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The UAE High School Students' Conceptions of the Nature of Science (NOS)

Eman Al-Bouti[1]

4. Student, The British University in Dubai, UAE

*Corresponding author's email: 20170238@student.buid.ac.ae

Abstract

Recently, science education has become an essential subject for all countries. Providing an appropriate science education affects students' conceptions of the Nature of Science (NOS). Participants in this study included 100 students from one secondary private American school in Al Ain; both girls and boys from different grades and with different nationalities were involved in the research. This study investigated the students' conceptions of the NOS. The research study followed a mixed qualitative and quantitative approach. A questionnaire was used to collect data, in both quantitative and qualitative formats. Data was analysed statistically using SPSS. The results of the statistical analysis of the questionnaire revealed the positive conception of students toward the NOS in general and toward scientific theory, scientific knowledge, scientific activities, and scientific inquiry in particular. The study concluded that most of the secondary school students have appropriate conceptions of the NOS in relation to the context of their science learning.

Keywords: Nature of Science (NOS), Scientific Inquiry, Scientific theory.

1. Introduction

The significance of this study attests to the importance of teaching and improving the understanding of the nature of science for high school students, in order to prepare them effectively for their future education and careers (Aflalo 2018; Karaman 2018). Through NOS students will be able to develop their scientific knowledge, in addition to improving their scientific skills. Furthermore, through improving the NOS conceptions of the students, their science literacy will be developed significantly (Aflalo 2018; Cakmakci 2017). The existence of effective teaching strategies, prepared science teachers, and appropriate curriculum with NOS inclusion affects students' conceptions of the NOS significantly (Nur & Fitnat 2015; Wong, Firestone, Ronduen, & Bang 2016). Providing teachers with appropriate professional developments enhances their NOS knowledge, in addition to providing them with effective teaching approaches in classrooms (Nur & Fitnat 2015; Milner, Sondergeld & Rop 2014). Furthermore, implementing inquiry-based learning allows students to engage scientific practices effectively in order to develop their scientific skills and knowledge, which leads them to improve their NOS conceptions (Cakmakci 2017). Additionally, applying both explicit and implicit approaches to teaching NOS concepts is an effective method to improve students' conceptions of the NOS (Carter and Wiles 2017; Forawi 2014; Williams and Rudge 2016).

The statement of the problem of this study indicates a need for investigating high school students' conceptions of the NOS, as it is an important part of science education and science literacy (Aflalo 2018; Wan & Wong 2017; Dogan 2017; Williams & Rudge 2016), in order to prepare a qualified generation with the required skills and knowledge for their future careers (Dogan 2017). There are many studies that are related to this field, however, there remain some gaps in the implementation and development processes of the NOS teaching (Aflalo 2018; Nur & Fitnat 2015; Dogan 2017). In addition, according to the central role of teachers in these processes, providing them with effective PD enhances the NOS teaching significantly (Cakmakci 2016; Sehin & Deniz 2016; Bilican, Cakiroglu & Oztekin 2015).

Moreover, according to the importance of the students' conceptions regarding the NOS and the importance of implementing effective strategies and approaches to teach NOS, the schools' orientations these days is to enhance students' conceptions of the NOS effectively in order to reinforce their science literacy. This is done by using appropriate strategies and by providing qualified teachers with adequate NOS knowledge and experience (Karaman 2017; Dogan 2017; Huang, Wu, She & Lin 2014). This is in addition to developing the scientific and 21st Century skills, such as, critical thinking and problem-solving, for high school students to match the required skills for the future career paths (Dogan 2017). Therefore, the main purpose of this study was to investigate UAE high school students' conceptions of the NOS. Specifically, the study answered the following questions:

1- What conceptions do UAE high school students hold of the NOS?
2- How do UAE high school students' conceptions of the NOS differ regarding their demographics?

2. Literature Review & Theoretical Framework

Along with the responsibility to teach science content and inquiry comes a responsibility to foster an understanding of the NOS. Developing the NOS is common to most science education curricula worldwide. Understanding the NOS is vital for effective science teaching, for valuable science learning and for participation in society. Through NOS, students learn what science is and how scientists work. They develop the skills, attitudes, and values to build a foundation for understanding the world. The following subheadings include the theoretical framework and literature review pertaining to the study.

