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The impact of perception of middle school curricula according to the next generation of science standards on conceptual comprehension and thinking skills

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ABSTRACT

There is an urgent need to update the science curricula content in light of the Next Generation Science Standards (NGSS). The purpose of this research is to present a proposal of the science curricula content in light of the NGSS. Secondly, the effect of NGSS on conceptual understanding and higher-thinking skills among first-year intermediate students is also analyzed. This work is unique as no research is conducted on the topic as per the best of our knowledge. Hence, the research may motivate further studies on the topic. The semi-experimental method was used to know the impact of teaching science in conceptual understanding and higher thinking skills. The sample consisted of 62 students divided into two groups. The control group was led the "nature of material" unit in the first-year intermediate book, issued by the Ministry of Education in 1438 AH. A list of science tools was prepared for analyzing the content of science curricula in light of Next-Generation Science Standards (NGSS). Two tests were prepared, a conceptual understanding test and a higher thinking skills test. The research revealed different results: the availability degree of science for the next-generation science standards curricula in the intermediate stage was low. The developed unit's size effect in light of these standards on conceptual understanding and higher-thinking skills among the research sample was high with a value of 0.89-0.91.

1. Introduction

Science curricula are scientific education tools that shape the students' personalities and develop their various abilities and skills. Therefore, it has become necessary to design these curricula in light of modern standards that encourage students to explore, experiment, discuss, and problem-solve. It contributes to their conceptual understanding (Nashwan, 2014), one of the most crucial science education goals. It represents depth in the student's knowledge of science's cognitive structure and the ability to explain and interpret it (MOE, 2012). It requires that modern science curricula focus on conceptual understanding and provide the learner with thinking skills to apply what he has learned in solving problems, and at the same time develop the practical skills that qualify him to live in the twenty-first century (Al-Rabeeh, 2016; Asiri, 2018; Al-Qarni, 2016; Fishman et al., 2003). It raises the level of conceptual understanding among students. It trains them the higher thinking skills that help them know their mental potentials and capabilities and then develop and invest them better (MOE, 2004). That is why educators see that among the schools' priorities in the current era is the students' higher thinking skills (Al-Atoum et al., 2009). Several conferences have also been recommended to develop the students' higher thinking skills, including the curricula for education and thinking development conference held in Egypt in 2000 A.D. and the Jubail International conference held in 2011 A.D.

The document of science education's general aims for the intermediate stage in Saudi Arabia has stipulated some purposes related to conceptual understanding and higher thinking skills. The most important of which is to make the student more able to clarify and interpret ideas and concepts, expand them, and apply them practically in new educational situations that contribute to raising his conceptual understanding level (MOE, 2009). Many institutions concerned with education have sought to develop

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science curricula by formulating scientific standards commensurate with the twenty-first-century skills and developing proposals for how these can be integrated into the educational system in general and basic academic fields in particular. The Next-Generation Science Standards (NGSS) is implemented by the National Research Center in the United States. It aims to develop standards for anticipating students' need for scientific knowledge in proportion to the current condition. The Next-Generation Science Standards focus on a few basic ideas and comprehensive concepts so that the student can explain, clarify, interpret, expand on them, and apply them in new educational situations through participation in science and engineering practices. This link between basic ideas, comprehensive concepts, and scientific methods refers to three-dimensional learning that integrates the educational process (Krajcik et al., 2014). It is confirmed by many previous studies that dealt with building or developing science curricula (Abu Laila, 2015; Shoman, 2015).

The science curricula in the Kingdom of Saudi Arabia have been affected by global trends. Amendments have been made to them many times to keep pace with international scientific and technical development, upgrade the curricula to consider individual differences, and develop thinking in various forms. Despite this, there are still shortcomings in developing science curricula for the intermediate stage. The results of many studies have indicated the need to develop science curricula at all educational levels in light of the Next-Generation Science Standards, work on learners' acquisition of higher-thinking skills, and develop their understanding (Abdul Karim, 2017; Al-Subaie, 2018).

