and quantity. 4. Systems and system models. 5. Energy and matter: Flows, cycles, and conservation. 6. Structure and function. 7. Stability and change.**
➢ **Disciplinary Core Ideas. *Physical Sciences*: PS 1: Matter and**

its interactions. PS2: Motion and stability: Forces and interactions. PS 3: Energy, PS 4: Waves and their applications in technologies for information transfer. *Life Sciences*: LS 1: From molecules to organisms: Structures and processes. LS 2: Ecosystems: Interactions, energy, and dynamics. LS 3: Heredity: Inheritance and variation of traits. LS 4: Biological evolution: Unity and diversity. *Earth and Space Sciences*: ESS 1: Earth's place in the universe. ESS 2: Earth's systems. ESS 3: Earth and human activity. *Engineering, Technology, and the Applications of Science*: ETS 1: Engineering design. ETS 2: Links among engineering, technology, science, and society

First Dimension: Science and Engineering practices

A Framework for K-12 Science Education (National Research Council, 2012, 30) and the Next Generation Science Standards (NGSS Lead States, 2013) differ from previous science education reform documents (e.g., NRC, 1996) in that they specify eight science and engineering practices rather than emphasize science inquiry processes. This shift away from processes and towards practices stems, in part, from the ambiguity surrounding the term inquiry. The science and engineering practices provide a clearer common language for science educators, and are thought to better describe both the nature of science and the work of science and engineering (Carpenter, etal., 2015, 2). Practices (S&EPs), the first dimension, describe the behaviors that scientists use as they investigate and build models and theories about the natural world. NRC decided to use the term "practices", rather than life skills, to emphasize that engaging in scientific investigation requires not only skill, but also knowledge that is specific to each practice. ((Rhoton, 2018, 7).

Participation in (S&EPs) helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview. The actual doing of science or engineering can also stimulate students' curiosity, capture their interest, and motivate their continued study; the insights thus gained help them recognize that the work of scientists and engineers is a creative endeavor-one that has deeply affected the world they live in. Students may then recognize that science and engineering can contribute to meeting many of the major challenges that confront society today, such as generating sufficient energy, preventing and treating disease, maintaining supplies of fresh water and food (NGSS, 2013B, 2).

There are guiding principles must take into account when developing Practices (S&EPs) (NGSS, 2013B, 2), these principles includes:

1- Students in grades K-12 should engage in all eight practices over each grade band
2- Practices grow in complexity and progression across the grades.
3- Each practice may reflect science or engineering.
4- Practices represent what students are expected to do, and are not teaching methods or curriculum.
5- The eight practices are not separate; they intentionally interconnect.
6- Performance expectations focus on some but not all capabilities associated with a practice.
7- Engagement in practices is language intensive and requires students to participate in classroom science discourse.

Eight Science and Engineering practices (NRC, 2012, 49-79; NGSS, 2013B, 4-33; Osborne, 2014, 183-189) can be explained

Practice 1: Asking Questions and Defining Problems"

1. *Asking Questions and Defining Problems Science:* Students at any grade level should be able to ask questions about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations	
***Science* begins with a question about a phenomenon, such as “Why is the sky blue?” or “How is electric power generated?,” and seeks to develop theories that can provide explanatory answers to such questions. A basic practice of the scientist is formulating empirically**	***Engineering* begins with a problem or desire that suggests an engineering problem that needs to be solved. A societal problem such as reducing the dependence on fossil fuels may engender a variety of engineering problems, such as designing more efficient transportation systems, or alternative power generation**

answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered.	devices such as improved solar cells. Engineers ask questions to define the engineering problem, identify criteria for a successful solution, and constraints.

Practice 2: Developing and Using Models

<table>
<tr><td colspan="2">2. Developing and Using Models: term "models" refer to conceptual models rather than mental models) to represent current understanding of a system (or parts of it) under study, Modeling can begin in the earliest grades, with students' models progressing from concrete "pictures" and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system.</td></tr>
<tr><td>Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond observables and imagine a world not yet seen. Models enable predictions of the form "if.. then . therefore" to be made in order to test hypothetical explanations.</td><td>Engineering makes use of models and simulations to analyze existing systems so as to see where flaws might occur or to test possible solutions to a new problem. Engineers also call on models of various sorts to test proposed systems and to recognize the strengths and limitations of their designs.</td></tr>
</table>

Practice 3: Planning and Carrying Out Investigations

<table>
<tr><td colspan="2">3. Planning and Carrying Out Investigations: Students should have opportunities to plan and carry out several different kinds of investigations during their K-12 years. At all levels, they should engage in investigations that range from those structured by the teacher-in order to expose an issue or question that they would be unlikely to explore on their own (e.g., measuring specific properties of materials)-to those that emerge from students' own questions.</td></tr>
<tr><td>Scientific investigation: may be conducted in the field or the laboratory. A major practice of scientists is planning and carrying out a systematic investigation,</td><td>Engineers use investigation both to gain data essential for specifying design criteria or parameters and to test their designs. Like scientists, engineers</td></tr>
</table>

which requires the identification of what is to be recorded and, if applicable, what are to be treated as the dependent and independent variables (control of variables). Observations and data collected from such work are used to test existing theories and explanations	**must identify relevant variables, decide how they will be measured, and collect data for analysis. Their investigations help them to identify how effective, efficient, and durable their designs may be under a range of conditions.**

Practice 4: Analyzing and Interpreting Data

4. ***Analyzing and Interpreting Data:*** **Once collected, data must be presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others; because raw data as such have little meaning.**

Scientific investigations **produce data that must be analyzed in order to derive meaning. Because data usually do not speak for themselves, scientists use a range of tools-including tabulation, graphical interpretation, visualization, and statistical analysis-to identify the significant features and patterns in the data. Sources of error are identified and the degree of certainty calculated. Modern technology makes the collection of large data sets much easier, thus providing many secondary sources for analysis.**	***Engineers*** **analyze data collected in the tests of their designs and investigations; this allows them to compare different solutions and determine how well each one meets specific design criteria-that is, which design best solves the problem within the given constraints. engineers require a range of tools to identify the major patterns and interpret the results.**

Practice 5: Using Mathematics and Computational Thinking

<table>
<tr><td colspan="2">5. Using Mathematics and Computational Thinking: Although there are differences in how mathematics and computational thinking are applied in science and in engineering, mathematics often brings these two fields together by enabling engineers to apply the mathematical form of scientific theories and by enabling scientists to use powerful information technologies designed by engineers. Both kinds of professionals can thereby accomplish investigations and analyses and build complex models, which might otherwise be out of the question.</td></tr>
<tr><td>In science, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks, such as constructing simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable predictions of the behavior of physical systems, along with the testing of such predictions.</td><td>In engineering, mathematical and computational representations of established relationships and principles are an integral part of design. For example, structural engineers create mathematically based analyses of designs to calculate whether they can stand up to the expected stresses of use and if they can be completed within acceptable budgets. Moreover, simulations of designs provide an effective test bed for the development of designs and their improvement.</td></tr>
</table>

Practice 6: Constructing Explanations and Designing Solutions

6. Scientific theories are developed to provide explanations aimed at illuminating the nature of particular phenomena, predicting future events, or making inferences about past events.	
The goal of science **is the construction of theories that can provide explanatory accounts of features of the world. A theory becomes accepted when it has been shown to be superior to other explanations in the breadth of phenomena it accounts for and in its explanatory coherence. Scientific explanations are explicit applications of theory to a specific situation or phenomenon, perhaps with the intermediary of a theory-based model for the system under study. The goal for students is to construct logically explanations of phenomena that incorporate their understanding of science, or a model that represents it, and consistent with the available evidence.**	***Engineering design*****, a systematic process for solving engineering problems, is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technological feasibility, cost, safety, esthetics, and compliance with legal requirements. There is usually no single best solution but rather a range of solutions. Which one is the optimal choice depends on the criteria used for making evaluations .**

Practice 7: Engaging in Argument from Evidence

7. Engaging in Argument from Evidence: The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the criterion for conducting such arguments. In that essence , students should argue for the explanations they construct, defend their interpretations of the associated data	
***In science*, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon .**	***In engineering*, reasoning and argument are essential for finding the best possible solution to a problem. Engineers collaborate with their peers throughout the design process, with a critical stage being the selection of the most promising solution among a field of competing ideas. Engineers use systematic methods to compare alternatives, formulate evidence based on test data, make arguments from evidence to defend their conclusions, evaluate critically the ideas of others, and revise their designs.**

Practice 8: Obtaining, Evaluating, and Communicating Information

8. *Obtaining, Evaluating, and Communicating Information*: Any education in science and engineering needs to develop students' ability to read and produce domain-specific text. As such, every science or engineering lesson is in part a language lesson, reading and producing the kinds of texts that are intrinsic to science and engineering.	
***Science* cannot advance if scientists are Unable to communicate their findings clearly and persuasively or to learn about the findings of others. A major practice of science is thus the**	***Engineers* cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. as with scientists engineers need to be able to express their ideas. Moreover, as**

communication of ideas and the results of inquiry-orally, in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers. Science requires the ability to derive meaning .	**with scientists, they need to be able to derive meaning from colleagues' texts, evaluate the information, and apply it usefully. In engineering and science alike, new technologies are now routinely available that extend communication.**

Some studies interested in incorporating and developing scientific practices. ***IN his study Rowland (2014)*** confirmed the effectiveness of incorporating three specified practices: developing and using models, using mathematics and computational thinking and engaging in argument from evidence on conceptual understanding of biological concepts ,motivation among students at Sheridan High School (SHS) in Sheridan Wyoming. And also the attitude of science instructor and engagement towards teaching improved during the intervention units. **The study of Osborne, et al., (2014)** aimed to develop a more dialogic approach to the teaching of science as a common instructional practice within the school. To achieve this goal, two lead teachers in each school worked to improve the use of argumentation as an instructional practice by embedding activities in the school science curriculum and to develop their colleague's expertise across the curriculum for 11- to 16-year-old students. students' conceptual understanding, reasoning, and attitudes toward science were improved. **In their study Idsardi, et al., (2015)**, they use the science practices in the Classroom Matrix (SPCM) to systematically determine how science teachers enact the scientific practices in their classrooms in meaningful ways.