2.1 Literature Review

2.1.1 NOS and Science Literacy

One of the main purposes of science education is to offer a significant education for all students (Carter & Wiles 2017; Forawi 2014). The NOS refers to multiple characteristics of science, such as, including the scientific inquiry, the role of scientific knowledge, how scientists work, and how the science affects and is affected by the social context (Wan & Wong 2017). The NOS is a major element to achieve the scientific literacy, which is why it is important to investigate the students' and teachers' conceptions of the nature of science (Nur & Fitnat 2015; Cakmakci 2017; Aflalo 2018). Furthermore, scientific literacy is one of the 21st Century skills that students have to obtain through science education (Dogan 2017; Carter & Wiles 2017) as scientific literacy improves critical thinking and problem-solving skills for students (Aflalo 2018; Wan & Wong 2017). Scientific literacy is considered as a vital goal of science education depending on its definition as "the development of deep understanding of major scientific concepts, process of scientific inquiry and the nature of science, as well as the development of the ability to make informed decisions regarding science and technology as they relate to personal and societal issues" (AAAS 1993; NRC 1996; Dogan 2017).

2.1.2 Explicit and implicit instructions and Students' conception of the NOS

Students have mixed perceptions about various categories of the NOS (Aflalo 2018). However, Nur and Fitnat (2015) indicated that using explicit NOS instruction within the science topic was an effective way to enhance students' conceptions significantly of the NOS and of scientific knowledge (Aflalo 2018; Forawi 2014; Pekbay & Yilmaz 2015; Russel & Aydeniz 2013). Moreover, Dogan (2017) suggested that applying an explicit approach is more effective than the implicit approach in order to increase students' understanding of the scientific inquiry. However, Carter and Wiles (2017) found that learning the NOS concepts implicitly through scientific inquiry, such as experiments and observations, and collections of reading developed students' views of the NOS concepts (Cakmakci 2017; Russel & Aydeniz 2013).

According to Forawi (2014), there are multiple factors that affect students' conceptions of the NOS. The first factor is related to the lack of instruction in the K-12 levels of the NOS that leads to a better understanding of it. Furthermore, the extensive use of text books is considered as another factor that affect students' conceptions of the NOS. That is why providing multiple activities and materials from different sources improved students' conceptions of the NOS (Cakmakci 2017; Forawi 2011).

Additionally, Williams and Rudge (2016) indicated that using historical instructional approaches as explicit instruction influenced students' NOS understanding positively (Nur & Fitnat 2015) by improving their abilities to think critically, and explain and discuss their own concepts of the NOS. However, Pekbay and Yilmaz (2015) found that the explicit–reflective approach was more effective than the historical approach.

Moreover, there are some previous studies that indicated the importance of the explicit instruction teaching approach in developing the teachers' conceptions of the NOS significantly (Wong, Firestone, Ronduen, & Bang 2016; Forawi 2011). According to Forawi (2011), both the implicit and explicit instruction of the NOS in parallel with the inquiry teaching played a vital role in improving the teachers' NOS conceptions (Russell & Aydeniz 2012). Moreover, it was realised that the explicit-reflective based NOS teaching was efficient in developing the pre-service teachers' NOS conceptions (Pekbay & Yilmaz 2015). However, Karaman (2017) found that there are no changes in the development of teachers' conceptions of the NOS regardless the gender.

Park, Nielsen and Woodruff (2014) found that the national situation and curriculum content are vital factors that affect students' views on the NOS. This agrees with the importance of the inclusion of the NOS concepts, strategies and activities in the curriculum content in order to engage students effectively in the classroom and to enhance their conceptions and understandings of the NOS (Maurines 2015). In addition, providing teachers with appropriate professional development can increase their abilities in conducting professional science curriculum with NOS aspects, implementing effective teaching strategies of the NOS (explicit and implicit), applying inquiry-based approach to engage students in the activities and improving their critical thinking and problem-solving skills (Maurines 2015; Sahin & Deniz 2016).

2.1.3 Teachers and NOS

Recent science education emphasises the importance of the instruction of NOS concepts at all levels of schooling from K-12 (Nur & Fitnat 2015). Delivering a proper NOS education to students is extremely dependent on their teachers having an adequate understanding of NOS concepts (Karaman 2017; Bilican, Cakiroglu & Oztekin 2015). Furthermore, combining both the implicit and explicit NOS instructional approaches in teacher professional development is a significant method to improve teachers' NOS conception (Milner, Sondergeld & Rop 2014). Preparing teachers with appropriate PD also affects the students' conceptions of the NOS positively (Bilican, Cakiroglu & Oztekin 2015). As the teaching strategies and approaches are important in the educational process, they are central to science teaching. Implementing appropriate teaching strategies affects the students' understandings and conceptions of science and the NOS (Nur & Fitnat 2015).

