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The level of understanding scientific and engineering practices in light of the next generation science standards among preservice student teachers

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The purpose of the study is to investigate the level of understanding of first three grade preservice teachers of the scientific and engineering practices according to next generation science standards (NGSS) at the World Islamic Sciences University. The sample of the study consisted of 154 fourth year female student teachers at International Islamic Sciences University in the academic year 2019/2020. The study administered a questionnaire containing 32 items that show the indicators of scientific and engineering practices. Its validity and reliability were checked by a committee of experts and by calculating Cronbach's Alpha coefficient which was 0.90. The findings of the study showed that the level of the student teachers' understanding of scientific and engineering practices in light of the next generation of science standards was low. The study recommended the need to reconsider the plans of the bachelor's degree class teacher and the importance of providing a science laboratory to teach scientific courses at the university.

Key words: First three grade teachers, scientific and engineering practices, Science Standards (NGSS).

INTRODUCTION

In light of the rapid changes in science, scientific knowledge and technological revolution, the need for development in scientific education programs became urgent, which led to global reform efforts in science. Among the most prominent projects and programs are Science curriculum reform based on the interaction between science, technology, and society (STS), Science for All Americans of the American Association for the Advancement of Science (AAAS), National Standards for Scientific Education (NSES) issued by the National Research Council (NRC), Science, Technology, Engineering and Mathematics Education (STEM), and Next Generation Science Standards (NGSS). Among the most important things that these projects focused on are: education quality, education for understanding, constructivism and scientific culture, scientific inquiry, problem solving, and critical thinking. Many countries designed their educational curricula for the sciences based on the thinking and educational developments introduced by these reform projects.

Bybee (2010) pointed out those learning outcomes in current science programs are no longer sufficient to

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prepare students for life and work in the twenty-first century, confirming that there is a great gap between the skills that school students learn and those they need in life and work in the knowledge-based economy. The science curricula should be blamed for not being able to prepare students for the current era. Therefore, the National Research Council (NRC: 2012) has presented a general framework for teaching science from kindergarten to twelfth grade (k-12) based on three pillars; The central ideas, overlapping concepts, scientific and engineering practices, with the aim of providing students with the skills of the twenty-first century. These three pillars have been integrated and interconnected together in the so-called Next Generation Science Standards: NGSS, which aims to prepare students for work, life and citizenship by adopting the term scientific and engineering practices - as an alternative to the idea of "skills". This calls for coordination between knowledge and skill at the same time. Scientific and engineering practices are considered a new start in science education, as they focus on students' possession of knowledge and skill at the same time. This means linking theory with application when teaching science, which is what we seek in science education (NGSS, 2013).

With these developments and radical changes in the science curricula in the Hashemite Kingdom of Jordan, educators agree that the success of these projects and achievement of their goals is primarily linked to the science teacher, so the need is urgent for an efficient teacher who can deal with the elements of this process in a way that helps to achieve the educational goals. It is unable to activate any reform in an educational system without qualified science teachers so that they combine the two knowledge: scientific knowledge in the specialization and educational knowledge to teach the developed science curricula. It is familiar with modern educational concepts on which it is built and can deal with developed textbooks and mastery of the skills that help him/her to teach science. It emphasizes knowledge and practices for the teacher to focus on pre-service teacher preparation programs on the educational preparation side, as it represents an important aspect of the teacher preparation program plans that aim to prepare the student / teacher from the educational aspect.

Also, all science standards for global, regional and local science teachers focus on the educational knowledge of a science teacher and consider it a basic standard within its standards. This confirms the significance of knowledge for the science teacher of the first three grades of educational developments that are no less significant than the specialized scientific knowledge. Studies by Al-Jarjawi and Nashwan (2006) and Al-Aalemat (2010) indicated that there is a decrease in the level of that knowledge, which limits teaching practices.

Whereas, the basic competencies of the general framework for science education in Jordan are in line with the competencies of the twenty-first century that were developed by the National Research Centre (NRC, 2012); it emphasized that the main goal of science education is to develop mind habits, preoccupation with scientific investigation and solving problems. It is what the Next Generation Science Standards (NGSS) aim at through scientific and engineering practices in which students learn content by studying a phenomenon in their surroundings, so that they follow the behaviour of the scientist to study this phenomenon and find solutions or design models (engineering). Therefore, the development of scientific and engineering practices for students require the teacher to play a different role from his/her role in traditional teaching, to become the guide, expert, supporter of students' learning, and the provider of continuous and direct feedback to them (Aspy et al., 1993). From this point,there is need for teacher preparation and training for his/her new roles, for without a trained and learned teacher who is fully aware of his/her role, no educational system can achieve its goals, and studies have shown the need to reconsider the content of teacher training and preparation programs to meet their needs and fill the gap in their competencies (Toqan, 2005). As it is significant for pre-service grade teachers to have have educational developments in which the science curriculum is built, this study reveals the level of understanding of the first three grade preservice teachers of scientific and engineering practices in light of next generation science standards (NGSS).

Statement of problem

From the experience of the researcher, it was observed that there is a clear weakness among teachers in general and first-grade teachers in particular in public and private schools in Jordan. It is represented by how to change their teaching practices in line with the requirements of the twenty-first century and the new roles of both teachers and students in the educational process. The World Bank report raised an important issue about education in the Jordan 2017 Ministry of Education, (2018), International Bank (2012), noting that teachers in Jordan possess insufficient skills, and that in-service training is limited.