Pre service teachers can sharpen their understanding of engineering practices through the integration of engineering into their programs of study. This may entail adding engineering into science education methods courses, incorporating engineering design and activities into core science courses for teachers, offering content courses that focus explicitly on teaching engineering to preservice teachers, or requiring mainstream engineering coursework ,the latter probably feasible only for preservice secondary teachers, because of extensive prerequisites.

(Cunningham & Carlsen, 2014, 198-208).

Second Dimension : Crosscutting concepts (CCs)

(CCs) are concepts that apply to all areas of science, illustrating how the different areas of science are linked together. (CCs) that unify the study of science and engineering through their common application across fields. The Framework notes that crosscutting concepts are featured prominently in other documents about what all students should learn about science for the past two decades. These have been called “themes” in Science for All Americans (AAA, 1989) and Benchmarks for Science Literacy (1993), “unifying principles” in National Science Education Standards (1996), and “crosscutting ideas” NSTA’s Science Anchors Project (2010). Although these ideas have been consistently included in previous standards documents the Framework recognizes that “students have often been expected to build such knowledge without any explicit instructional support. Hence the purpose of highlighting them as Dimension 2 of the framework is to elevate their role in the development of standards, curricula, instruction, and assessments.” Crosscutting concepts had been synthesized into the performance expectations for all students- so they cannot be left out., (CCs) can help students develop a cumulative, coherent, and usable understanding of science and engineering. (NGSS, 2013C, 1-2; NRC, 2012, 83; Rhoton, 2018, 7)

The Framework recommended crosscutting concepts be embedded in the science curriculum beginning in the earliest years of schooling and suggested a number of guiding principles for how they should be used. (NGSS, 2013C, 2-3)

- Crosscutting concepts can help students better understand core ideas in science and engineering
- Crosscutting concepts can help students better understand science and engineering practices
- Repetition in different contexts will be necessary to build familiarity
- Crosscutting concepts should grow in complexity and progression across the grades
- Crosscutting concepts can provide a common vocabulary for science and engineering
- Crosscutting concepts should not be assessed separately from

practices or core ideas.

- Performance expectations focus on some but not all capabilities associated with a crosscutting concept
- Crosscutting concepts are for *all* students
- Inclusion of Nature of Science and Engineering Concepts.

Seven Crosscutting concepts: Progression of (CCs) across the grades (NRC, 2012, 85-101; NGSS, 2013C, 3-11) can be explained:

1. **"Patterns concept** exist everywhere-in regularly occurring shapes or structures and in repeating events and relationships. For example, patterns are noticeable in the symmetry of flowers and snowflakes, the cycling of the seasons, and the repeated base pairs of DNA.". "Once patterns and variations have been noted, they lead to questions; scientists seek explanations for observed patterns and for the similarity and diversity within them. Engineers often look for and analyze patterns, too.

Progression of Patterns concept Across the Grades	Performance Expectation from the NGSS
***In grades K-2,* children recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.**	**1-ESS 1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted.**
***In grades 3-5,* students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.**	**4-PS 4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.**
***In grades 6-8,* students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide**	**MS-LS 4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life**

information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.	**on Earth under the assumption that natural laws operate today as in the past.**
***In grades 9-12,* students should recognize that different patterns may be observed at each of the scales at which a system is studied. Thus classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced (e.g., classifications based on DNA comparisons versus those based on visible characteristics).**	**HS-PS 1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.**

2. **Cause and Effect: Mechanism and Prediction** lies at the heart of science. Often the objective of a scientific investigation is to find the cause that underlies a phenomenon, first identified by noticing a pattern. Later, the development of theories allows for predictions of new patterns, which then provides evidence in support of the theory. In engineering, the goal is to design a system to cause a desired effect.

Progression of Cause and Effect Across the Grades	Performance Expectation from the NGSS
***In grades K-2,* students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.**	**1-PS 4-3. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of alight beam**
***In grades 3-5,* students identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.**	**4-ESS 2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.**

***In grades 6-8*, students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems.**	**MS-PS 1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.**
***In grades 9-12*, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They recognize changes in systems may have various causes that may not have equal effects.**	**HS-LS 3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors**

3. **Scale, Proportion and Quantity** are important in both science and engineering. These are fundamental assessments of dimension that form the foundation of observations about nature. Before an analysis of function or process can be made (the *how* or *why*), it is necessary to identify the *what*. These concepts are the starting point for scientific understanding**.** The crosscutting concept of Scale, Proportion, and Quantity figures prominently in the practices of “Using Mathematics and Computational Thinking” and in “Analyzing and Interpreting Data.” This concept addresses taking measurements of structures and phenomena, and these fundamental observations are usually obtained, analyzed, and interpreted quantitatively. This crosscutting concept also figures prominently in the practice of “Developing and Using Models.” Scale and proportion are often best understood using models.

Progression of Scale, Proportion and Quantity Across the Grades	Performance Expectation from the NGSS
***In grades K-2*, students use scales (e.g., bigger and smaller; hotter and colder; faster and**	

slower) to describe objects, and length units	
***In grades 3-5,* students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.**	**5-ESS 1-1. Support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth.**
***In grades 6-8,* students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.**	**MS-LS 1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.**
***In grades 9-12,* students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Students use orders of magnitude to understand how a model at one scale relates to a model at another**	**HS-ESS 1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.**

scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).	

4. **Systems and System Models** are useful in science and engineering because the world is complex, so it is helpful to isolate a single system and construct a simplified model of it. “To do this, scientists and engineers imagine an artificial boundary between the system in question and everything else. They then examine the system in detail while treating the effects of things outside the boundary as either forces acting on the system or flows of matter and energy across it-for example, the gravitational force due to Earth on a book lying on a table or the carbon dioxide expelled by an organism. Consideration of flows into and out of the system is a critical element of system design. The properties and behavior of the whole system can be very different from those of any of its parts, and large systems may have emergent properties, such as the shape of a tree, that cannot be predicted in detail from knowledge about the components and their interactions.”**. Systems and system models** are used explore how the system functions, or what may be going wrong. Sometimes investigations are too dangerous or expensive to try out without first experimenting with a model.

Progression of Systems and System Models Across the Grades	Performance Expectation from the NGSS
In grades K-2, **students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.**	**K-ESS 3-1. Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.**
In grades 3-5, **students understand that a system is a group of related parts that and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.**	**3-LS 4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.**

In grades 6-8, **students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions-such as inputs, processes and outputs-and energy, matter, and information flows within systems..**	**MS-PS 2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.**
In grades 9-12, students can investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They can also use models and simulations to predict the behavior of a system, and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They can also design systems to do specific tasks.	**HS-LS 2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere .**

5. **Energy and Matter: Flows, Cycles, and Conservation** are essential concepts in all disciplines of science and engineering, often in connection with systems. "The supply of energy and of each needed chemical element restricts a system's operation-for example, without inputs of energy (sunlight) and matter (carbon dioxide and water), a plant cannot grow. **Energy and matter** are basic to any systems model, whether of a natural or a designed system. Systems are described in terms of matter and energy. Often the focus of an investigation is to determine how energy or matter flows through the system, or in the case of engineering to modify the system, so a given energy input results in a more useful energy output.

Progression of Energy and Matter Across the Grades	Performance Expectation from the NGSS
In grades K-2, **students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.**	**2-PS 1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.**
In grades 3-5, **students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.**	**5-LS 1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.**
In grades 6-8, **students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.**	**MS-ESS 2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.**
In grades 9-12, **students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place,**	**HS-PS 1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processe**

between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	

6. **Structure and function** can be thought of as a special case of cause and effect. Whether the structures in question are living tissue or molecules in the atmosphere, understanding their structure is essential to making causal inferences. Engineers make such inferences when examining structures in nature as inspirations for designs to meet people's needs. Structure and Function are complementary properties. "The shape and stability of structures of natural and designed objects are related to their function(s). The functioning of natural and built systems alike depends on the shapes and relationships of certain key parts as well as on the properties of the materials from which they are made. A sense of scale is necessary in order to know what properties and what aspects of shape or material are relevant at a particular magnitude or in investigating particular phenomena-that is, the selection of an appropriate scale depends on the question being asked, for example, the substructures of molecules are not particularly important in understanding the phenomenon of pressure, but they are relevant to understanding why the ratio between temperature and pressure at constant volume is different for different substances.