It became clear that there is a weakness in including the Next-Generation Science Standards in the "nature of matter" unit in the science book for the first intermediate grade. It has included some basic thoughts (29.06%) and scientific and engineering practices (60.69%). At the same time, the percentage of comprehensive concepts inclusion is 10.26%. A decrease in the students' conceptual understanding level is also observed (Al-Rabeeh, 2016; Al-Qahtani, 2015; Al-Qarni, 2018). A decline in higher-order thinking skills is also reported (Al-Shehri, 2014; Asiri, 2018; Al-Qarni, 2018).

From the above, the research problem is identified in the weakness of including the science curricula content in the middle stage of the Next-Generation Science Standards in its three dimensions and the low level of intermediate school students in both conceptual understanding and higher thinking skills. Therefore, according to the Next-Generation Science Standards, the research has attempted to overcome these problems by preparing a proposal for developing science curricula at the first intermediate grade. The science curricula content proposal tells an academic unit's effect in light of the Next-Generation Science Standards on the conceptual understanding among the first intermediate grade students. According to the science curricula content's proposal in light of the Next-Generation Science Standards, it highlights an academic unit's impact on developing higher thinking skills among first-intermediate grade students. The research sought to verify the validity of the two hypotheses. There are no statistically significant differences at the level of significance (α=0.05) between the mean scores of the experimental and control groups in the post-application of the conceptual understanding test. There are no statistically significant differences at the level of significance (α=0.05) between the mean scores of the experimental and control groups in the post-application of the higher thinking skills test. The research's importance lies in the fact that it presents a proposal of the science curricula content in light of the Next-Generation Science Standards. It can direct the interest of those in building science curricula and developing them at the intermediate level to review science curricula at the primary and secondary levels in light of these standards. It provides science subject supervisors, teachers, and researchers with a conceptual understanding test. A higher-thinking skills test may help evaluate these aspects and prepare similar tools. It presents a proposal unit based on the Next-Generation Science Standards.

2. Theoretical framework

The researchers define the conceptual understanding procedure as the first intermediate grade students' ability to fully perceive a topic or phenomenon based on it in the "Nature of Matter" unit in the science curriculum. It reaches a conceptual understanding that enables them to explain concepts related to the topic, interpret them, expand on them, and apply them in new situations. The researchers define the higher-order thinking skills as "the set of mental processes that students of the first intermediate grade use when they learn the unit "nature of matter" in the first intermediate grade's science curricula. These processes are represented in building concepts, solving open-ended problems, prediction, synthesis, and analysis. The researchers define the Next-Generation Science Standards procedurally as new educational rules and foundations for science education, devised for the availability of global science education and achieving a vision for education in the field of science and engineering.

According to the Next-Generation Science Standards, the research's experimental treatment materials consisted of a middle school's science curricula content proposal. The course unit's structuring and characteristics were developed according to the Next-Generation Science Standards of the "Nature of the subject" unit of the first intermediate grade science course for the first semester. Two research tools are represented in the conceptual understanding test and the higher thinking skills test for intermediate first-grade students.

The proposal of the science curricula content at the intermediate level was prepared according to the Next-Generation Science Standards (NGSS) after seeing many studies and research that prepared proposed scenarios for science curricula' content (Al-Shahrani, 2011; Issa and Ragheb, 2017). According to the Next-Generation Science Standards, the science curricula for the United States have also been viewed. The initial picture of the proposal of the science curricula content was constructed, which included 15 critical ideas in each of the three grades of the intermediate stage. It had included 42 sub-pivotal ideas in the first grade, and 44 sub-pivot ideas in the second grade, and 54 statements in the third grade. The proposal was presented to specialists in science education to consider the main pivotal ideas and the essential ideas. They approved that how appropriate it was for middle school students. It has indicated the need to reconsider the selected titles for each core and sub-core theory. It demonstrated the suitability of the ideas included in middle school students' perceptions in Saudi Arabia. It consisted of four sub-fields (natural sciences, life sciences, earth and space sciences, engineering and technology, and their applications in the sciences) with the same number of central and sub-fields in each study description field.