The results of the Jordanian students in the Program of International Student Assessment (PISA) indicated that the test results of Jordanian students for the year (2018) reached 400 point, which is less than the acceptable average of the Organization for Economic Cooperation and Development (489 points), so Jordan was ranked 59, and the universally accepted rank is 24 (PISA, 2018). Several studies indicated the need for teachers to undergo focused and convincing training programs in order to achieve the goals of the Jordanian Ministry of Education, such as the study of Amayrah et al. (2012)

which showed that the degree of possession and practice of basic stage teachers to the principles of knowledge economy was of a moderate degree; the study of Al-Jaafara and Al-Zaydyeen (2016) showed that the perspectives of school principals and school supervisors in possession of primary school teachers' degree were at a moderate level; the study of Al-mutiri A, Al-mafaraj (2007) recommended the followings: to implement training programs in order to prepare and train teachers to keep pace with the accelerating developments of the age; to move from traditional training to modern technological training; to stand by all means on the international contemporary trends in developed countries in the field of preparing and training teachers and making use of them in proportion to the specificity of each country and its educational system.

The teacher has the primary role to play in the educational process and performs the vital function in the teaching process, so it is imperative to prepare the teachers professionally in line with the developments in the twenty-first century.The educational process in Jordan is witnessing a remarkable development and a qualitative shift in education. It has sought through the development of curricula for the educational stages from kg-12 with the aim of bringing about changes in educational outcomes.Currently, after the new released standards (NGSS -the Next Generation Standards for Science), there arouse interest in the education system, for several reasons, like preparing students for jobs so that they possess critical thinking and investigation-based problem solving skills (NGSS, 2012). Senider (2012), Senider et al., (2014), study ensured that scientific and engineering practices and training of science teachers on how to deal with science curricula and new strategies in teaching and evaluation have not been adequately taken care of. This requires determining what science teachers possess and what they have been trained on. Due to the lack of educational literature, addressing scientific and engineering practices in the light of NGSS of the first three grade pre-service teachers in Jordan, there is need to diagnose this reality, the knowledge related to these standards and to present proposals that help in employing them in educational programs and plans for student teachers before their graduation. Thus, the problem of the study is in accordance with this approach to identify the level of understanding of the first three grade pre-service teachers of scientific and engineering practices in light of the next generation Science Standards (NGSS).

Study questions

(i) What is the level of the first three grade pre-service teachers' understanding of scientific and engineering practices according to NGSS standards?
(ii) What is the effect of the studying year level on the evaluations of the first three grade pre-service teachers' knowledge of scientific and engineering practices according to NGSS standards?

Study objectives

Exploring the level of the first three grades classroom teachers understanding of scientific and engineering practices; according to NGSS standards in the light of the difference in the studying year.

Study Significance

The importance of the study is presented in the advantages offered to the field of teaching science for the first three grades, through:

(i) Drawing universities' attention to the need of developing their teaching plans for the Bachelor's degree for classroom teacher major in the light of NGSS standards.
(ii) Directing the attention of higher education and the ministry of education towards the preparation of professional development programs for the first three grades teachers according to NGSS and providing necessary support to facilitate its implementation in the classroom.

Study limitations

The findings of the study is limited to:

Objective limitations: The study used NGSS (Next generation science standards) only.
Time limitations: The first semester of the academic year 2019/2020.
Place limitations: The World Islamic Sciences University.
Human limitations: Bachelor's students/ classroom teacher major.

The tools used in this study were developed by the researcher, depending on the validity and reliability coefficients. Psychometric properties were checked.

Definition of terms

Next Generation Science Standards (NGSS): New standards for teaching science are stated in the United States of America (NGSS Lead States, 2013). These were phrased into: pivoting ideas**,** overlapping concepts, science and engineering practices based on the general frame of teaching science from kindergarten to secondary stage.

Science and Engineering Practices: It is a NGSS domain referring to the applied aspect for those

standards. It consists of eight main practices used by scientists when;asking questions (for science) and defining problems (for engineering), developing and using models, planning and carrying out investigations, analyzing and interpreting data, mathematics and computational thinking, constructing explanations (for science) and designing solutions (for engineering), engaging in argument from evidence and obtaining, evaluating, and communicating information (NRC, 2012). These were measured through interviews prepared especially for measuring scientific and engineering practices (pre and post) for preservice teachers inside lectures as well as the samples' responses on the scientific and engineering practices questionnaire developed for the purposes of the current study.

Previous studies

Despite the importance of the first three grades teachers' knowledge of all educational developments in the field of their majors, the researcher found only a few studies on this particular topic. Staver (2007) indicated that our life is filled with the results of scientific investigations and engineering and technological developments. Therefore, students must be trained on how to conduct scientific inquiry. Furthermore, the findings of studies (Ambosaidi, 2013; Reiser et al., 2012) showed that there is a gap between theory and practice and there is a low level of applying scientific practices by science teachers.

In a dramatic response to embody the practical and applied picture to see the general framework for science education, the next generations of science standards NGSS were set in 2013 by the NRC council in cooperation with the National Academy of Science (NAS) and American Association for the Advancement of Science (AAAS) as well as National Science Teachers Association (NSTA), phrased to work through three dimensions at the same time inside the classroom (pivoting ideas**,** overlapping concepts, science and engineering practices). The National Science Teachers Association (NSTA) warned about the responsibility of science teachers to understand the general framework of science education and study it in all its details and focus on scientific and engineering practices in order for them to implement the vision of NGSS (Lead States, 2013: NGSS).