Progression of Structure and function Across the Grades	Performance Expectation from the NGSS
***In grades K-2,* students observe the shape and stability of structures of natural and designed objects are related to their function(s).**	**2-LS 2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants**
***In grades 3-5,* students learn different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions.**	

MS-PS 4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	***grades 6-8,*** **students model complex and microscopic structures and systems and visualize how their function depends on their shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. They design structures to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.**
HS-ESS 2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes	***In grades 9-12,*** **students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to show the system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.**

7. **Stability and change** are ways of describing how a system functions. Whether studying ecosystems or engineered systems, the question is often to determine how the system is changing over time, and which factors are causing the system to become unstable. Stability and Change are the primary concerns of many, if not most scientific and engineering endeavors. "Stability denotes a condition in which some aspects of a system are unchanging, at least at the scale of observation. Stability means that a small disturbance will fade away-that is, the system will stay in, or return to, the stable condition. Such stability can take different forms, with the simplest being a static equilibrium, such as a ladder leaning on a wall. By contrast, a system with steady inflows and outflows (i.e., constant conditions) is said to be in dynamic equilibrium. For example, a dam may be at a constant

level with steady quantities of water coming in and out. A repeating pattern of cyclic change-such as the moon orbiting Earth can also be seen as a stable situation, even though it is clearly not static.

Progression of Stability and change Across the Grades	**Performance Expectation from the NGSS**
In grades K-2, **students observe some things stay the same while other things change, and things may change slowly or rapidly.**	**2-ESS 2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.**
In grades 3-5, **students measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change**	
In grades 6-8, **students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time**	**MS-LS 2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.**
In grades 9-12, **students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback**	**HS-PS 1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibriu**

can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.	

Students' understanding of these crosscutting concepts should be reinforced by repeated use of them in the context of instruction in the disciplinary core ideas**.**

Third Dimension :Disciplinary Core Ideas (DCIs)

The continuing expansion of scientific knowledge makes it impossible to teach all the ideas related to a given discipline in exhaustive detail during the K-12 years. But given the great number of information available today virtually at a touch-people live, after all, in an information age-an important role of science education is not to teach "all the facts" but rather to prepare students with sufficient core knowledge so that they can later acquire additional information on their own. An education focused on a limited set of ideas and practices in science and engineering should enable students to evaluate and select reliable sources of scientific information, and allow them to continue their development well beyond their K-12 school years as science learners, users of scientific knowledge, and perhaps also as producers of such knowledge. (NGSS, 2013D, 5)

Specifically, a core idea for K-12 science instruction (NRC, 2012, 30-31) should:

1. Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline.
2. Provide a key tool for understanding or investigating more complex ideas and solving problems.
3. Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge.
4. Be teachable and learnable over multiple grades at increasing levels of depth and experience. That is, the idea can be made accessible to younger students but is broad enough to sustain continued investigation .

In organizing Dimension 3, disciplinary ideas were grouped into four major domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology, and applications of science. (NGSS, 2013E; NGSS, 2013F; NGSS, 2013G, 3; NRC, 2012, 203)

Physical Science	Life Science	Earth and Space Science
PS1 Matter and Its Interactions ***PS1A*** **Structure and Properties of matter** ***PS1B*** **Chemical Reactions** ***PS1C*** **Nuclear Processes** ***PS2 Motion and Stability: Forces and Interactions*** ***PS2A*** **Forces and Motion** ***PS2B*** **Types of Interactions** ***PS2C*** **Stability and Instability in Physical Systems** ***PS3 Energy*** ***PS3A*** **Definitions of Energy** ***PS3B*** **Conservation of Energy and Energy Transfer** ***PS3C*** **Relationship Between Energy and Forces** ***PS3D*** **Energy and Chemical Processes in Everyday Life** ***PS4 Waves and Their Applications in***	***LS1 From Molecules to Organisms: Structures and Processes*** ***LS1A*** **Structure and Function** ***LS1B*** **Growth and Development of Organisms** ***LS1C*** **Organization for Matter and Energy Flow in Organisms** ***LS1D*** **Information Processing** ***LS2 Ecosystems: Interactions, Energy, and Dynamics*** ***LS2A*** **Interdependent Relationships in Ecosystems** ***LS2B*** **Cycles of Matter and Energy Transfer in Ecosystems** ***LS2C*** **Ecosystem Dynamics, Functioning, and Resilience** ***LS2D*** **Social Interactions and Group Behavior** ***LS3 Heredity:***	***ESS1 Earth's Place in the Universe*** ***ESS1A*** **The Universe and Its Stars** ***ESS1B*** **Earth and the Solar System** ***ESS1C*** **The History of Planet Earth** ***ESS2 Earth's Systems*** ***ESS2A*** **Earth Materials and Systems** ***ESS2B*** **Plate Tectonics and Large-Scale System Interactions** ***ESS2C*** **The Roles of Water in Earth's Surface Processes** ***ESS2D*** **Weather and Climate** ***ESS2E*** **Biogeology** ***ESS3 Earth and Human Activity*** ***ESS3A*** **Natural Resources** ***ESS3B*** **Natural Hazards** ***ESS3C*** **Human Impacts on Earth**

Technologies for Information Transfer ***PS4A* Wave Properties** ***PS4B* Electromagnetic Radiation** ***PS4C* Information Technologies and Instrumentation**	***Inheritance and Variation of Traits*** ***LS3A* Inheritance of Traits** ***LS3B* Variation of Traits** ***LS4 Biological Evolution: Unity and Diversity*** ***LS4A* Evidence of Common Ancestry** ***LS4B* Natural Selection** ***LS4C* Adaptation** ***LS4D* Biodiversity and Humans**	**Systems** ***ESS3D* Global Climate Change**
Engineering, Technology, and the Applications of Science		
Core Idea ETS1: Engineering Design ***ETS1.A*: Defining and Delimiting an Engineering Problem** ***ETS1.B*: Developing Possible Solutions** ***ETS1.C*: Optimizing the Design Solution** **Core Idea ETS2: Links Among Engineering, Technology, Science, and Society** ***ETS2.A*: Interdependence of Science, Engineering, and Technology** ***ETS2.B*: Influence of Engineering, Technology, and Science on Society and the Natural World**		

Engineering and technology provide a context in which students can test their own developing scientific knowledge and apply it to practical problems; doing so enhances their understanding of science and, for many, their interest in science as they recognize the interplay among science, engineering, and technology. (NRC, 2012, 12). Engineering would soon be described in the Next Generation Science Standards (NGSS Lead States, 2013). Using three disciplinary core ideas (DCIs), whereas the other 38 DCIs and all seven cross-cutting concepts were described using nouns (e.g., ‘‘Forces and motion,’’ ‘‘Natural selection’’), the engineering DCIs used verbs: ‘‘Defining and delimiting an engineering problem,’’ ‘‘Developing possible solutions,’’ and ‘‘Optimizing the design solution.’’ The core ideas of engineering here sound like activities, not concepts, principles, or theories.

Integrating the Three Dimensions :Performance Expectations

The integration of the three dimensions of The NGSS should occur in student performance expectations that link to the standards expectations, that “describe activities and outcomes that students are expected to achieve in order to demonstrate their ability to understand and apply the knowledge described in the disciplinary core ideas” (NRC, 2012, 218). Performance expectations are not a set of instructional or assessment tasks, but they are the assessable statements of what students should know and be able to do. Some states consider these performance expectations alone to be “the standards,” while other states also include the content of the three foundation boxes and connections to be included in “the standard.” (NGSS, 2013G, 1-2).

" MS-PS1-2" performance expectation can read as follow: the first digit or symbol indicates a grade MS (middle school), the next alpha-numeric code specifies the discipline core idea and sub-idea. (physical science) (NGSS, 2013E).

NRC recommendations for standards development (NRC, 2012, pp. 297-307; Bybee, 2014, 213) ,the standards should: set strong goals for all students, Be scientifically accurate, be limited in number, emphasize all three dimensions, include performance expectations that integrate the three dimensions, be informed by research on learning and teaching, meet the diverse needs of students and states, have potential for a coherent progression across grades and within grades, be explicit about resources, time, and teacher expertise, align with other K-12 subjects; especially the Common Core State Standards and take into account diversity and equity.