Moreover, Russel and Aydeniz (2013) found that applying explicit/reflective NOS instruction with inquiry-based learning emphasising many aspects of the NOS impacted the teachers' and students' NOS conceptions. Engaging students with science practices helps them to construct their understanding of the NOS aspects; including science definition and what is the scientist work instead of depending on the textbooks (Forawi 2014; Bloom, Binns & Koehler 2015). In addition to that, the inquiry-based approach allows students to explore, discuss, communicate with others, and to be able to take correct decisions (Russel & Aydeniz 2013). Thus, engagement in inquiry encourages the students to develop an enhanced understanding of aspects of NOS, such as, the empirical nature of scientific knowledge (Maurines 2015).

Implementing explicit/reflective instruction in the complex aspects of NOS is critical in the enhancement of students' understandings of those implicit aspects of NOS (Russel & Aydeniz 2013; Huang, Wu, She & Lin 2014). Some teachers indicated that interesting hands-on activities, creating concepts that are real and visible, including activities and projects that helped with learning to collect and analyse data, were the most common characteristics of the science practices (Forawi 2014; Bulunuz 2015). However, Maurines (2015) indicated that high school science syllabus impacts the science teaching. Regarding some examples of the high school syllabuses, it has been found that the implicit discourse is the most common while the explicit discourse is almost missed.

Research studies found that teachers lack the adequate understanding, training and teaching of the NOS, which affect their conception (Bilican, Cakiroglu & Oztekin 2015). Therefore, providing teachers with appropriate professional development improve their knowledge of the NOS aspects in order to improve students' NOS conceptions also (Sehin & Deniz 2016; Bilican, Cakiroglu & Oztekin 2015; Karaman & Apaydin 2014; Maurines 2015). Moreover, other research studies indicated that teachers with negative attitudes toward science tend to use pedagogical approaches instead of practical approaches (Bulunuz 2015).

Additionally, Sehin & Deniz (2016) found that teachers like to teach NOS if they realise that science curriculum accepts the inclusion of the NOS aspects. They are also focused on the importance of developing pedagogical content knowledge (PKG) for NOS, which is related to the students' knowledge (students' understanding, conceptions and misconceptions of particular aspects in the subject). Furthermore, the knowledge of curriculum was related to the PKG, which is focused on the knowledge of instructional materials, knowledge of appropriate skills those students have to obtain in the classroom, and knowledge of specific subjects regarding the grade level.

Actually, all of the science, scientific knowledge, and the NOS concepts are situated in the same area and cannot be separated from each other, however, the concepts of the NOS can be imbedded in the scientific knowledge (Park, Nielsen & Woodruff 2014). Practicing science can allow students to think deeper and work harder to understand how the science works, which motivates their knowledge of science and NOS concepts.

2.2 Theoretical Framework

The theoretical framework consists of the Scientific Ways of Knowing Model (SWKM) (Forawi & Liang 2011), Next Generation Science Standards (NSTA 2013), and Conjecture and Refutation Theory (Popper 1953), as indicated in the figure 1 and the description below to best constitute the theoretical framework of this study.

The SWKM was conceptualised to maximise the impact of the NOS and the guide-inquiry instruction with the participation of science teachers. It includes the main components of the science instruction: the NOS, guided-inquiry strategies, and teacher development. Both history of science and philosophy of science are connected with the inquiry-guided strategies and the theory and practice in order to build up a comprehensive SWKM. This model provides an "informed" instruction that recognises planning of NOS to be delivered through the guided-inquiry instruction. Instructing teachers with adequate information of the NOS prepares them to engage students effectively to experience different aspects of the scientific ways of knowing. Using SWKM requires teachers to discuss NOS explicitly in the classes through the inquiry-guided approach, which increases their understanding of the NOS and improves their abilities to integrate the main components of the model in order develop students' understanding of science and scientific learning. SWKM in the NOS teaching process is an "informed" process that includes the explicit and implicit notions of the NOS. Applying teaching of explicit and implicit aspects of scientific ways of knowing encourages teachers to improve students' inquiry skills and their understanding of scientific concepts.