In another study (Duschi and Bybee, 2014; Boesdorfer and Staude, 2014), it was confirmed that the effective professional development starts when teachers realize what they are teaching in their classrooms and the practices they used before adopting NGSS directly. Kawasaki (2015) investigated in a qualitative study the ability of teachers to integrate scientific and engineering practices in their classroom practices. A sample of 7 intermediate stage teachers were interviewed, then a questionnaire was answered after visiting them in their classes. The researcher focused on the goals teachers seek to achieve at the end of the semester and the variety of strategies used by them to achieve the vision of NGSS. The findings of the study showed differences in teachers' ability to use these strategies, and Kawasaki attributed this disparity mainly to pre- and in-service teacher training and training programs. He recommended what he called: "Teacher NGSS Standards (NGSS) teachers " should be built on standards for the next generation of learners (NGSS Learners).

Brownstein and Horvath (2016) evaluated the performance of preservice teachers in applying scientific and engineering practices. The study adopted a qualitative approach by developing Educative Teacher Performance Assessment: EDTPA, 4 male teachers and 6 female teachers were trained for 90 h; then each one of them taught for 10 weeks in public schools. The teacher case was analyzed. Tthe results indicated that the most common practices undertaken by teachers were in the following order: the practice of analyzing and interpreting data, constructing interpretations, designing solutions, obtaining information and communicating with it; while the least practices were "asking questions".

Furthermore, Harris et al. (2017) evaluated science teachers and the results showed that most teachers are not well prepared to incorporate the proposed changes in NGSS into their curricula and educational plans. Based on the foregoing, it is clear that teachers are responsible for promoting their professional growth before and during the service through knowledge of educational developments and the need to employ them in their teaching. This would require high competence in proportion to their new tools as well as high competence in scientific and engineering practices.

METHODOLOGY

The researcher adopted the descriptive approach which is based on describing the phenomenon as in the real situation by collecting data from the educational field; thereafter, data were analyzed and results extracted.

Population and sample

The sample of the study consisted of 154 first degree student teachers at the World Islamic Sciences University in Jordan in the first semester of the academic year 2019/2020; they were selected through random sampling. The sample (50%) consists of female student teachers from the same university (300 teachers). Table 1 shows the numbers of student teachers from year one to year four.

Study tool

The study administered a questionnaire based on the description of (NGSS) standards of scientific and engineering practices (http://ngss.nsta.org/practicesfull.aspx). To ensure its validity, all the related standards were taken into consideration. They were categorized into eight domains, and then items were distributed into

Table 1. the numbers of student teachers from year one to four.

Study level	Numbers
First year	15
Second year	63
Third year	42
Fourth year	34
Total	154

Table 2. Reliability of the tool.

S/N		Cronbach-Alpha	Pearson
1	Asking questions (for science) and defining problems (for engineering)	0.81	0.87
2	Developing and using models	0.86	0.78
3	Planning and carrying out investigations	0.88	0.74
4	Analyzing and interpreting data	0.82	0.81
5	Using mathematics and computational thinking	0.80	0.86
6	Constructing explanations (for science) and designing solutions (for engineering) and engaging in argument from evidence	0.84	0.80
7	Obtaining, evaluating, and communicating information	0.86	0.83
	Total	0.90	0.88

The criteria used to determine the level of understanding is:(0.66- 1.66) low; (1.67-2.33) average; 2.34- 3.00) high.

the domains. The researcher presented the items to a committee of 12 experts from the faculties of education in the Jordanian universities. In order to ensure the importance and relevance of the items that were chosen, and based on the opinions of the arbitrators, the researcher chose the items that are most representative and important to the fields . The number of the items were 32; thereafter, it became 42 items which were distributed into eight domains. The researcher verified the validity of the tool.

Reliability of the tool

Reliability was confirmed using two methods: the internal consistency method using the Cronbach-Alpha equation, and the test-retest method. The two questionnaire was applied to 30 individuals from outside the study sample, and was re-applied after two weeks. The test reliability factor was calculated using Pearson correlation coefficient between the results of the two applications, as shown in Table 2.

FINDINGS

This part contains the results of the study obtained from the questions.

The first question: What is the level of the first three grade teachers' understanding of scientific and engineering practices according to NGSS standards?

To answer this question, means and standard deviations of the first three grades teachers' understanding of scientific and engineering practices according to NGSS standards were calculated in general and for each domain. Table 3 shows the results. Table 3 shows that the level of classroom student teachers' understanding of scientific and engineering practices according to NGSS was low, as the total mean was 1.62 with a standard deviation of 0.34; the domains ranged between low and average levels as the means ranged between 1.45 and 1.72. Asking questions and defining problems domain came in the first rank with a mean of 1.72 and standard deviation of .39 at an average level. Furthermore, planning and investigations were carried out with a mean of 1.70 and standard deviation of 0.42 within an average level. Meanwhile, developing and using models domain came in the last rank with a mean of 1.55 and standard deviation of 0.41 at a low level. Moreover, analyzing and interpreting data domain came in the last rank with a mean of 1.45 and standard deviation of 0.36 at a low level. Regarding the items of each domain, they are as follows.

Asking questions and defining problems

Table 4 shows that the level of understanding of the classroom student teachers of scientific and engineering practices in light of the next generation of science standards for the items in the domain of asking questions

Table 3. Means and standard deviations of the first three grades teachers understanding of scientific and engineering practices according to NGSS arranged in descending order.