Some studies *Interested in developing visions of programs, curricula and units of science based on NGSS* **. In his study Abu Laila (2015)** developed the program of activities for "the first three grad in the primary stage" in light of the NGSS to achieve the educational effectiveness of the learner. **In their study Roseman, et al., (2015)** they realized the vision of Next Generation Science

Standards (NGSS) requires curriculum materials that truly integrate disciplinary core ideas, science and engineering practices, and crosscutting concepts to support three-dimensional learning, in which students use practices to develop and use the science ideas to make sense of phenomena and design solutions to problems. **In their study Algabr & Otaibi (2017)** they identified the extent of inclusion of Next Generation Science Standards (NGSS) in Energy Unit in Science Textbooks in Saudi Arabia. **Alrobian & Aal Hamamah** (2017) analyzed the content of science textbooks of the first grade of intermediate school in Saudi Arabia in the light of the (NGSS). **In their study Issa & Ragheb (2017)** they provided a proposed vision for the development of geological education across the different educational stages in Eygpt from the perspective of "NGSS". **Omar (2017).** Evaluated the content of life sciences curriculum in the secondary stage in the Arab Republic of Egypt in the light of "NGSS".

The researcher benefited from the theoretical framework and previous studies of "the Next Generation Science Standards" in the preparation of the proposed program and preparation of research tools

Second: Science Teacher prepration and the professional Development in the light of NGSS

Given the shifts required of K-12 education under Next Generation Science Standards (NGSS Lead States, 2013), it is certain that change is also required in un/*iversities that prepare science teachers. It would be to involve science undergraduate students in a full investigation that involves a team with the science and engineering practices, crosscutting concepts, and disciplinary core ideas and progresses from an initial question about natural phenomena to the formulation of a model, collection and analysis of data, discourse about the evidence and proposed explanation, and communication of the explanation. Such an experience should provide opportunities to learn about science with most, if not all, of the educational shifts of NGSS, the experience would be very meaningful for future teachers. (Bybee, 2014, 218)

The National Science Education Standards (NRC, 1996) included similar components, but they were not stated as performance expectations. So, content, inquiry, and unifying concepts could be taught separately. The NGSS use of performance expectations requires an integrated approach to instruction, curriculum and assessment. Reforming science teacher education programs would be a direct implication of the adoption. It would be an opportunity to think about the NGSS and the unique needs of elementary, middle, and high school science teachers. Then, design a program for them. Some components of the program might include scientific investigations, an introduction to engineering design, an in-depth study of a scientific breakthrough, study of NGSS, applications in classrooms, and design of a NGSS-based units for student teaching. (Bybee, 2014, 219)

In their study (Krajcik, et al., 2014, 163-164), they provided **a ten-step process** that teachers and curriculum designers can use to design lessons that meet the intent of dimensions of (NGSS). These ten steps are: ***Step 1:*** Select PEs that work together as bundle: Ex. focus on developing understanding of chemical reactions in the middle school band, three related PEs (MS-PS1-1, MS-PS1-2, MS-PS1- 5). ***Step 2:*** Inspect the PEs, clarification statements, and assessment boundaries to identify implications for instruction. ***Step 3:*** Examine (DCIs), science and engineering practices (S & EPs), and crosscutting concepts (CCs) coded to the PEs to identify implications for instruction. ***Step 4****:* Look closely at the DCI (s) and PE (s). What understandings need to be developed? What content ideas will students need to know? What must students be able to do? Take into consideration prior PEs that serve as the foundation for cluster of PEs the lessons will address. ***Step 5***: Identify science and engineering practices (S & EPs) that support instruction of the core ideas (DCIs). Develop a coherent sequence of learning tasks that blend together various science and engineering practices with the core ideas and crosscutting concepts. ***Step 6****:* Develop lesson level PEs. Lesson level expectations guide lesson development to promote student learning; they build to the level of understanding intended in the bundle of PEs. ***Step 7:*** Determine the acceptable evidence for assessing lesson level performances, both formative and summative. ***Step 8****:* Select related Common Core Mathematics Standards (CCSS-M) and Common Core Literacy Standards (CCSS-L). ***Step 9:*** Carefully construct a storyline to help learners build sophisticated ideas from prior ideas, using evidence that builds to the understanding described in the PEs. Describe how the ideas will unfold. What do students need to be introduced to first? How would the ideas and practices develop over time?. ***Step 10****:* Ask: How do the task(s)/lesson(s) help students move towards an understanding of the PE (s)?. ***The researcher*** provide an example of some ten-steps for performance expectation (MS-PS1-2), that bundle with (MS-PS1-1, MS-PS1- 5), and they are focusing on developing understanding of chemical reactions in the middle school band. (NGSS, 2013E, 54-55)

<table>
<tr><td colspan="3">(step 1 &2) Performance Expectation
MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with HCl]. [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]</td></tr>
<tr><td colspan="3">Step 3</td></tr>
<tr><td>science and engineering practices (S&EPs)</td><td>crosscutting concepts (CCs)</td><td>Disciplinary Core Ideas (DCIs)</td></tr>
<tr><td>Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 and progresses to
extending quantitative analysis to investigations,
distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
*Analyze and interpret data to determine similarities
and differences in findings. (MS-PS1-2)</td><td>Patterns:
Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)</td><td>PS1.A: structure and properties of matter: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
PS1.B: chemical reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have</td></tr>
</table>

***Connections of (MS-PS1-2) to Nature of Science: Scientific Knowledge is Based on Empirical Evidence: Science knowledge is based upon logical and conceptual connections between evidence and explanations**		**different properties from those of the reactants molecules, and these new substances have different properties from those of the reactants.**
Step4: Connections of (MS-PS1-2) to other DCIs in this grade-band: *MS.PS3.D; MS.LS1.C; MS.ESS2. A*		
Step4: Articulation of (MS-PS1-2) across grade-bands: *5. PS1. B; HS.PS1. B*		
Step 8: Common Core State Standards Connections: **ELA/Literacy-** **RST. 6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. RST. 6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).** **Mathematics-** **MP.2 Reason abstractly and quantitatively. 6. RP.A. 3 Use ratio and rate reasoning to solve real-world and mathematical problems. 6. SP.B. 4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots. 6. SP.B. 5 Summarize numerical data sets in relation to their context**		

Accounting for student performance across the NGSS' three-dimensional learning will need to have ***multiple means of assessing student learning***: diagnostic, formative, summative, standardized tests and student portfolios. To measure the depth of learning, assessment tasks may ask students to perform hand-on activities, engage with science simulations, create artifacts, develop models, provide explanations, and answer sets of related, complex questions .Assessments must be able to place students along a continuum of progressively more complex understandings. (Best & Dunlap, 2014, 2; Wilson & Bintz, 2014)

Some studies interested in preparing prospective science teachers in the light of (NGSS) such as **study of (Acare, et al., 2015)** its results indicated that prospective secondary science teachers enrolled in Physics by Inquiry (PbI) course at a Midwestern US university developed mostly counter-argument and rebuttal practice. In their study **Campbell & Mc Kenna (2016)**. They examined a scholarship program at a large public research university in California designed to recruit and better prepare undergraduate chemistry, physics, engineering, and computer science majors for teaching careers in high-need secondary schools. In this program, 12 prospective teachers from these majors had the opportunity to "intern" in local physical science and engineering classrooms. These internships took place in the unique classroom contexts of STEM-focused academies within traditional public high schools in classrooms where the prospective teacher participants were able to observe and interact with exceptional mentor teachers and their students. In their study **Idsardi, et al., (2015)** they Recommended with, implications of the use of the "SPCM: science practices in the Classroom Matrix" in prospective science teacher education and practicing teacher professional development. In the study of **Wiyanto, *et al*., (2017)** they aimed to reveal the prospective science teacher' understanding about questioning practice and how the science teacher implement of that in the scientific approach learning, data of the prospective science teacher understanding was explored from their teaching plan that producing during microteaching. The microteaching is an activity that should be followed by students before they conduct partnership program in school. Data about the implementation of facilitating that conducted by the teacher was be collected by video-assisted observation in junior science classes. The results showed that majority of the prospective science teacher had difficulty to write down in their teaching plan about how to facilitate student to ask their questions, even majority of them understood that questioning is not students activity, but it is an activity that be done by teachers. Based on observation showed that majority of teacher did not yet implement a learning that facilitate students to ask questions. **Windschitl & Stroupe (2017)** argued that teacher educators should use powerful principles for instruction, derived from the research referenced in the *Framework*, to inform the design of courses and other preparatory experiences for novices. This implementation strategy contrasts with an alignment approach, in which novices would be asked to familiarize themselves with the *Next Generation Science Standards (NGSS)*, integrate student performance expectations into lesson plans, and teach activities similar to those described in the *NGSS*. They describe the more principled approach as a “three-story challenge” in which students, teachers, and teacher educators have responsibilities to learn and to take up new roles in the educational system that are fundamentally different from the status quo.

Wiyanto, et al., (2018) Recommended with improving the quality of teachers including prospective science teachers should be pursued. Introducing the integrated science learning to prospective physics teachers is needed. In order to achieve this purpose, the “Integrated Science Learning Development” course was designed to prepare the prospective physics teachers to teach integrated science learning in junior high school.