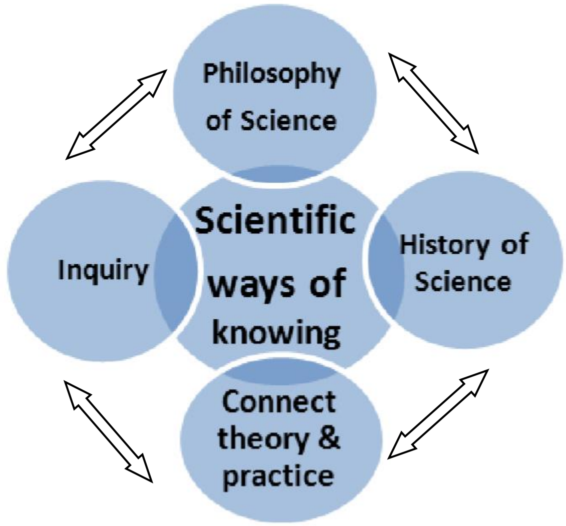

Figure 1: Scientific Ways of Knowing Model (Forawi & Liang 2011)

The Next Generation Science Standards (NSTA 2013) are K–12 science content standards. The NGSS were developed by states to improve science education for all students. These standards set the expectations for what students should know and be able to do. The standards are rich in content and practice and are arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education. There are three main dimensions of the NGSS which are: crosscutting concepts, science and engineering practice, and disciplinary core ideas. These dimensions are combined to form each standard (performance expectation).

The crosscutting concepts help students to connect the science domains, including: physical science, life science, earth and space, and engineering design. As these concepts are described explicitly for students, they can develop their scientific view of the world. The science and engineering practices describe the work of scientific investigation of the natural world, while engineers design and build systems. Practice is a better form of learning to understand, explain and explore, which is why inquiry is an important teaching approach in science, as it allows students to engage these practices to improve their knowledge of such crosscutting concepts. The disciplinary ideas are the most important concepts in science and engineering as well. Students build these ideas through process of progression through the grade levels depending on their extended understanding and experience of science.

The effective implementation requires a great collaboration among all stakeholders: teachers, schools' principal, states' leaders and districts, parents and students. This helps teachers to prepare a qualified scientific literate generation for future careers. Therefore, it is important to implement effective new teaching strategies to have an effective outcome.

The implementation of the NGSS needs appropriate instructional materials, which should be aligned with the standards for schools and states. This is essential as teachers have a central role in the NGSS implementation process; effective teacher preparations can affect the implementation positively. Providing teachers with professional developments improves their science conception and understanding, makes them familiar with the new standards, how to apply them efficiently, how to update the curriculum in parallel with the standards, and provides them with some appropriate strategies which can be applied in the classroom in order to develop the students' science learning. The science inquiry teaching approach has been one of the more effective strategies for the actual implementation of the new science framework. The science-inquiry teaching approach is an appropriate way for crosscutting between disciplines to improve students' science literacy (NSTA 2013).

Conjectures and Refutations is one of Karl Popper's most popular works. Popper notes that a common way to distinguish science from pseudo-science and he called this issue the "problem of demarcation" and the solution by “Falsificationism”. Falsificationism claims that a hypothesis is scientific if, and only if, it has the potential to be refuted by some possible observation. He focused on that many disciplines depend on the observation, but that we refuse calling them sciences. One such example is astrology; that discipline relies on a very extensive system of observations, but almost no one would consider it a science. Confirmation is a myth. For Popper, it is not possible to confirm a theory depending on observations only. The observational test can be done to assure that the theory is false. Therefore, the truth of any scientific theory cannot be supported by observational evidence. Popper came up with two suggestions for the inductive problem that is the acquisition of knowledge can be undertaken by the non-inductive process (thereby rational), or repetition and induction (a kind of belief of begetting belief). Popper’s theory has an appealing simplicity. Science changes through a cycle that repeats endlessly. In first stage is conjecture: a scientist will offer a hypothesis that might describe and explain part of the world. A good conjecture is a bold one that takes a lot of risks by making novel predications. While the second stage is refutation: the hypothesis is subjected to critical testing, in an attempt to show that it is not true (false). Once the hypothesis is refuted, then a new conjecture should be offered in stage 1 and so on (Godfrey 2009).