S/N		M	SD	RANK	Level
1	Asking questions and defining problems	1.72	0.39	1	Average
3	Planning and carrying out investigations	1.70	0.42	2	Average
5	Using mathematics and computational thinking	1.70	0.38	2	Average
7	Obtaining, evaluating, and communicating information	1.69	0.38	4	Average
6	Constructing explanations (for science) and designing solutions (for engineering) engaging in argument from evidence	1.56	0.41	5	Low
2	Developing and using models	1.55	0.41	6	Low
4	Analyzing and interpreting data	1.45	0.36	7	Low
	Total	1.62	0.34		Low

Table 4. Means, Standard Deviations and ranks for teacher students' understanding of scientific and engineering practices in the domain of asking questions and defining problems arranged in descending order.

S/N	Item	M	SD	Rank	Level
2	The teacher encourages students to ask questions showing understanding of the concept or phenomenon	2.01	0.81	1	Average
3	The teacher encourages students to ask questions that demonstrate their ability to apply concepts in new life situations	1.68	0.73	2	Average
1	The teacher encourages students to ask questions.	1.59	0.66	3	Low
4	The teacher encourages students to ask questions that lead them to produce new knowledge	1.59	0.67	3	Low
	Asking questions and defining problems	1.72	-039		Average

and defining the problem was average; the mean was 1.72 and the standard deviation of 0.39. The items came in the middle and low levels, as the means ranged between 2.01 to 1.59. Item 2 came first in the rank, which states: "The teacher encourages students to ask questions that show their level of understanding of the concept or phenomenon" ; it has a mean of 2.01 and standard deviation of 0.81. Item 3 came second in the rank which states, "The teacher encourages students to ask questions that show their ability to apply concepts in new life situations"; it has a mean of 1.68 and standard deviation of 0.73; it is on average level. Item 1 came last in the rank, which states that, "the teacher encourages students to ask questions" and Item 4 which states "The teacher encourages students to ask questions that lead them to produce new knowledge"; it has a mean of 1.59 and two standard deviations of 0.66 and 0.67 at a low level.

Planning and carrying out investigations

Table 5 shows that the level of understanding of the classroom student teachers of scientific and engineering practices in light of the next generation of science standards for the items in the domain of planning and carrying out investigations was at an average level with a mean of 1.70 and standard deviation of 0.042. The items ranged between average and low levels with means ranging between 1.44 and 1.99. Item 10 came first in the rank, which states: "The teacher encourages students to implement what they have planned by identifying dependent and independent variables and controlling them during the experiment"; it has a mean of 1.99 and a standard deviation of 0.81; it is on average level. Item 12 came second, which states, "The teacher motivates students to plan and investigate and then determine what the teacher collects from the data"; it has a mean of 1.73 and a standard deviation of 1.04; it is on an average level. Item 11 came before the last rank, which states: "The teacher leads students to plan the investigation step by step. The students implement what guides them"; it has an average level of 1.64 and a standard deviation of 0.72; it is on a low level. Item 13 came last which states: "The teacher leads students to obtain results supported by evidence; it has a mean of 1.44 and standard deviation of 0.58, at a low level.

Using mathematics and computational thinking

Table 6 shows that the level of understanding of the classroom student teachers of scientific and engineering practices in light of the next generation of science standards for the items in the domain of using mathematics and computational thinking was at an

Table 5. Means, standard deviations and ranks for teacher students understanding of scientific and engineering practices in the domain of planning and carrying out investigations arranged in descending order.

S/N	Item	M	SD	Rank	Level
10	The teacher encourages students to implement what they have planned by identifying dependent and independent variables and how to control them during the experiment.	1.99	0.81	1	Average
12	The teacher motivates students to plan and investigate so that students ask questions and then determine how and what the teacher collects from the data.	1.73	1.04	2	Average
11	The teacher leads students to plan their inquiry step by step. And students implement what guides them	1.64	0.72	3	Low
13	The teacher leads students to reach evidence-based results	1.44	0.58	4	Low
	Planning and carrying out investigations	1.70	0.42		Average

Table 6. Means, standard deviations and ranks for teacher students understanding of scientific and engineering practices in the domain of Using mathematics and computational thinking in descending order.

S/N	Item	M	SD	Rank	Level
18	The teacher encourages students to use Mathematics and computational thinking using ICT	2.01	0.81	1	Average
19	The teacher encourages students to use mathematical skills (measurement, choosing appropriate units, converting units, calculating ratios, and percentages).	1.68	0.73	2	Average
20	The teacher encourages students to express the relationship between the variables in mathematical formulas. To help them predict and interpret	1.58	0.68	3	Low
21	The teacher urges students to use mathematical relationships to design programs with the help of technological programs and tools available to them.	1.55	0.65	4	Low
	Using mathematics and computational thinking	1.70	0.38		Average

average level; it has a mean of 1.70 and standard deviation of .038. The items ranged between low and average levels as the mean ranged between 1.55 and 2.01. Item 18 (The teacher encourages students to use Mathematics and computational thinking by using ICT) came in the first rank with a mean of 2.01 and standard deviation of 0.81. Item 19 was in the third rank, which states that 'The teacher encourages students to use mathematical skills (measurement, choosing appropriate units, converting units, calculating ratios, and percentages) with a mean of 1.68 and standard deviation of 0.73 at an average level. Furthermore, Item 20 provided that: "The teacher encourages students to express the relationship between variables in mathematical formulas that came in the penultimate rank with a mean of 1.58 and standard deviation of 0.68)at a low level. Finally, Item 21 provided that 'The teacher urges students to use mathematical relationships to design programs with the help of technological programs and tools available to them'; it has a mean of 1.55 and standard deviation of 0.65 at a low level.