According to the Next-Generation Science Standards, the developed unit was prepared in its two forms (teacher's guide and student activities brochure) after seeing many Arab and foreign studies. According to the Next-Generation Science Standards, these studies have dealt with building science lesson topics to include scientific & engineering practices and comprehensive concepts in the unit's content. According to each field, a list was also made to distribute the main sub-concepts currently present in the science curricula for the three intermediate grades and make a suggested list according to the Next-Generation Science Standards. Each field distributed the main sub-concepts that must be included in the science curricula for the intermediate stage's three academic grades. The appropriate topics, activities, and evaluation methods were chosen to be included in the "Nature of Material" unit according to the Next-Generation Science Standards into a new division called "Structure and Characteristics of the Course," from the science book for the first intermediate grade for the first semester. After completing the unit's preparation in its two pictures, it was presented to a group of referees specialized in curricula and methods of science education to take their opinions and proposals. The unit was modified by adding some topics and removing the duplicate from them. An introduction was made to include an overview of the Next-Generation Science Standards applied in this unit and add more illustrations, legends, and evaluation methods. Accordingly, the unit was ready for implementation in its final form.

3. Research methodology

This research used the experimental method with its semi-experimental design known as the control and experimental groups of pre and post-measurements. It identifies the effect of teaching a proposal unit on developing conceptual understanding and higher-thinking skills among first-intermediate grade students. A random sample of 62 boys was selected from first-intermediate grade students in Gohayra Intermediate Schools of the Sabya Education Administration. The total population consists of 6250 boys students distributed in 125 boys' government schools. This study was applied in the first semester of 1440-1441 AH. A proposal of science curricula at the intermediate stage in light of the Next-Generation Science Standards has three dimensions: (basic ideas, comprehensive concepts, scientific and engineering practices). The "Nature of Subject" unit included in the science curriculum the first semester of the first intermediate grade for the year 1440-141 A.H., which was prepared in light of the Next-Generation Science Standards. Dimensions of conceptual understanding (illustration, interpretation, application, perspective-taking) are suitable for middle school students. Higher-order thinking skills have been represented (prediction, analysis, synthesis, evaluation, solving open-ended problems) due to their suitability to the students' age and previous studies that have proven the need to study these skills (Alsaid, 2017; Al-Shehri, 2014).

The conceptual understanding test was prepared. It consisted of four dimensions represented in (clarification, interpretation, application, and taking the perspective) with a total of 35 questions in its initial form. It was controlled by calculating the psychometric properties. The test's initial image was presented to a group of experts and specialists in education and psychology. In light of the arbitrators' opinions, the test was modified by deleting some questions for their similarity with others. The wording of some questions was altered. The test consisted of 34 questions of the multiple-choice type in its final form. It has instructions for answering the questions, and it is ready to be applied to the pilot sample. The test was applied to an exploratory sample consisting of 29 students from the first intermediate grade to determine internal consistency. The correlation coefficients are shown in Table 1.

By extrapolating Table 1, it becomes clear that the questions of the conceptual understanding test, which are 34 questions, all came with significant correlation coefficients at the level of 0.01, between them and the total score of the dimension, and between them and the total score of the test. The stability was calculated through the Kweder Richardson equation (Formula 21), which came with a value of 0.849. It was calculated by the half-segmentation method, where the value of Spearman's reliability coefficient came 0.901. It indicates the consistency of test scores if applied to the same sample under the same conditions. Applying the conceptual understanding test to the exploratory sample took 45 minutes, including reading the instructions. Table 2 presents a detailed distribution of the test questions.