From above studies and Within the limits of the researcher's knowledge,- there is no study- interested in the development of understanding of (NGSS) and scientific interpretations among science students- teachers in general diploma for education

Some studies interested in professional development of science teachers in the light of (NGSS). In their study **Drape, et al. (2013)**, they recommend that ongoing professional development from the school and professional development organization be more deliberate and the integration of more science and NGSS is necessary to keep agriculture education programs competitive as a valuable curriculum within the pre-k-12 system. In their study **Haag & Megowan (2015)** demonstrated that high school teachers in America were reported a higher degree of motivation to use all eight NGSS science and engineering practices than middle school teachers. High school teachers’ responses indicated they felt more prepared to implement NGSS science and engineering practices than middle school teachers. In their study **Ahmed & Almokbel (2016)**. They identified professional development needs for high school biology teachers in Saudi Arabia in the light of the NGSS. In her study **Smith & Nadelson (2017)** investigated the science instruction of three grade 3-5 elementary-level teachers. they used observation, interviews, and surveys to determine the level to which the teachers perceived they taught and engaged in teaching science aligned with the eight NGSS practices. The results showed that the teachers were partially, and intrinsically implementing several of these practices in their instruction, and at the same time could not articulate the eight NGSS practices, teachers' perceive professional development, school culture, and access to additional instructional resources to be essential to their adoption of the NGSS practices. **Rawashdah, et al., (2018)**, confirmed the effectiveness of training program for Science Teachers based on (NGSS) in the developing of the eight Science and Engineering Practices and Self Efficacy among them in Jordan.

The researcher benefited from the theoretical framework and previous studies of science teacher prepration in the light of NGSS in the preparation of the proposed program and preparation of NGSS-aligned lesson plan analysis tool.

Third: Understanding

It's not enough for students to simply memorize science subject for a test; educators want their students to truly understand what they're learning. In "Understanding by Design," Wiggins and Mc Tighe (1998) present a theory of the six facets of understanding. The six facets of understanding are described as what we can do when we understands. We can explain, interpret, apply, have perspective, empathize, and have self-knowledge. (Wiggins & McTighe, 2005; Tomlinson & Mc Tighe, 2006).

Facet1"Explanation": Providing credible reasons- theories and principles based on good evidence and argument to illuminate an event, fact, text or idea; justified and systematic accounts of phenomena, facts, and data; make insightful connections and provide illuminating examples or illustrations.

Facet2 "Interpretation': tell meaningful stories; offer apt translations; provide a revealing historical or personal dimension to ideas and events; make the object of understanding personal or accessible through images, storys, analogies, and models.

Facet3 "Application": effectively use and adaption the structure of science from "facts- concepts- principles- laws- theories" or skill learned in new real situations and diverse contexts.

Facet4 "Perspective": see and hear points of view through critical eyes and ears; see the big picture.

Facet5 "Empathy": find value in what others might find odd, alien, or implausible; perceive sensitively on the basis of prior direct experience.

Facet5 "Self-Knowledge": show meta cognitive awareness; perceive the personal style, prejudices, projections, and habits of mind that both shape and impede our own understanding; aware of what we do not understand; reflect on the meaning of learning and experience.

Some studied interested in developing understanding among teachers, **Penuel and others (2009)** developed teaching for understanding in Earth Science through comparing impacts on planning and instruction in three Professional development designs for Middle school science teachers. In their study **Carpenter, et al., (2015)** They focused their investigation on the prospective teachers' experiences with and understanding of the eight science and engineering practices of (NGSS). The findings suggest that prospective teachers may not understand or recognize all competencies of the eight science and engineering practices that K-12 students are expected to master. This has important implications for teacher education, teachers need to be adequately supported so that they can fully understand the practices as defined in the NGSS and so that they can help their students achieve mastery of all components. Understanding which components of the practices prospective teachers understand the most and which they understand the least can help teacher educators better target their instruction and guidance. **Hanuscin and Zangori, (2016)** suggested that participation of "members of a cohort of 19 elementary education majors enrolled in science methods course" in the methods course and field experience supported the development prospective teachers' practical knowledge of the NGSS in several ways by providing opportunities to experience and plan NGSS-aligned lessons, to 'try out' and analyze the impacts of their instructional designs on student progress toward meeting the NGSS, and to refine their lesson designs in light of that. they presented themes related to three areas in which prospective teachers developed practical knowledge of the standards in ways that were personally meaningful: (a) the NGSS as an appropriate and useful guide for planning and designing instruction, (b) the NGSS as a benchmark for student and self-evaluation, (c) the NGSS as an achievable vision for teaching and learning. Within each theme, they highlight dimensions of practical knowledge including prospective teachers' beliefs about the NGSS, their knowledge of effective teaching and learning, and how that connected to their lesson enactment and teaching practice. **Abd Elkarim,** (2017), confirmed the effectiveness of training program based on the Next Generation Science Standards "NGSS" in developing deep understanding of (NGSS) among primary school Science Teachers in Egypt. In their study **Shernoff, et al., (2017),** they conducted a model of teacher professional development (PD) on the alignment of middle and high school curricula and instruction to the Next Generation Science Standards (NGSSs), The PD model included a 4-day summer academy emphasizing project-based learning (PBL) in the designing of NGSS-aligned curricula and instruction, as well as monthly follow-up Professional Learning Community meetings throughout the year providing numerous opportunities for teachers to develop and implement lesson plans, share results of lesson writing and implementation (successes and challenges), provide mutual feedback, and refine curricula and assessments. An analysis of their written lessons suggested a great range in the extent to which teachers effectively applied their understanding of NGSS to write lessons aligned to NGSS. Interviewed teachers believed that the PD model was helpful to their development as science teachers, and all reported that there were no aspects of the PD that were not helpful. Even though most teachers obtained a basic understanding and conceptualization of NGSS and PBL, their application of this understanding in their curriculum writing varied.

From above studies and Within the limits of the researcher's knowledge, there Scarcity in studies which interested in the development of understanding of (NGSS) among science students-teachers in general diploma for education

The researcher benefited from the theoretical framework and previous studies of understanding in the preparation of the a proposed program as well as in the preparation of the understanding test.

Fourth: Scientific Explanations

The Framework and the Next Generation Science Standards (NGSS), based on the Framework, emphasize scientific explanations construction as "practice 6" of the eight science practices. Scientific explanations practice interrelates to another seven science practices; in response to questions, explanations are developed through analyses of data from investigations and refined through argumentation.

Scientific explanations are accounts that link scientific theory with specific observations or phenomena-for example, they explain observed relationships between variables and describe the mechanisms that support cause and effect inferences about them. Very often the scientific theory is first represented by a specific model for the situation in question, and then a model-based explanation is developed. For example, if one understands the theory of how oxygen is obtained, transported, and utilized in the body, then a model of the circulatory system can be developed and used to explain why heart rate and breathing rate increase with exercise. (NGSS, 2013B, 3; NRC, 2012; 67)

A scientific explanation defined as a statement that is composed of the following: at least one claim, the evidence that is related to the claim, and the reasoning that makes clear the nature of the relationship between them, the explanation framework includes three components: a claim, evidence, and reasoning. The claim makes conclusion that addresses the original question or problem about a phenomenon. The evidence supports the student’s claim using scientific data. This data can come from an investigation that students complete or from another source, such as observations, reading material, or archived data, and needs to be both appropriate and sufficient to support the claim. An appropriate means data that are relevant to the problem and help determine and support the claim. 'Sufficient refers to providing enough data to convince another individual of the claim. Providing sufficient evidence often requires using multiple pieces of data. The reasoning links the claim and evidence and shows why the data counts as evidence to support the claim. In order to make this link, students must often apply appropriate scientific principles. (College Board, 2009; McNeill & Krajcik, 2012, 1-4).