Obtaining, evaluating, and communicating information

Table 7 shows that the level of understanding of the classroom student teachers of scientific and engineering practices in light of the next generation of science standards for the items in the domain of obtaining, evaluating, and communicating information was at an average level with a mean of 1.69 and standard deviation of 0.38. The items ranged between low and average levels with mean ranging between 1.47 and .2.02. Item 26 provided that 'The teacher encourages students to read scientific article through books or to view the Internet to access scientific information'; it came in the first rank with a mean of 2.02 and standard deviation of 0.81 at an average level. This is fo;;owed by Item 28 which states that, 'The teacher urges students to display and share information with others in more than one way'; it has a mean of 1.72 and standard deviation of 0.76 at an average level.Item 30 was ranked next to the last, which states: "The teacher urges students to employ the best technology in the field of social networks as a source of obtaining information or offerring and exchanging knowledge" it has a mean of 1.57 and a standard deviation of 0.73, and at a low level. Item 29 provided that 'The teacher urges students to write scientific articles in a scientific way'; it came in the last rank, with a mean of 1.47 and standard deviation of 0.59, at a low level.

Constructing explanations (for science) and designing solutions (for engineering and engaging in argument from evidence

Table 8 shows that the level of understanding of the

Table 7. Means, Standard Deviations and ranks for teacher students understanding of scientific and engineering practices in the domain of Obtaining, evaluating, and communicating information in descending order.

S/N	Item	M	SD	Rank	Level
26	The teacher encourages students to read the scientific article through books or to view the Internet to access scientific information.	2.02	0.81	1	Average
28	The teacher urges students to display and share information with others in more than one way.	1.72	0.76	2	Average
27	The teacher urges students to use more than one source of information to obtain scientific information	1.65	0.72	3	Low
30	The teacher urges students to employ the best technology in the field of social networks as a source for obtaining information, presenting and sharing knowledge	1.57	0.73	4	Low
29	The teacher urges students to write scientific articles in a scientific way	1.47	0.59	5	Average
	Obtaining, evaluating, and communicating information	1.69	0.38		Average

Table 8. Means, Standard Deviations and ranks for teacher students understanding of scientific and engineering practices in the domain of Constructing explanations (for science) , designing solutions (for engineering) &Engaging in argument from evidence arranged in descending order.

S/N	Item	M	SD	Rank	Level
22	The teachers encourage students to interpret data and design solutions	1.66	0.77	1	Low
25	The teacher urges students to debate evidence by refuting and criticizing the scientifically unconvincing claim and accepting the scientifically convincing claim.	1.58	0.66	2	Low
23	The teacher encourages students to construct descriptive explanations. (Do not explain how or why this phenomenon occurred. Students do not use appropriate evidence to support the explanations)	1.51	0.69	3	Low
24	The teacher encourages students to interpret data supported by convincing scientific evidence.	1.51	0.67	3	Low
	Constructing explanations (for science) and designing solutions (for engineering)	1.56	0.41		Low

classroom student teachers of scientific and engineering practices in light of the next generation of science standards for the items in the domains of constructing explanations (for science) and designing solutions (for engineering and engaging in argument from evidence); it was at a low level with a mean of 1.56 and standard deviation of 0.41. All the items were at a low level as their means ranged between 1.51 and 1.66. Item 22 stated that 'The teachers encourage students to interpret data and design solutions'; it came in the first rank with a mean of 1.66 and standard deviation of 0.77, at a low level. Item 25 stated that 'The teacher urges students to debate evidence by refuting and criticizing scientifically unconvincing claim and accepting scientifically convincing claim'; it came in the second rank with a mean of 1.58 and standard deviation of 0.66, at a low level. Item 23 stated that 'The teacher encourages students to construct descriptive explanations, not to explain how or why a phenomenon occurs'. Item 24 states that, 'The teacher encourages students to interpret data supported by convincing scientific evidence'. Both items (23 and 24) came in the least rank within a low level as the mean for both of them was 1.51 with standard deviations of 0.69 and 0.67.

Developing and using models

Table 9 shows that the level of understanding of classroom student teachers of scientific and engineering practices in light of the next generation of science standards for the items in the domain of developing and using models was at a low level with a mean of 1.55 and standard deviation of 0.41. All the items were at a low level with means ranging between 1.50 and 1.64. Item 6 stated that 'The teacher encourages students to use models that illustrate the phenomenon through drawings or pictures; it came in the first rank with a mean of 1.64 and standard deviation of 0.77 at a low level. Item 9 provided that 'The teacher motivates students to evaluate the development of models to choose the best ones or to develop new models' it came in the second rank with a mean of 1.56 and standard deviation of 0.65 at a low level. Furthermore, Items 7 and 8 came in the last rank: iten 7 states that: 'The teacher encourages students to develop models that simulate reality and explain natural phenomena' and Item 8 states that 'The teacher encourages students to predict new phenomena or new characteristics of phenomena'; they have a mean of 1.50 and standard deviations of 0.69 and 0.67, at a low level.