3. Methodology

The mixed method approach is a developing methodology of research that advances the mixing of quantitative and qualitative data within a single investigation or sustained programme of inquiry. Mixed methods research is a methodology for conducting research that involves collecting, analysing and integrating quantitative and qualitative research. This integration provides a better understanding of the research problem than either of each alone (Creswell 2014). This research adopts the mixed method approach and follows the pragmatist philosophy (Dewey 1916). Dewey’s philosophy is a ‘theory of inquiry’. Thus, the pragmatics recognise that there are multiple methods of undertaking research, wherein no single view or data collection approach can ever give the whole reality and truth (Creswell 2014). Selecting the mixed method data collection approach relies on the need for quantitative and qualitative data in order to answer, comprehensively, the questions of this study. The quantitative data includes closed-end information (students’ conceptions) which statistically analyses data to provide numerical results, while the qualitative data is more subjective and open-ended, providing further explanation of these conceptions (Creswell 2014).

This study was conducted in an American K-12 private school in Al Ain, in the United Arab Emirates. The research population is based on some secondary classes from grade nine until 12 for both males and females. Sampling is a convenience one and based on indicated high level classes that the school selected to conduct the study in. As per Creswell (2014), the convenience sampling “is a specific type of non-probability sampling method that relies on data collection from population members who are conveniently available to participate in study”. The participants in this study consisted of 34 girls and 45 boys from grades nine, 10, 11 and 12 of the secondary section of the private American school. All students studied science and were familiar with the main concepts and aspects of the NOS.

The questionnaire was the selected data collection approach for this research study. It was an effective tool used to gather required information from the population of individuals in a specific geographic are. In addition, it was appropriate to collect data quickly and with an explanation from the researcher to the science teachers. The data collection was guided by an adapted questionnaire (Appendix 2), which includes three related parts: the demographic, qualitative and quantitative parts. The demographic part depends on the gender, grade, and nationality of the students, and the quantitative part was adapted from a set of main concepts of the NOS using 5-Likert scale in order to measure students’ conception. While the qualitative part included two open-ended questions to provide more detailed and specific information that leads to a more comprehensive understanding of students’ conception of the NOS.

SPSS statistical software has been used to analyse the collected data. The data is collected to adequately analyse and later interpret the students’ conceptions of the NOS. Students’ perceptions of the scientific theories, scientific inquiry investigation and how it affects their understanding of the science concepts and the scientific knowledge characteristics were also assessed.

The quantitative data was analysed using the SPSS statistical instrument that measured the students’ conceptions of the NOS through the science learning process. Students' conceptions of the NOS were built up within a progression process form K-12. The qualitative data was determined by students' responses to the open-ended questions. In addition, the qualitative data has been used to identify the difference between girls' and boys' conceptions of the main aspects of the NOS based on their science learning process and their scientific experiences.

The sampling technique was convenience based on the permission guaranteed by the schools and the head of science department (Appendix 1). The researcher communicated with the science teachers for the secondary section and explained the main purpose of the study and explained the main parts of the questionnaire in detail after obtaining the permission to conduct the research and the questionnaire in that school. The school principal and science teachers collaborated effectively throughout the research study period.

4. Data Analysis and Results

The analyses of both quantitative and qualitative data showed the positive conceptions of the students regarding the NOS.

4.1 Quantitative Results

All of the students' responses to the quantitative part in the questionnaire were analysed statistically in order to identify the quantitative results. Each of the 25 items and the summation, mean and the standard deviation of females and males were compared. The SPSS statistical tool has been used to analyse the quantitative data by implementing various types of statistical analysis tests. The results of each are presented below:

Table 1: Reliability test for all items:

Reliability Statistics

Cronbach's Alpha	N of Items
.606	28

Cronbach's Alpha = 0.606 < 0.7 (but we can accept this reliability)

The Cronbach's Alpha = 0.606 which is below the 0.7 value, which means that the questionnaire used is not a fully reliable and solid instrument, however it is still an acceptable value in order to explore the high school students' conceptions of the NOS.

Table 2: Distribution of sample size:

Gender	**Number**	**Percentage**
Male	45	57
Female	34	43
Grade	**Number**	**Percentage**
Grade 9	26	32.9
Grade 10	13	16.5
Grade 11	25	31.6
Grade 12	15	19
Nationality	**Number**	**Percentage**
Emirati	59	74.7
Egyptian	8	10.1
Jordanian	5	6.3
Omani	4	5.1
Syrian	1	1.3
Bahraini	2	2.5

According to the above analysis, the number of female participant students (34) is less than the number of male participants (45). Most of the participants from grades nine and 11. While there are various nationalities of students; the UAE students form the highest percentage of the participants (47.7%) comparing to other nationalities.