Table 1: Correlation coefficients between each question's score, the total score of the dimension to which it belongs, and the total score of the test

No.	Correlation coefficient with the total score of the dimension	Correlation coefficient with the total score of the test	No.	Correlation coefficient with the total score of the dimension	Correlation coefficient with the total score of the test
1	0.716**	0.685**	18	0.765**	0.665**
2	0.677**	0.616**	19	0.622**	0.536**
3	0.661**	0.610**	20	0.696**	0.678**
4	0.809**	0.620**	21	0.787**	0.669**
5	0.725**	0.611**	22	0.849**	0.746**
6	0.706**	0.618**	23	0.654**	0.685**
7	0.891**	0.608**	24	0.684**	0.646**
8	0.768**	0.616**	25	0.829**	0.782**
9	0.657**	0.643**	26	0.806**	0.674**
10	0.745**	0.688**	27	0.850**	0.769**
11	0.671**	0.538**	28	0.798**	0.679**
12	0.684**	0.641**	29	0.799**	0.613**
13	0.745**	0.722**	30	0.849**	0.764**
14	0.631**	0.556**	31	0.635**	0.617**
15	0.708**	0.656**	32	0.602**	0.567**
16	0.849**	0.589**	33	0.739**	0.689**
17	0.712**	0.702**	34	0.779**	0.626**

**: Significant at 5% level of significance

Table 2: The conceptual understanding test questions

Dimensions of conceptual understanding	No. of questions in the test	Total No. of questions	Relative weight (%)
Illustration	1, 2, 10, 14, 17, 20, 24	7	20.5
Interpretation	3, 9, 11, 15, 19, 23, 25, 31	8	23.5
The application	4, 7, 13, 16, 21, 28, 29, 32, 34	9	26.5
Take perspective	5, 6, 8, 12, 18, 22, 26, 27, 30, 33	10	29.5
Total		34	100

The higher-thinking skills exam was prepared. Its initial form of five primary skills consisted of (prediction, analysis, structure, evaluation, and open-ended problem solving) with a total of 32 questions. Arbitrators' validity has calculated the psychometric properties. The test's initial image was presented to a group of experts and specialists in education and psychology. In light of the arbitrators' responses, the test was modified after modifying some questions' wording to express the skill you measured and deleted others. Finally, the test consists of 30 questions, of the multiple-choice type, with the instructions for answering the questions added. It was ready to be applied to the pilot sample. The correlation coefficients were calculated to determine the internal consistency. The test was applied to an exploratory sample consisting of 29 students from the first intermediate grade. The results are shown in Table 3.

Table 3: Correlation coefficients between each question's degree and the total degree of the basic skill that it measures, and the test's total score

No.	Correlation coefficient with the total score of the basic skill	Correlation coefficient with the total score of the test	No.	Correlation coefficient with the total score of the basic skill	Correlation coefficient with the total score of the test
1	0.864**	0.880**	16	0.559**	0.566**
2	0.859**	0.661**	17	0.512**	0.582**
3	0.841**	0.665**	18	0.597**	0.695**
4	0.861**	0.602**	19	0.686**	0.580**
5	0.677**	0.728**	20	0.770**	0.505**
6	0.854**	0.621**	21	0.751**	0.790**
7	0.834**	0.596**	22	0.621**	0.703**
8	0.756**	0.488**	23	0.573**	0.571**
9	0.738**	0.630**	24	0.809**	0.561**
10	0.600**	0.543**	25	0.861**	0.565**
11	0.542**	0.506**	26	0.828**	0.622**
12	0.752**	0.622**	27	0.891**	0.745**
13	0.847**	0.743**	28	.693**	0.621**
14	0.804**	0.801**	29	0.849**	0.599**
15	0.794**	0.646**	30	0.820**	0.745**

**: Significant at 5% level of significance

By extrapolating the results of Table 3, it becomes clear that the 30 questions of the higher-thinking skills test all came with correlation coefficients at the level of 0.01, whether between them and the total score of the main skills or between them and the total score of the test. The half-segmentation method has calculated the stability, where the value of Spearman's reliability coefficient was 0.923. It indicates the consistency of test scores if applied to the same sample under the same conditions. Applying the higher-thinking skills test to the exploratory sample took 45 minutes, including reading the instructions, which consisted of 30 questions in its final form. Table 4 presents a detailed distribution of the test questions.