Scientific explanations have great importance: it engage students' higher order thinking skills, support content understanding and model-based reasoning, all of which are considered 21st Century skills. In learning how to construct explanations, students will develop an understanding and communication of the scientific meanings of concepts, theory, hypothesis and "model", appropriate use of evidence, the ability to justify their own written claims and to provide coherent and logical arguments. Students will also gain deeper knowledge of the major theories and models underlying current scientific knowledge, such as the theory of evolution, kinetic-molecular theory and the greenhouse-gas model of climate change; and how these models can explain data patterns or observed phenomena. Participating explanations for phenomena such as climate change can lead to rich discussions in the classroom about how well each explanation is supported by the data, allows students to make informed decisions, and satisfies other scientific values. Constructing model-based or data-based explanations is a powerful skill that gives students opportunities to learn science content more deeply and gain profound insight into the nature of science and the practices and values of professional scientists. (Hoffenberg & Saxton, 2015, 2-3**;** McNeill & Krajcik, 2012, 1-4)

Some studies have been conducted to asses and develop the students' scientific explanations. **Krajcik, (2011)** showed that focusing on scientific explanation skill across the middle school grades helps students develop a deeper and more complete understanding of the scientific phenomena. A scientific explanation should become more advanced as students have more experience with developing and critiquing them. **Hui, Deborah Goh Hui and Mohd Salleh, Shireen Bte** (2015) confirmed the effectiveness of scaffolding strategy DINE (describe, interpret, evaluate) and constructing arguments and explanations to explain phenomena for lower secondary science students. **Hoffenberg and Saxton (2015)** recommended that students need multiple experiences over time to practice science inquiry and scientific explanations, so that by the time students reach high school they will have had sufficient experiences to be successful. Thus, professional development should include not just collaboration with other teachers at same grade level teaching in the same content strand, but also collaboration across grade levels (elementary and secondary) and content strands to structure SI activities in a progressive, age-appropriate way with increasing accurate as students move through the grades. The study of **Hsu, et al., (2015)** confirmed the influence of using A web-based collaborative synchronous inquiry system, ASIS (Argumentative Scientific Inquiry System)) with the structured argumentation scaffold which support students as they worked in groups to carry out inquiry tasks to enhance sixth grade students' skill in constructing scientific explanations and engaging in electronic dialogues. The proposed approach is designed to scaffold the following aspects of argumentation: the argumentation process, the explanation structuring, explanation construction, and explanation evaluation. The study of Ibrahim **(2015)** confirmed the effectiveness of the cooperation between middle school teacher's instructional practices in two different units (plants and water quality). (part 1) and using supports within a mobile devices (part 2) in supporting students in constructing explanations. Cooperation can be thought of as generic and content-specific scaffolds working together to enable students to accomplish challenging tasks, such as creating explanations that they would not normally be able to do without the scaffolds working together. Providing instruction (part 1) focused on understanding how the teacher scaffolds students' initial understanding of the claim-evidence-reasoning (CER) framework. The second component of examining cooperation (part 2: using mobile devices) investigated how this teacher used mobile devices to provide feedback when students created explanations. In their study **Gilmanshina, et al., (2016)** recommended for university teachers working with students- future teachers of chemistry, for young chemistry teachers, for students of extension courses. In view of the results of this study can identify a number of scientific problems and promising areas for further consideration: the deepening and widening of certain provisions contained in the article related to the formation and accumulation of psychologicalpedagogical potential of scientific explanation in teaching chemistry; development of scientific and methodological provision of electronic scientific explanations in teaching chemistry with the aim of developing the unified educational space.

From above studies and Within the limits of the researcher's knowledge,- there is no study- interested in the development of scientific interpretations among science students- teachers in general diploma for education

The researcher benefited from the theoretical framework and previous studies of scientific explanations in the preparation of the proposed program as well as in the preparation of the scientific explanations test.

Research Hypotheses:

To solve the research problem, the researcher tested the following hypotheses:

1. There is a statistically significant difference at significance level (0.05) between the mean rank scores of the research group in the pre and post- administration of the understanding test, in favor of the post- administration.
2. There are moderate science students- teachers' curricular shifts in understanding NGSS reflected in the lesson plans that they developed after studying the proposed program.
3. There is a statistically significant difference at significance level (0.05) between the mean rank scores of the research group in the pre and post- administration of the scientific explanations test, in favor of the post- administration

Methodology

To foster the development of understanding of (NGSS) and scientific explanations for science students- teachers of electronic deploma. For this purpose a proposed program based on Next Generation Science Standards (NGSS) was prepared. Prior to preparation of the proposed program, field literature on NGSS, Science teacher preparation, understanding, scientific explanations were scanned.

First: Preparation of the Proposed Program based on NGSS

The preparation of the proposed program has gone through the following steps:

❖ **Determination of the Principles of the Proposed Program**

principles of the proposed program includes:

- Objectives of science teacher preparation programs in Egypt.
- Requirements of science teacher preparation in the light of (NGSS): to provide the science students - teachers with the knowledge, skills and experience of teaching the learning three dimensions of (NGSS) in science curricula, the following were considered:
  - Emphasis on the knowledge necessary for the professional practices of the science teacher include:
    - Knowledge related to the nature and characteristics of science learners.
    - Knowledge related to the nature of the science curriculua and their objectives which should be learned in the light of (NGSS).
    - Knowledge related to teaching and evaluation to achieve learning goals and performance expectations of (NGSS).
    - Knowledge related to understanding and Scientific Explanations
- ▪ Emphasis on effective teaching skills "planning- implementation-evaluation", and the affective aspects of increasing the interest and motivation of science students- teachers towards learning the program according to the integration of the three dimensions of (NGSS): Practices, Crosscutting Concepts, and Core Ideas.
- ▪ Training science students- teachers on how to adapt existing science curricula to achieve learning dimensions for (NGSS). and practice scientific explanations .
- Principles of constructive and directed self learning approches.

❖ Determination of the Program's General Objectives

the proposed program aims to develop the understanding of (NGSS) and Scientific Explanations among science students-teachers of electronic deploma by using the proposed program.

❖ Determination of the Program's Content

the content of the proposed program includes the main ideas: Importance of the Next Generation Science Standards (NGSS), dimensions of (NGSS), Science and Engineering practices, Crosscutting Concepts (CCs), Disciplinary Core Ideas (DCIs), Integration of three dimensions of (NGSS), and implementation of dimensions of (NGSS) in science curricula**.**

❖ Determination of the Program's Procedural Objectives

The procedural objectives of the proposed program represented by the procedural objectives of the each main idea in the content, as identified in the program in the light of general objectives.

❖ Designing Program's activities

The activities of the proposed program have been formulated in the light of principles of constructivist and student- centered educational approaches, according to $5E_s$ model, which is a learning model that consists of five phases including engaging, exploring, explaining, extending and evaluation. In the engaging phase of the $5E_s$ model, activities that could grab the attention of students are conducted; in the exploring phase, certain experience processes are carried out; in the explaining phase, students are promoted to define and infer; in extending phase, students are expected to make new transfers to existing knowledge; finally in the evaluation phase, the reflections of the processes on the students are evaluated. (Shernoff, et al., 2017, 2).

The Program's activities includes: ***(1****) **engaging activities" claims production",*** which aimed to identify previous students' knowledge and excite their motivation to learn (NGSS), It includes: asking questions, presentation, providing a brief pre- test, training students on strategy of self-questioning, allowing students to formulate the claims; ***(2) exploring activities "evidences identifications"***, which aimed to the construction of new knowledge structures of (NGSS) in memory that can be linked to existing knowledge**,** it includes**:** investigative and exploration activities "in which students practice science and engineering practices to conclude the targeted content of (NGSS) and identify the *evidence*s; ***(3) explanation activities*** **"reasoning formation"**: which aimed to generate links between new concepts of (NGSS) and previous concepts through communication process, students expressed and interpret what they conclude in the previous step; ***(4) extending activities***, in which students apply core principles of (NGSS) (5) ***Evaluation activities***, Where students assess and reflect on their understanding about practices, core ideas and crosscutting concepts of (NGSS). and on implementation of dimensions of (NGSS) in science curricula**.**

- **Teaching aids and Learning Resources used in the program**

It has been identified in each module of (NGSS)

Evaluation methods in the Program

it includes: preliminary evaluation, formative evaluation through "during activities" of phases of $5E_s$ model, and final evaluation represented by the understanding test, NGSS-aligned lesson plan analysis tool, and the Scientific Explanations test

- **Program's validity**

the proposed program was judged by a panel of jury (experts and professors in curricula and methods of Science teaching) (Appendix 1), then the proposed Program was made ready for implementation. (Appendix 2).

Second: Preparation of the instruments of the research

To identify the effectiveness of "the proposed Program" in developing the understanding of (NGSS) and Scientific Explanations among science students- teachers of electronic diploma, the following procedures were followed:

- **Preparation of content understanding (NGSS) test**

This test was prepared as follows: ***Identifying the aim of the test,*** this test aimed at measuring science students-teachers' content understanding of (NGSS**).** ***Identifying understanding facets,*** after reviewing literature and previous related studies**,** the researcher identified four facets of understanding: **(1) Explanation**: students provide developed and meaningful explanations or theories to expand upon events, actions, and ideas. **(2) Interpretation**: students identify meaning in what they've learned. (**3) Application:** students demonstrate the ability to adapt what they've learned for a variety of situations. (**4) Perspective**: students identify a variety of insightful views. ***Formulating the test items,*** some items of the test were in a multiple choice format, complete format, another items were in a true-false format with reasoning. ***Test validity,*** to check the test validity, it was submitted to a panel of jury to validate the comprehensiveness of the items, their suitability to the aims, preciseness of their formulation, their relationship to the sub-understanding facets and preciseness and clarity of instructions. In light of the jury' opinions, modifications were done and the test included 50 items**.** ***Piloting the test,*** the test was administered to a piloting group that consisted of (15 science students in general diploma: Non-search group) at the first term of the academic year "2017-2018"; to achieve these porposes, **(a) Test reliability,** test reliability was calculated by using Quaider Richardson equation 21 (Ali, 2010, 579), reliability coefficient was 0.83 which is an acceptable and suitable one and indicates reliability of the test **(b) The time needed for answering the test,**the average time taken by the students was "55 minutes" including reading the test instructions. ***The final version of content understanding of (NGSS) test,*** in light of the previous results, the test in its final form consisted of 50 items (Appendix 3). the maximum score of the test was "50" and the minimum score was zero. Table (1) shows the specifications of the content understanding of (NGSS) test.