Table 3: Distribution of all students' answers for all questions

Questions	Strongly disagree		Disagree		Don't Know		Agree		Strongly Agree	
	#	%	#	%	#	%	#	%	#	%
Scientific Theory Questions										
A scientific theory is always valid	19	24.1%	19	24.1%	3	3.8%	32	40.5%	6	7.6%
For a theory to have scientific merit it must be tested			1	1.3%	8	10.1%	23	29.1%	47	59.5%
A scientific theory describes a real phenomenon which is independent of human perception			5	6.3%	25	31.6%	38	48.1%	10	12.7%
Scientific theories are subject to change based on new improved results	1	1.3%	2	2.5%	9	11.4%	38	48.1%	29	36.7%
Scientific theories are subject to change based on new technologies	1	1.3%	8	10.1%	7	8.9%	39	49.4%	24	30.4%
A scientific theory is accepted based on experimental evidence	5	6.3%	21	26.6%	9	11.4%	24	30.4%	20	25.3%
A scientific theory determine the nature of			1	1.3%	4	5.1%	39	49.4%	34	43%

Questions	Strongly disagree		Disagree		Don’t Know		Agree		Strongly Agree	
	#	%	#	%	#	%	#	%	#	%
science work										
Total	26	2.97%	57	9.36%	65	13.68%	233	45.08%	170	29.62%
Scientific Inquiry Questions										
Scientific inquiry investigations allow scientist to obtain accurate results	1	1.3%	2	2.5%	14	17.7%	37	46.8%	25	31.6%
Scientific inquiry investigations are used to answer questions about nature to reveal reality.			2	2.5%	9	11.4%	39	49.4%	29	36.7%
Processes of scientific investigations are transferable that can be used in different scientific investigations			7	8.9%	11	13.9%	29	36.7%	31	39.2%
Scientific hypotheses are never wrong; they are just not supported by results	3	3.8%	10	12.7%	14	17.7%	38	48.1%	14	17.7%
Scientist follow the same systematic step-by-step scientific investigation	14	17.7%	16	20.3%	16	20.3%	16	20.3%	17	21.5%
Results of scientific investigations are used to draw generalizable conclusions	3	3.8%	14	17.7%	11	13.9%	31	39.2%	20	25.3%
Total	47	6.65%	108	10.77%	140	15.82%	423	40.08%	306	28.67%
Scientific Activities Questions										
Scientific activities are difficult	2	2.5%	11	13.9%	13	16.5%	34	43%	19	24.1%
Science concepts are easy to grasp	2	2.5%	18	22.8%	15	19%	29	36.7%	14	17.7%
Science content can be easily understood	15	19%	21	26.6%	14	17.7%	25	31.6%	4	5.1%
You prefer to do investigation with group of classmates	5	6.3%	21	26.6%	14	17.7%	29	36.7%	10	12.7%
Knowing science is vital to real-life experience	1	1.3%	9	11.4%	5	6.3%	35	44.3%	29	36.7%
Science plays a major role part in science, technology, engineering, and mathematics (STEM)			5	6.3%	5	6.3%	44	55.7%	25	31.6%
Scientific activities are difficult			9	11.4%	7	8.9%	33	41.8%	30	38%
Total	25	7.28%	94	17.52%	73	12.65%	229	41.13%	131	23.63%
Scientific Knowledge Questions										
A scientific knowledge is reliable until new information is obtained	2	2.5%	6	7.6%	12	15.2%	33	41.8%	26	32.9%
Only an error free idea is accepted as scientific knowledge	6	7.6%	16	20.3%	13	16.5%	27	34.2%	17	21.5%

Questions	Strongly disagree		Disagree		Don't Know		Agree		Strongly Agree	
	#	%	#	%	#	%	#	%	#	%
A scientific knowledge application is subject to ethical judgment	11	13.9%	13	16.5%	20	25.3%	27	34.2%	8	10.1%
A scientific knowledge is a proven truth	9	11.4%	13	16.5%	17	21.5%	23	29.1%	17	21.5%
A scientific knowledge is not affected by the emotions of the scientist	2	2.5%	5	6.3%	11	13.9%	27	34.2%	34	43%
Total	55	7.58%	147	13.44%	146	18.48%	366	34.70%	233	25.80%
Overall	85	8.60%	200	14.61%	219	19.14%	503	33.28%	335	24.38%