Table 9. Means, Standard Deviations and ranks for teacher students understanding of scientific and engineering practices in the domain of Developing and using models arranged in descending order.

S/N	Item	M	SD	Rank	Level
6	The teacher encourages students to use models that illustrate the phenomenon through drawings or pictures	1.64	0.77	1	Low
9	The teacher motivates students to evaluate the development of models to choose the best ones or to develop new models	1.56	0.65	2	Low
5	The teacher encourages the building and use of models to understand the lesson.	1.54	0.65	3	Low
7	The teacher encourages students to develop models that simulate reality and explain natural phenomena	1.50	0.69	4	Low
8	The teacher encourages students to predict new phenomena or new characteristics of a phenomenon.	1.50	0.67	4	Low
	Developing and using models	1.55	0.41		Low

Analyzing and interpreting data

Table 10 shows that the level of understanding of the classroom student teachers of scientific and engineering practices in light of the next generation of science standards for the items in the domain of analyzing and interpreting data was at a low level with a mean of 1.45 and standard deviation of 0.36. Item 17 provided that 'The teacher leads students to obtain accurate results (validity and reliability)'; it came in the first rank with a mean of 1.59 and standard deviation of 0.66 at a low level. This is followed by Item 14, which provided that 'The teacher encourages students to collect and analyze data. And organize them in tables or graphs'; it has a mean of 1.53 and standard deviation of 0.73, at a low level. Item 16 provided that 'The teacher urges students to explain the relationship between the variables (causal and associative)' ; it has a mean of 1.36 and standard deviation of 0.56, at a low level. Finally, Item 15 provided that 'The teacher encourages students to choose appropriate methods of presenting data and clarifying relationships between them' ; it has a mean of 1.32 and standard deviation of 0.57, at a low level

Results of the second question: What is the effect of the studying year level in the evaluations of the first three grades classroom teachers' knowledge of scientific and engineering practices according to NGSS standards?

To answer this question, means and standard deviations for the evaluations of the samples for the first three grades of classroom teachers' knowledge degree of scientific and engineering practices were calculated according to NGSS standards and the study year. Table 11 shows that there are apparent differences between the means of the samples' evaluations for the first three grade classroom teachers' knowledge of scientific and engineering practices according to NGSS standards and the study year; fourth year category had the highest mean (2.02) while second year category came in the second rank (1.61); finally, third year category had a mean of 1.56. To determine the significance of the differences at the level of α =0.05, one Way ANOVA was used as shown in Table 12.

The results in Table 12 indicate the presence of statistically significant differences at the level of α = 0.05 in the estimates of the individuals of the research sample; it shows the levels of the female student teachers' knowledge of scientific and engineering practices in light of the next generation of science standards NGSS according to the variable of the school year. Based on the value of P calculated, it reached 8,614, and its level of significance was 0,000. There were statistically significant differences in most fields. The calculated values of P ranged between 11.957 and 5.673, while there were no statistically significant differences in the field of data analysis and its interpretation. From the calculated value of P it amounted to 2.343; the level of significance was 0.075. Differences exist in the overall levels of their knowledge. The areas in which the differences occurred were also determined. *Scheffe* test was applied for the dimensional comparisons. Table 13 shows the results. Table 13 shows that the differences were in favor of the fourth year category when compared with the rest of the categories (third, second and first), in the overall degree, and all the areas in which the differences occurred .

DISCUSSION

The results of the study indicated that there is a level of pre-service female student teachers' understanding of scientific and engineering practices in light of the next generation of NGSS science standards; it was both medium and low. This general result is due to the fact that scientific and engineering practices and their indicators are the bases of the teaching process and studying of scientific subjects in the university. The result

Table 10. Means, Standard Deviations and ranks for teacher students understanding of scientific and engineering practices in the domain of analyzing and interpreting data arranged in descending order.

S/N	Item	M	SD	Rank	Level
17	The teacher leads students to obtain accurate results (validity and reliability)	1.59	0.66	1	Low
14	The teacher encourages students to collect and analyze data and organize them in tables or graphs	1.53	0.73	2	Low
16	The teacher urges students to explain the relationship between the variables (causal and associative)	1.36	0.56	3	Low
15	The teacher encourages students to choose appropriate methods of presenting data and clarifying relationships between them	1.32	0.57	4	Low
	analyzing and interpreting data	1.45	0.36		Low

Table 11. means and standard deviations for the evaluations of the samples for the first three grades classroom teachers' knowledge degree of scientific and engineering practices according to NGSS standards and the study year.

Practice	Year	No	M	SD
Asking questions and defining problems	First	34	1.67	0.306
	Second	42	1.69	0.370
	Third	63	1.66	0.415
	Fourth	15	2.12	0.208
	Total	154	1.72	0.385
Planning and carrying out investigations	First	34	1.40	0.274
	Second	42	1.52	0.377
	Third	63	1.53	0.427
	Fourth	15	2.03	0.291
	Total	154	1.55	0.405
Using mathematics and computational thinking	First	34	1.73	0.505
	Second	42	1.68	0.367
	Third	63	1.62	0.376
	Fourth	15	2.08	0.278
	Total	154	1.70	0.416
Obtaining, evaluating, and communicating information	First	34	1.42	0.312
	Second	42	1.46	0.307
	Third	63	1.40	0.405
	Fourth	15	1.67	0.336
	Total	154	1.45	0.359
Constructing explanations (for science) and designing solutions (for engineering) and engaging in argument from evidence	First	34	1.66	0.307
	Second	42	1.69	0.370
	Third	63	1.65	0.402
	Fourth	15	2.08	0.244
	Total	154	1.70	0.379
Developing and using models	First	34	1.46	0.298
	Second	42	1.52	0.380
	Third	63	1.53	0.408
	Fourth	15	2.10	0.296
	Total	154	1.56	0.406

Table 11. Contd.