Table 4: Specifications for the higher-thinking skills test

Dimensions of higher-thinking skills	No. of questions in the test	Total No. of questions	Relative weight (%)
Prediction	1, 6, 10, 17, 22, 26	6	20
Analysis	2, 5, 12, 18, 25, 29	6	20
Construction	8, 11, 14, 19, 23	5	16.7
Evaluation	3, 9, 13, 16, 21, 27	6	20
Open-ended problem solving	4, 7, 15, 20, 24, 28, 30	7	23.3
Total	30		100

The two conceptual understanding tests and higher thinking skills were pre-applied to the two research groups (experimental and control) to ensure the research sample's equivalence. The T test's values were calculated for the differences between the two research groups' mean scores in the pre-application of the conceptual understanding test. The results are shown in Table 5.

Table 5: The averages, standard deviations, and "T" value of the differences between the mean scores of the two research groups students in the pre-application of the conceptual understanding test n=62

Skills	Group	Mean	Standard deviation	Freedom Degree	(T)value	Significant level
Illustration	Experimental	1.9667	1.37674	60	0.357	0.722
	Control	2.0938	1.42239			
Interpretation	Experimental	2.2000	1.09545		0.709	0.481
	Control	2.4063	1.18755			
The application	Experimental	3.0667	1.33735		0.938	0.352
	Control	2.7500	1.31982			
Take perspective	Experimental	3.3000	1.51202		0.384	0.703
	Control	3.1563	1.43930			
Total	Experimental	10.5333	3.10432		0.176	0.861
	Control	10.4063	2.56351			

It is evident from the results of Table 5 that the (T) values are not statistically significant at (α=0.05) level. The calculated significance value (ρ) was much greater than the value of the imposed significance (α) for each conceptual understanding dimension separately and the test's total. Accordingly, it is verified that there is equality between the research sample in the conceptual understanding in science. The (T) test's values were calculated for the differences between the two research groups' mean scores in the pre-application of the higher-thinking skills test. The results are shown in Table 6.

By extrapolating the results mentioned in Table 6, it becomes clear that the values of (T) are not statistically significant at the level of (α=0.05). The calculated significance value (ρ) is much greater than the significance value imposed (α) for each individual's higher thinking skill and the test's total. Accordingly, there is a verification of parity between the research sample in higher-thinking skills in science.

Table 6: The averages, standard deviations, and "T" value of the differences between the mean scores of the students of the two groups in the pre-application of the test of higher-thinking skills n=62

Skills	Group	Mean	Standard deviation	Freedom Degree	T-value	Significant level
Prediction	Experimental	1.4667	0.93710	60	0.260	0.796
	Control	1.5313	1.01550			
Analysis	Experimental	1.6333	0.96431		0.350	0.728
	Control	1.7188	0.95830			
Construction	Experimental	1.0667	0.69149		0.328	0.744
	Control	1.1250	0.70711			
Evaluation	Experimental	1.6000	0.77013		0.813	0.419
	Control	1.4375	0.80071			
Open-ended problem solving	Experimental	2.1333	1.13664		0.366	0.716
	Control	2.0313	1.06208			
Total	Experimental	7.9000	1.90009		0.117	0.907
	Control	7.8438	1.86840			

4. Research results and discussions

The first question is "What is the proposal for developing the science curricula content at the intermediate level, in light of the Next-Generation Science Standards?" The proposal for the science curricula content was developed after reviewing the relevant studies and research. The proposal included 15 pivotal ideas in each of the three grades of the intermediate stage. It had 42 sub-pivotal ideas in the first grade. In comparison, it included 44 sub-pivotal ideas in the second intermediate grade, and the initial image included 54 pivotal sub ideas in the third intermediate grade. So the first question is answered by the proposal for developing the science curricula in its final form.

The second question is "What is the effect of a unit of study according to the proposed perception of the content of science curricula in light of the next generation of science standards on the conceptual understanding of the first intermediate grade students?" The associated hypothesis is verified, and there are no differences of interest. There is a statistical significance at the level of significance (α=0.05) between the mean scores of the experimental and control groups in the post-application of the conceptual understanding test. The (T) test values for the differences between the two research groups' mean scores in the post-application of the conceptual understanding test prepared for this test are calculated, shown in Table 7.