The above table presents the students' conceptions of each item of the questionnaire under each cluster; it answered the first question of the research study. Most students submitted 'agree' to 'strongly agree' to the main aspects of the NOS with total percentages of 33.28% and 24.38%, respectively, of the 5-Likert scale. This means that most of them have a good understanding of the NOS, scientific theories, scientific knowledge, scientific concepts and scientific inquiry. Moreover, 29.6% of the students' responses were 'strongly agree' in relation to the scientific theories, while only 23.6% of the responses were 'strongly agree' the scientific activities. Only 7.6% of the students' responses were 'strongly disagree' to the scientific knowledge questions, while 25.8% of responses showed 'strongly agree'. However, the whole percentage of students' responses were positive and agreed with the NOS concepts, and almost all of them were familiar with all clusters related to the NOS and agreed them.

Table 4: Distribution of all students' answers for all questions

Questions	Percentage	Mean	SD	Rank
A scientific theory is always valid	48.10%	2.84	1.38	22
For a theory to have scientific merit it must be tested	88.60%	4.47	0.73	2
A scientific theory describes a real phenomenon which is independent of human perception	60.80%	3.68	0.78	16
Scientific theories are subject to change based on new improved results	84.80%	4.16	0.82	5
Scientific theories are subject to change based on new technologies	79.80%	3.97	0.96	7
Scientific theory is established from imagination	55.70%	3.42	1.30	18
A scientific theory is accepted based on experimental evidence	92.40%	4.36	0.64	1
A scientific theory determine the	78.40%	4.05	0.85	9

nature of science work				
Scientific inquiry investigations allow scientist to obtain accurate results	86.10%	4.20	0.74	4
Scientific inquiry investigations are used to answer questions about nature to reveal reality.	75.90%	4.08	0.95	11
Processes of scientific investigations are transferable that can be used in different scientific investigations	65.80%	3.63	1.04	14
Scientific hypotheses are never wrong; they are just not supported by results	41.80%	3.08	1.41	24
Scientist follow the same systematic step-by-step scientific investigation	64.50%	3.65	1.16	15
Results of scientific investigations are used to draw generalizable conclusions	67.10%	3.72	1.06	13
Scientific activities are difficult	54.40%	3.45	1.11	19
Science concepts are easy to grasp	36.70%	2.77	1.23	25
Science content can be easily understood	49.40%	3.23	1.17	21
You prefer to do investigation with group of classmates	81.00%	4.04	1.01	6
Knowing science is vital to real-life experience	87.30%	4.13	0.79	3
Science plays a major role part in science, technology, engineering, and mathematics (STEM)	79.80%	4.06	0.97	7
A scientific knowledge is reliable until new information is obtained	74.70%	3.95	1.01	12
Only an error free idea is accepted as scientific knowledge	55.70%	3.42	1.25	17
A scientific knowledge application is subject to ethical judgment	44.30%	3.10	1.22	23
A scientific knowledge is a proven truth	50.60%	3.33	1.30	20

A scientific knowledge is not affected by the emotions of the scientist	77.20%	4.09	1.03	10

Furthermore, above table presents the percentage, mean, standard deviation, and the rank for each question in the questionnaire which reflects the students' responses for all questions. Most students agreed that the scientific theory is accepted depending on the experimental evidences, as it is situated as the first rank for all questions, followed by that the theory that has a scientific merit has to be tested. However, the hardest of grasping the scientific concepts was the least agreed with question.

Table 5: ANOVA Test

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		194.519	74	2.629		
Within People	Between Items	384.866	24	16.036	15.310	.000
	Residual	1860.174	1776	1.047		
	Total	2245.040	1800	1.247		
Total		2439.559	1874	1.302		

Grand Mean = 3.7205

We found a significant F=15.310, at Alfa = 0.00. This means approximately 100% of the participant students strongly agreed with the NOS based on the questionnaire. Moreover, ANOVA test found that there is a significant difference between male and female conceptions of the NOS, shown as Alfa = 0.00.