***Table 1: Specifications of* content understanding (NGSS)test**

facets of understanding	No. of items	total	%
Explanation	2,5,7,9,25,26,28,29,30,32,38,41,42,44,46,47, 48 ,50	18	36
Interpretation	3,8,13,21,22,23,31,33,36,40,45	11	22
Application	1,6,11,12,14,15,16,17,18,27, 34, 35,37,39, 49	15	30
Perspective	4,10,19,20,24,43	6	12
total		40	100

❖ Preparation of NGSS-aligned lesson plan analysis tool

To identify science students -teacher's curricular shifts in understanding NGSS reflected in the lesson plans that they developed, the researcher prepare NGSS-aligned lesson plan analysis tool in the light of reviewing literature such as (Krajcik, et al., 2014, 163-164; Schiller, 2015; Shernoff, et al., 2017; NGSS, 2016; NGSS, 2013E). Lesson plan analysis list contains (6 main items) in its initial form, these items are: (1) Selection of PEs that Proportional to existing science topic. (2) Inspection the PEs: clarification statements and assessment boundaries to identify implications for instruction*"2-sub. Items"*. (3) identifiying (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs) coded to the PEs. *"3- sub. items"*. (4) Integration of the three dimensions of NGSS: sensemaking "i.e., making sense out of phenomena and/or designing solutions to a problem to drive student learning", and problem solving with (SEPs), (DCIs), and (CCCs) through the second and third phases of $5E_s$ learning model *"2- sub. items"*. (5) Development of performance assessments (eliciting observable evidence of three-dimensional learning) through the 4^{th} and 5^{th} phase of $5E_s$ learning model "2- sub. items". (6) Monitoring student progress, feedback, and revision (i.e., authentic assessments) through 5 phases of $5E_s$ learning model.

Scale of each sub- item is (1: low level; 2: moderate level and 3: high level). The list was validated by a panel of jury": experts from the field of science education" (Appendix 1), after modifications they suggested were done, then. (Appendix4) represent the final NGSS-aligned lesson plan analysis tool "which include 11 items as a total". the maximum score of the analysis tool was "33" and the minimum score was "11"

- **Preparation of scientific explanations test:** This test was prepared as follows: An open-ended scientific explanation instrument was prepared to measure science students-teachers' skills to construct scientific explanations. The instrument consisted of ten items which ask the students to write scientific explanations for different content areas (i.e. physical science, biological science, and Earth and space). A base explanation rubric was developed to assess, the student skills of writing evidence-based scientific explanations. This explanation rubric included the three components of a scientific explanation; i.e. claim, evidence, and reasoning, to see if greater learning occurred regarding one component compared to another. The rubric offered guidance for thinking about different levels of student achievement for each of those components (McNeill & Krajcik,2012, 4). The rubric included three levels: level 1 = zero score, level 2= one score, and level 3 = two scores. The score for each item was six scores (two scores for each of three components). To check the test validity, it was submitted to a panel of jury" Experts from the field of science education" (Appendix 1). modifications were done. Test was administered to a piloting group, (15) science students' who were not part of the research group. Reliability of the test was calculated by using Cronbach's alpha (Sulaiman, 2010, 579). Reliability coefficient was 0.87 which is an acceptable and suitable one and indicates reliability of the test. The **scientific explanations test** took approximately 35 minutes for students to complete. The final instrument consisted of "10 items", so that the maximum score was "60" and minimum is "zero"

Table 2: Basic scientific explanation rubric

Components	Level 1=0	Level 2 = 1	Level 3=2
Claim: a sentence that answers the scientific question	Does not make a claim, or makes an inaccurate claim	Makes an accurate but incomplete claim	Makes an accurate and complete claim
Evidence: data or observations that support the claim	Does not provide evidence, or only provides inappropriate evidence that does not support the claim)	Provides appropriate, but insufficient evidence to support the claim; may include some inappropriate evidence	Provides appropriate and sufficient evidence to support the claim
Reasoning: Using Scientific principles to show how the evidence supports the claim	Does not provide reasoning, or only provides reasoning , that does not link the evidence to the claim	Provides reasoning that links the claim and evidence; repeats the evidence and/or . includes some scientific principles, but is not sufficient	Provides reasoning that links evidence to claim; includes appropriate and sufficient scientific principles- .

Third: Research design and experiment procedures

❖ Research design

The research followed the descriptive method in identifying the theoretical frame. Also used the quasi-experimental method; pre/ post one group

❖ Selection of the population and research group

The research population was general diploma at the Faculty of Graduate Studies for Education, Cairo University for the academic year 2017/ 2018. Participants were fifteen (15) electronic diploma students who studied the science methods course.

❖

❖ Pre- administration of the instruments

The instruments of the research (content understanding (NGSS) test and scientific explanation test) were administrated to

the research group 26 /3/2018.

❖ Implementation of the proposed program

The implementation of the proposed program began on 2 /4/2018, and ended on 7 /5/2018. The proposed program was uploaded on the site of electronic diploma http://ies.elearning.cu.edu.eg/new/ at the Faculty of Graduated Studies for Education, Cairo University, the second semester 2017-2018. Where the program was raised on the forum of science teaching methods course

http://ies.elearning.cu.edu.eg/new/mod/forum/view.php?id=71, and also uploaded on special WhatsUp group

In the first week, the researcher began a preliminary lecture explaining the idea of the program, the bases on which it is based, the basic rules on which the program goes, how important it is for them and the tasks they will perform.

The researcher has met students at virtual classroom in science teaching methods course twice a week for two hours "sum. Of hours are (20 hr_s.); to foster challenges, which faced students during the study of the program moduels and to discuss the results of activities and to assess students through application and evaluation activities.

Post- administration of the instruments of the research After the research experiment, the research instruments (content understanding (NGSS) test, NGSS-aligned lesson plan analysis tool and scientific explanations test) were administrated to the research group on 14/5/2018, face to face not online and data were statistically treated.

Results of the study and their interpretations

This section presents results of the research in terms of its hypotheses.

First: Results of administration of conent understanding (NGSS) test To Check the validity of the first hypothesis: "there is a statistically significant difference at level (0.05) between the mean rank scores of the research group in the pre and post-administration of the understanding test", the researcher used SPSS- program "version" 19, and used Wilcoxon test for two-related samples to calculate Z- Values and effect size as presented in table (3)

Table 3: Mean Rank, Sum. of Ranks, z-values and effect size of the pre-post scores of understanding test for research group N= 15

Understanding facets		No.	Mean Rank	Sum. of Ranks	Z-Value	**Effect Size**
Explanation	Neg. rank	0	.00	.00	-3.439*	o.638
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				
Interpretation	Neg. rank	0	.00	.00	-3.497*	0.638
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				
Application	Neg. rank	0	.00	.00	-3.455*	0.631
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				
Perspective	Neg. rank	0	.00	.00	-3.482*	o.636
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				
Total test	Neg. rank	0	.00	.00	-3.434*	0.627
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				

(* means Z significant at 0.01). To ascertain the magnitude of the experimental effect of the independent variable "the proposed program", effect size has calculated from the equation Effect Size = $z/\sqrt{N}$ (Cohen, 1988), where N refers in the case of "2- related sample" with The total number of participants multiplied by the number of times the tool was applied; i.e N = 15×2=30.

It is clear from Table () that there is a statistically significant difference at level (0.01) between the mean rank scores of the research group in the pre and post- administration of the understanding test as a whole and its facets, in favor of the post-administration, where Z-Value "Wilcoxon" was significant at level (0.01) in the test as a whole and its facets. And also the effect size was great in the test as a whole and its facets, which indicates a great effect of "the proposed program" in developing understanding of (NGSS) among science students. **Thus, *the first hypothesis is accepted.*** Moreover, the researcher calculated "Black’s modified gain ratio" from post- mean score (42.80) and pre- mean score (3.53), Gain ratio =(1.64), which indicate the effectiveness of " the proposed program "in developing understanding of (NGSS) among science students. **Thus, *The second question of research was answered.***

This result of the research" the great effect **and** effectiveness of the proposed program in developing understanding of (NGSS)**" is consistent with the results of studies** (Carpenter, et al., 2015;; Hanuscin and Zangori, 2016; AbdulKarim, 2017; Shernoff, et al., 2017) in the effectiveness of preparing and professional programs in developing knowledge and practical understanding of (NGSS) for prospective and in- service science teachers. **The previous result of the current research can be attributed to**: the proposed program is based on providing the science students with the knowledge of the three dimensions: S&EPs, DCIs and CCs of (NGSS) and its integration through instruction and curriculum. The program based on principles of constructivist, learner- centered educational approaches. And due to Program’s activities were practiced by science students during each topic of Program content topic**s according to5E$_S$ model,** whic**h** includes**: *(1*)** ***engaging activities*"*:** which aimed to identify previous students' knowledge and excite their motivation to learn (NGSS); ***(2) exploring activities***, which aimed to the construction of new knowledge structures of (NGSS), it includes**:** investigative and exploration activities" in which students practiced science and engineering practices to conclude the targeted DCIs of (NGSS) through CCs, which developed *explanation facet* of understanding, which developed *application facet* of understanding; ***(3) explanation activities***, in which students illustrated their understanding of (NGSS), which developed *interpretation facet* of understanding; (4) extending activities: in which students apply their accepted knowledge of (NGSS) in new authentic teaching situations, which developed *application facet* of understanding. (5) ***Evaluation activities***, Where students assessed their ideas, concepts and practices about (NGSS)), which developed perspective facet of understanding. **This result of the current research also can be attributed to** good communicate through synchronous and synchronous tools in electronic diploma and through the Whats Up group.