Analyzing and interpreting data	First	34	1.70	0.366
	Second	42	1.71	0.340
	Third	63	1.58	0.378
	Fourth	15	2.03	0.301
	Total	154	1.69	0.377
Total Degree	First	34	1.57	0.277
	Second	42	1.61	0.325
	Third	63	1.56	0.351
	Fourth	15	2.02	0.228
	Total	154	1.62	0.341

Table 12. MANOVA of samples' evaluations for the first three grades classroom teachers' knowledge degree of scientific and engineering practices according to NGSS standards and the study year.

Variance	Proactive	Squares	Freedom	M	F	Sig
Year	Asking questions and defining problems	2.689	3	0.896	6.723	0.000*
	Developing and using models	4.237	3	1.412	10.183	0.000*
	Planning and carrying out investigations	2.703	3	0.901	5.673	0.001*
	Analyzing and interpreting data	.883	3	0.294	2.343	0.075
	Using mathematics and computational thinking	2.433	3	0.811	6.220	0.001*
	Obtaining, evaluating, and communicating information	4.879	3	1.626	11.957	0.000*
	Constructing explanations (for science) and designing solutions (for engineering) and engaging in argument from evidence	2.466	3	0.822	6.386	0.000*
Total			3		8.614	0.000*
Error	Asking questions and defining problems	0.873	150	0.133	8.614	0.000*
	Developing and using models	0.133	150			
	Planning and carrying out investigations	0.139	150			
	Analyzing and interpreting data	0.159	150			
	Using mathematics and computational thinking	0.126	150			
	Obtaining, evaluating, and communicating information	0.130	150			
	Constructing explanations (for science) and designing solutions (for engineering)	0.136	150			
Total		0.129	150			0.101
Total degree	Asking questions and defining problems	22.689	153			
	Developing and using models	25.041	153			
	Planning and carrying out investigations	26.527	153			
	Analyzing and interpreting data	19.720	153			
	Using mathematics and computational thinking	21.987	153			
	Obtaining, evaluating, and communicating information	25.281	153			
	Constructing explanations (for science) and designing solutions (for engineering)	21.774	153			

shows plans should be made to prepare the female students. The students should use 15 h to study five subjects, and be taught how to study them such as chemical concepts, biology, environmental education, engineering concepts, the structure of preparation. Also, the background of the female students in high school should also be considered when preparing them. The result shows that in a non-scientific nation, building

Table 13. Scheffe test for the differences samples' evaluations for the first three grades classroom teachers' knowledge degree of scientific and engineering practices according to NGSS standards and the study year.

Practice	Year	M	4th	2nd	1st	3rd
			2.12	1.69	1.67	1.66
Asking questions and defining problems	4th	2.12	-	*0.43	*0.45	*0.46
	2nd	1.69		-	0.02	0.03
	1st	1.67			-	0.01
	3rd	1.66				-
	Year	M	4th	2nd	1st	3rd
			2.03	1.53	1.52	1.40
Developing and using models	4th	2.03	-	*0.50	*0.51	*0.63
	2nd	1.53		-	0.01	0.13
	1st	1.52			-	0.12
	3rd	1.40				-
	Year	M	4th	2nd	1st	3rd
			2.08	1.73	1.68	1.62
Planning and carrying out investigations	4th	2.08	-	*0.35	*0.40	*0.46
	2nd	1.73		-	0.05	0.11
	1st	1.68			-	0.06
	3rd	1.62				-
	Year	M	4th	2nd	1st	3rd
			2.08	1.69	1.66	1.65
Using mathematics and computational thinking	4th	2.08	-	*0.39	*0.42	*0.43
	2nd	1.69		-	0.03	0.04
	1st	1.66			-	0.01
	3rd	1.65				-
	Year	M	4th	2nd	1st	3rd
			2.10	1.53	1.52	1.46
Constructing explanations (for science) and designing solutions (for engineering and Engaging in argument from evidence	4th	2.10	-	*0.57	*0.58	*0.64
	2nd	1.53		-	0.01	0.07
	1st	1.52			-	0.06
	3rd	1.46				-
	Year	M	4th	2nd	1st	3rd
			2.03	1.71	1.70	1.58
Obtaining, evaluating, and communicating information	4th	2.03	-	*0.32	*0.33	*0.45
	2nd	1.71		-	0.01	0.13
	1st	1.70			-	0.12
	3rd	1.58				-
	Year	M	4th	2nd	1st	3rd
			2.02	1.61	1.57	1.56
Total	4th	2.02	-	*0.41	*0.45	*0.46
	2nd	1.61		-	0.04	0.05
	1st	1.57			-	0.01
	3rd	1.56				-

Sig at : 00.05.

interpretations and designing solutions, the field of developing and using forms, the field of data analysis and interpretation came low. This result can also be attributed to the fact that female students 'practice of scientific and engineering needs a long time; and it is not commensurate with the high numbers of students enrolled for one course because the university's science lab is not ready for them.This finding is consistent with that of Harris et al. (2017).