Table 7: The averages, standard deviations, and "T" value of the differences between the mean scores of the research two groups' students in the post-application of the conceptual understanding test (n=62)

Skills	Groups	Means	Standard deviations	Freedom Degree	(T)values	Significant level	Effect Size (η^2)
Illustration	Experimental	5.8333	1.1768		11.129		0.67
	Control	2.2813	1.3255				Large
Interpretation	Experimental	7.0000	1.2865		14.616		0.78
	Control	2.6875	1.0298				Large
The application	Experimental	7.6333	1.6709	60	13.602	0.000	0.76
	Control	2.8438	1.0506				Large
Take perspective	Experimental	8.0000	2.4353		9.915		0.62
	Control	3.1875	1.2296				Large
Total	Experimental	28.466	3.7299		21.601		0.89
	Control	11.000	2.5652				Large

By extrapolating the results in Table 7, it becomes clear that there are statistically significant differences at the level of significance (α=0.05) in favor of the experimental group in each dimension of conceptual understanding separately and for the overall test. The first zero hypotheses is rejected, and the alternative hypothesis is accepted. There are statistically significant differences at the level of significance (α=0.05) between the mean scores of the experimental and control groups in the post-application of the conceptual understanding test. The differences have come in favor of the experimental group in the arithmetic mean. Regarding the independent variable effect on conceptual understanding development, the values are high (0.67, 0.78, 0.76, 0.62, and 0.89) for the conceptual understanding dimensions (illustration, interpretation, application, taking-perspective, and total test). We found 67%, 78%, 76%, and 62% variances in the four dimensions of conceptual understanding and 89% of the variance in conceptual understanding as a whole. It is found due to the independent variable (the study unit according to the science curricula content proposal, in light of the next generation science standards). Thus, the second question of the research questions is answered that there is excellent effectiveness of the applied unit of the proposal of the science curricula content according to the next generation in developing conceptual understanding dimensions among first-grade intermediate students.

The aforementioned result could be attributed to several reasons, the most important of which is the inclusion of the unit's topics content with many activities and enriching ideas that contribute to students' performance of scientific and engineering practices. The unit has deepened its understanding of the concepts involved in it. Besides, the students' implementation of scientific and engineering techniques has helped increase their activity significantly and effectively in the learning process. It has led to training them to apply what they have learned in different life situations. In addition to the students' feeling of positivity towards the learning process, it has increased their motivation to practice activities again and make the necessary attempts to avoid weaknesses and develop strengths. It has allowed students to express their opinions before and after conducting the activity, especially concerning chemical reactions. It has helped them to interpret the data logically based on sound scientific foundations and procedures. It has provided opportunities for cooperation between students during the exercise of some tasks within the activities. It develops a deep understanding of concepts and increases their ability to understand well, which agrees with the previous studies (Schlobohm, 2016; Abdul Karim, 2017). These studies have also indicated the importance of including the next-generation science standards in the science curricula content and their role in developing concepts and methods of achieving them among students, affecting their comprehension and understanding.

The third question is "What is the effect of a unit according to the proposal of the science curricula content, in light of the next generation science standards on the development of higher thinking skills among students of the first intermediate grade?" The hypothesis is verified that there are no statistically significant differences at the level of significance (α=0.05) between the mean scores of the experimental and control groups in the post-application of the higher thinking skills test. The results are shown in Table 8.

It is evident from the results of Table 8 that there are statistically significant differences at the level of significance (α=0.05) in favor of the experimental group with each skill of higher thinking skills separately and for the test as a whole. Accordingly, the second null hypothesis of the research hypotheses is rejected, and the alternative idea is accepted.