Second: Results of administration of the lesson plan analysis tool

To Check the validity of the second hypothesis: "There are moderate science students- teachers' curricular shifts in understanding NGSS reflected in the lesson plans that they developed after studying the proposed program". Table (4) indicates the result of NGSS-aligned lessons plans analysis. Table (4) results of NGSS-aligned lessons plans analysis

Students	PEs Selec. "1sub-item" 3scores	PEs Inspec. "2sub-items" 6scores	3-D Ident. "3sub-items" 9scores	3-D Integ. "2sub-items" 6scores	PEs Assess. "2sub-items" 6scores	Monitoring Progress "1sub-item" 3scores	Total 33scores
Stud.1	3	4	9	4	4	3	29
Stud.2	3	4	9	4	4	2	28
Stud.3	3	5	8	5	3	3	27
Stud.4	2	4	9	4	4	3	26
Stud.5	3	5	8	4	4	2	26
Stud.6	3	4	9	4	4	3	27
Stud.7	2	4	9	3	4	2	24
Stud.8	3	4	8	4	5	3	27
Stud.9	3	4	8	5	5	3	28
Stud.10	3	3	8	4	5	3	26
Stud.11	3	4	9	4	4	2	26
Stud.12	3	5	9	5	4	2	28
Stud.13	3	3	8	4	4	3	25
Stud.14	2	4	9	3	3	2	23
Stud.15	3	4	9	4	4	3	27

Note: Scale of each sub- item is (1: low level; 2: moderate level and 3: high level). **It** is clear from table (4)**. For (1) Selection of PEs item:** most of science students- teachers (12 from 15) have high level. **For (2) Inspection the PEs item:** most of science students- teachers (10 from 15) have moderate level**. For (3) Identifiying three dimensions**: all students have high level. **For (4) Integration of the Three Dimensions of NGSS**: most of students (9 from 15) have moderate level. **For** (5) **Development of Performance Assessments:** most of students (10 from 15) have moderate level**. For** (**6) Monitoring Student Progress, Feedback, and Revision:** most of students (9 from 15) have high level**. For total plan:** most of students have moderate level, which indicate moderate curricular shifts in science students- teachers' understanding NGSS reflected in the lesson plans that they developed. **Thus*, the second hypothesis is accepted and The second question of research was answered.***

The previous result of the current research "moderate curricular shifts" **is consistent with the results of studies** (Shernoff, et al., 2017; Smith & Nadelson, 2017; Hanuscin and Zangori, 2016)

The previous result of the current research can be explained as follow: For moderate shift in ***inspection the PEs,*** it may be a attributed to shortage in determination of PEs clarification statements and assessment boundaries. For moderate shift in ***integration of the three dimensions of NGSS,*** students- teachers found success in utilizing the Performance Expectations, their unpacking of these in designing lessons was limited to the Science Practices and Disciplinary Core Ideas. That is, they did not develop an understanding of how to utilize the Crosscutting Concepts to achieve the kind of 'three-dimensional learning' advocated for in the NGSS. For moderate shift in ***development of performance assessments,***students may be have not mastered this step in ---.For high level of ***monitoring student progress, feedback, and revision***, students practiced them through lessons plans aligned to $5E_S$ model in science methods course.

Third: Results of administration of the scientific explanations test

To Check the validity of the third hypothesis: "there is a statistically significant difference at level (0.05) between the mean rank scores of the research group in the pre and post- administration of the scientific explanation test", the researcher used SPSS-program "version" 19, and used Wilcoxon test for two-related samples to calculate Z- Values and effect size as presented in table (5)

Table 5: Mean Rank, Sum. of Ranks, z-values and effect size of the pre-post scores of scientific explanations test for research group N= 15

Explanations component		No.	Mean Rank	Sum. of Ranks	Z-Value	**Effect Size**
Claim	Neg. rank	0	.00	.00	-3.431*	o.626
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				
Reasoning	Neg. rank	0	.00	.00	-3.425*	0.625
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				
Evidence	Neg. rank	0	.00	.00	-3.442*	0.628
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				
Total test	Neg. rank	0	.00	.00	-3.425*	0.625
	Pos. rank	15	8.00	120.00		
	Ties. rank	0				
	Total.	15				

(* means Z significant at 0.01)

It is clear from Table (5) that there is a statistically significant difference at significance level (0.01) between the mean rank scores of the research group in the pre and post- administration of the scientific explanations test, in favor of the post- administration, where Z-Value "Wilcoxon" was significant at level (0.01) in the test as a whole and its skills. And also the effect size was great in the test as a whole and its facets, which indicates a great effect of "the proposed program" in developing scientific explanations skills among science students. Thus, ***the third hypothesis is accepted***. Moreover, the researcher calculated "Black's modified gain ratio" from post- mean score (55.80) and pre- mean score (6.67), Gain ratio = (1.74), which indicates the effectiveness of "the proposed program" in developing scientific explanations skills among science students. ***Thus, The fourth question of research was answered.***

This result of the research" the great effect **and** effectiveness of the proposed program in developing scientific explanations**" is consistent with the results of studies** (Acare, et al., 2015; Smith & Nadelson, 2017; Wiyanto, et al., 2017) in the effectiveness of preparing and professional programs in developing scientific and engineering practices of (NGSS) for prospective and in- service science teachers. **The previous result of the current research can be attributed to**: the proposed program is based on providing the science students with the skills and experience of the three dimensions: S&EPs, DCIs and CCs of (NGSS) and its integration through instruction and curriculum. The program based on principles of constructivist, learner- centered educational approaches. And can be attributed **to** Program's activities were practiced by science students during each topic of the Program **according to5E$_S$ model,** whic**h** includes**:** ***(1)*** ***engaging activities*"**:** which aimed to identify previous students' knowledge, in which they could practice *claims production of scientific explanation*; ***(2) exploring activities***, in which students practiced Science and Engineering Practices and utilized CCs, they could practice *"evidence identifications of scientific explanation;* since scientific explanation related to many of scientific practices" and utilizing CCs develop formation of components of scientific explanation.; ***(3) explanation activities***, in which students illustrated their conclusions and understanding of (NGSS), they could practice *"all component of scientific explanation, Especially reasoning formation"*; (4) extending activities: in which students apply their accepted knowledge of (NGSS) in new authentic teaching situations, they could apply *three components formation of scientific explanation* (5) ***Evaluation activities***, Where students assessed and reflected their ideas, concepts and practices about (NGSS)), they could reflect *three components of scientific explanation*.

Recommendations

In the light of the results of the current research, the researcher recommends these recommendations:

- A deep understanding of content is important to successful implementation of the NGSS.
- Preparing science students- teachers to implement NGSS.
- Implement a series of connected lessons (unit) with students. As a consequence, prospective teachers were unable to develop an understanding of long-range planning and evaluation of students' progress toward meeting standards.
- Professional development (PD) is important to assist science teachers to design high quality curricula and generate instruction aligned to NGSS.
- Teacher educators should learn how to unpack the NGSS and understand how can make the Crosscutting Concepts a more salient feature of their instruction and how might provide images of the NGSS in action that explicitly highlight this dimension.
- Identifying and building teacher educators' understanding of three-dimensional learning is critical in supporting pre service elementary teachers in understanding and including each of the three dimensions in their own lesson planning.

Suggestions for further research: In light of the results of the research, the researcher suggests the following researches:

1. A proposed program based on Next Generation Science Standards (NGSS) for the development of science and engineering practice among pre service science teacher.
2. A proposed program based on Next Generation Science Standards (NGSS) for the development of deep understanding and scientific inquiry skills among pre service science teacher.
3. A proposed program based on Next Generation Science Standards (NGSS) to develope nature of science and design thinking among pre service science teacher.
4. A training program based on the Next Generation Science Standards "NGSS" to develop deep understanding and Scientific argumentation among biology teachers.

5. A training program based on the Next Generation Science Standards "NGSS" to develop understanding and Scientific explanations among physics teachers.
6. A proposed program based on the Next Generation Science Standards "NGSS" to develop future thinking and Scientific argumentation among secondary school students.
7. A proposed program based on the Next Generation Science Standards "NGSS" to develop understanding and Scientific argumentation among preparatory School students.

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