It can be explained by the fact that female students in the fourth year receive a better estimate in understanding scientific and engineering practices, that all students postpone the scientific courses to the fourth year due to fear and as a way of escaping from studying these courses. There is a negative trend towards scientific subjects, which necessitates the need of working to modify the scientific trends of female students who are pre-service teachers and will teach scientific subjects after graduation.

Recommendatıons

(i) Reconsidering the academic plans for the baccalaureate stage for students who want to be class teachers
(ii) Giving attention to the indicators of scientific and engineering practices that showed the results of the research are weak in its ownership and taken as an introduction to teaching scientific courses at the university.
(iii) There is need to employ practical teaching during the training of female students in practical education; the time of the practical education course should be 9 h per three courses in order to train female teachers to employ scientific and engineering practices in the light of NGSS.
(iv) There is need for the university to speed up the preparation of the science selector to teach scientific courses in the laboratory in order to modify the scientific trends of female students.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

Ambosaidi A (2013). Evaluations of twelfth grade students in the Sultanate of Oman to the degree that science teachers possess the characteristics of an effective teacher and its relationship to some variables. Mu'tah for Humanities and Social Sciences Research and Studies 28(2):313-342.

Al-Aalemat H (2010). The degree of practicing elementary school teachers in Jordan for professional competencies in light of modern national standards for the professional development of teachers. Islamic University Journal 18(2):140-191.

Al-Jaafara A, Al-Zaydyeen K (2016). The degree to which teachers of the first basic stage have competencies Teaching staff from the point of view of school principals and supervisors of the stage in the Southern Jordan region according to standards comprehensive quality. Al-Balqa Journal for Research and Studies 9(1):141-117.

Al-Jarjawi Z, Nashwan J (2006). Evaluation of teachers 'professional performance in UNRWA schools in light of the overall quality indicators. A working paper submitted to the first scientific conference of the College of Education, the Palestinian Experience in Curriculum Preparation, Reality and Aspirations, Al-Aqsa University, Gaza.

Al-mutiri A, Al-mafaraj B (2007). Contemporary trends in teacher preparation and professional development. Educational Research Sector and Curricula, Kuwait Ministry of Education.

Amayrah M, Khawaldeh T, Maqableh A (2012).The degree to which primary school teachers in Jordan possess the principles of knowledge economy and apply them in their teaching from their own point of view**.** Journal of Al-Quds Open University for Research. And studies 26(2):280-243.

Aspy N, Aspy B, Quimby M (1993). What doctor can teach teacher about problem- based learning. Educational Leadership 50(7):22-24.

Boesdorfer S, Losbach A (2014). PCK in Action: Examining One Chemistry Teacher,s practices Through The Lens of her Orientation Toward Science Education. International Journal of Science Education 36(13):2111- 2132.

Brownstein M, Horvath L (2016). Next Generation Science Standards and edTPA: Evidence of Science and Engineering Practices. Electronic Journal of Science Education 12(4):44-62.

Bybee R (2010). The Teaching of Science: 21st Century Perspective, NSTA press. Electronic Journal of Science Education 12(4):44-62. Retrieved at 20/10/2018, from: www.nsta.org/files/PB283x web. pdf

Harris K, Sithole A, Kibirige J (2017). A Needs Assessment for the Adoption of Next Generation Science Standards (NGSS) in K-12 Education in the United States. Journal of Education and Training Studies 5(9):54-62. Retrieved from http://redfame.com/journal/index.php/jets/article/view/2576/2718

International Bank (2012). Report about education in Jordan. Amman: Jordan.

Kawasaki J (2015). Examining teachers' goals classroom instruction around the science and engineering practices in the next generation science standards. Unpublished dissertation, university of California.

Ministry of Education (2018). The Ministry of Education Strategic Plan 2018-2022 Amman, Jordan.

National Research Council (NRC) (2012). A Framework for (k-12) Science Education: practices, Crosscutting Concepts, and Core Ideas. Washington, D. C., National Academy of Science. Retrieved at 14-10-2018 from www.nap.edu/read/13165

Next Generation Science Standards (NGSS) (2013). Conceptual Shifts in the (NGSS). Retrieved at 13-10-2018 from: www.nextgenscience.org/next-generation-science- standards.

Reiser B, Berland L, Kenyon L (2012). Engaging students in the scientific practices of explanation and argumentation. Science and Children 49(8):8-13. Retrieved from https://www.mydigitalchalkboard.org/cognoti/content/file/resources/documents/e7/e7d98e4d/e7d98e4d7712f6549ac47e5d4c47a78a9aaf5975/PRACTICESR2ReiserArticle.pdf

Senider C (2012). Core Ideas of Engineering and Technology: Understanding A Framework for K-12 Science Education. Science and children 49(5):8-12. Retrieved from http://static.nsta.org/files/sc1205_8.pdf

Senider C, Stephenson C, Schafer B, Flick L (2014). Exploring the Science Frame work and NGSS: Computational thinking in the science classroom. Science Scope 38(3):10-15. Retrieved from http://static.nsta.org/files/ss1403_10.pdf

Staver J (2007). Teaching Science. International Bureau of Education, International Academy of Education, France. Retrieved from www.ibe.unesco.org/fileadmin/user_upload/Practice_17

Program for International Student Assessment (PISA) (2018). Program for International Student Assessment Result. Retrieved from https://www.oecd.org/pisa/publications/PISA2018_CN_JOR.pdf

Toqan K (2005). Teachers' competencies: Unpublished lecture. Amman: Jordan.