Table 8: The averages, standard deviations, and "T" value of the differences between the mean scores of the research two groups' students in the post-application of the higher thinking skills test (n=62)

Skills	Groups	Means	Standard deviations	Freedom Degree	T-values	Significant level	Effect Size (η^2)
Prediction	Experimental	4.9333	1.3628	60	9.388	0.000	0.59
	Control	1.9063	1.1738				Large
Analysis	Experimental	4.8667	0.86037		11.504		0.69
	Control	2.0313	1.0620				Large
Construction	Experimental	4.1667	0.94989		9.458		0.60
	Control	1.5313	1.2177				Large
Evaluation	Experimental	5.0333	1.2452		12.287		0.72
	Control	1.6563	0.90195				Large
Open-ended problem solving	Experimental	5.7667	1.3565		11.35		0.68
	Control	2.3750	0.97551				Large
Total	Experimental	24.7667	2.5008		24.967		0.91
	Control	9.5000	2.3140				Large

There are statistically significant differences at a significance level (α=0.05) between the mean scores of the experimental and control groups in the post-application of the higher thinking skills test where the differences came in favor of the highest average, which is the experimental group. Regarding the values of the independent variable effect on the development of higher thinking skills, the values are high (0.59, 0.69, 0.60, 0.72, 0.68, and 0.91) for higher thinking skills (prediction, analysis, synthesis, evaluation, solving, open-ended problems, and total test). It means that 59%, 69%, 60%, 72%, 68% of the variation in the five skills, respectively, and 91% of the variation in the level of higher thinking skills as a whole is due to the independent variable (the proposal unit of the science curricula content, in light of the next generation science standards). Thus the third question of the research questions is answered that there is excellent effectiveness for the applied proposal unit of the science curricula content according to the next generation in developing higher thinking skills among first intermediate grade students.

This result could be attributed to many reasons, the most important of which are asking students appropriate questions and giving them adequate opportunity to think about the answer. It has led to the development of their ability to believe in proper solutions accurately. The unit is also distinguished by its inclusion of multiple activities based on scientific and engineering practices that require practicing thinking skills as building interpretations, proposing solutions, presenting logical arguments, and scientific evidence on their conclusions. These are direct mechanisms for developing higher thinking skills and then setting the desire to search for uncommon ideas, creating multiple skills such as solving open-ended problems. It has also led the teacher to present activities to develop the talent of collecting information about the content's main ideas to create the students' analysis and synthesis skills. The activities that have dealt with different life applications stimulate the students towards curiosity and apply new ideas in situations similar to those have studied. It allows students to comment on their colleagues' answers in developing the skill of criticizing and evaluating ideas. This research's findings are consistent with the results of a previous study (Shoman, 2015), which has indicated the importance of including the next generation science standards in the science curricula content and its role in improving the educational output with his various thinking skills.

5. Conclusions and recommendations

The proposal for the science curricula content is developed. It has been found that according to the next generation, there is excellent effectiveness of the applied unit of the proposal of the science curricula content in developing conceptual understanding dimensions among first-grade intermediate students. There are statistically significant differences at a significance level (α=0.05) between the mean scores of the experimental and control groups in the post-application of the higher thinking skills test, where the differences have come in favor of the experimental group. It is concluded that there is excellent effectiveness for the applied proposal unit of the science curricula content according to the next generation in developing higher thinking skills among first intermediate grade students. There are statistically significant differences at the level of significance (α=0.05) in favor of the experimental group with each skill of higher thinking skills separately and for the test as a whole.

The research recommends adopting the Next-Generation Science Standards list in building and developing the science curricula content at the intermediate level. It suggests providing science laboratories at the intermediate stage and providing them with means and tools commensurate with the scientific and engineering practice requirements that must be included in the science curricula, in line with the next generation science standards. It also emphasizes including the Next-Generation Science Standards in middle school science teachers' courses to develop their necessary skills to make them more effective in teaching science. It further suggests focusing on scientific and engineering practices in the intermediate stage science books' activities and linking them to comprehensive concepts and main ideas in each topic.

Moreover, the research suggests conducting a comparative study between the content of intermediate-level science curricula in Saudi Arabia and in one of the countries with advanced levels in applying the Next-Generation Science Standards. According to the Next-Generation Science Standards, there is a dire need to develop other science curricula modules at the intermediate stage and experiment with their effectiveness in developing various educational outputs, including creative thinking skills. Besides, it is recommended to evaluate the science curricula content according to other international standards and compare them with the Next-Generation Science Standards.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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