Table 6: Scientific theory: Determining the dependent variables that affect students' conceptions of the NOS regarding the main clusters:

Statement	**Mean**	**Std. Deviation**	**Test Statistics**
Scientific theory: Gender	Male = 3.79 Female = 3.97	Male = 0.31 Female = 0.41	<u>Independent sample t-test</u> t = - 2.234 P-value = 0.028
Scientific theory: Grade	9 = 3.90 10 = 3.85 11 = 3.74 12 = 4.05	9 = 0.38 10 = 0.28 11 = 0.36 12 = 0.36	<u>One-way ANOVA</u> F= 2.489 P-value = 0.067
Scientific theory: Nationality	Emirates = 3.86	Emirates = 0.38	<u>One-way ANOVA</u>

	Egypt = 4.00 Jordan = 3.70 Oman = 3.84 Syria = 3.50 Bahrain = 4.13	Egypt = 0.31 Jordan = 0.36 Oman = 0.31 Syria = 0.00 Bahrain = 0.00	F= 0.820 P-value = 0.539

From the test it can be concluded that there is significant difference between students' conceptions of the scientific theories by gender. According to the mean values, female students agreed the main aspects of the scientific theory more so than male students. However, there is no significant difference between students' conceptions of the scientific theory by grade levels and nationality.

Table 7: Scientific Inquiry

Statement	**Mean**	**Std. Deviation**	**Test Statistics**
Scientific inquiry: Gender	Male = 3.66 Female = 3.81	Male = 0.49 Female = 0.49	Independent sample t-test t = -1.386 P-value = 0.170
Scientific inquiry: Grade	9 = 3.70 10 = 3.58 11 = 3.75 12 = 3.87	9 = 0.54 10 = 0.53 11 = 0.43 12 = 0.49	One-way ANOVA F= 0.833 P-value = 0.480
Scientific inquiry: Nationality	Emirates = 3.75 Egypt = 3.75 Jordan = 3.40 Oman = 3.67 Syria = 3.33 Bahrain = 3.92	Emirates = 0.50 Egypt = 0.46 Jordan = 0.51 Oman = 0.56 Syria = 0.00 Bahrain = 0.59	One-way ANOVA F= 0.654 P-value = 0.659

According to the above table it can be concluded that there is no significant difference between students' conceptions of the scientific inquiry, its importance, and its implementation by gender, or grade levels or even by nationality.

Table 8: Scientific Activities

Statement	**Mean**	**Std. Deviation**	**Test Statistics**
Scientific activities: Gender	Male = 3.43 Female = 3.85	Male = 0.42 Female = 0.41	Independent sample t-test t = -4.467 P-value = 0.000
Scientific activities: Grade	9 = 3.47 10 = 3.63 11 = 3.59 12 = 3.89	9 = 0.49 10 = 0.36 11 = 0.46 12 = 0.40	One-way ANOVA F= 2.848 P-value = 0.043
Scientific activities: Nationality	Emirates = 3.64 Egypt = 3.60 Jordan = 3.57 Oman = 3.50 Syria = 3.00 Bahrain = 3.58	Emirates = 0.49 Egypt = 0.50 Jordan = 0.35 Oman = 0.14 Syria = 0.00 Bahrain = 0.12	One-way ANOVA F= 0.433 P-value = 0.824

According to the scientific activities, it is obvious that there is significant difference between students' conceptions by gender and grade. By comparing the mean values of both male and female students, it was found that female students have a greater mean value, which means that female students are more familiar with the scientific activities than male students. Furthermore, the grade level affected the results as the following: 12 = 10 = 11 > 9. So, greater grades were more positive toward the scientific activities than the lowest grades. However, there is no difference between students' conceptions regarding their nationality.

Table 9: Scientific Knowledge

Statement	**Mean**	**Std. Deviation**	**Test Statistics**
Scientific knowledge: Gender	Male = 3.29 Female = 3.95	Male = 0.62 Female = 0.41	Independent sample t-test t = -4.467 P-value = 0.000
Scientific knowledge: Grade	9 = 3.35 10 = 3.52 11 = 3.61 12 = 3.97	9 = 0.68 10 = 0.56 11 = 0.63 12 = 0.41	One-way ANOVA F= 2.848 P-value = 0.043
Scientific knowledge: Nationality	Emirates = 3.65 Egypt = 3.50 Jordan = 3.64 Oman = 3.10 Syria = 3.00 Bahrain = 2.90	Emirates = 0.61 Egypt = 0.68 Jordan = 0.79 Oman = 0.68 Syria = 0.00 Bahrain = 0.14	One-way ANOVA F= 0.433 P-value = 0.824

From the above table it can be concluded that there is significant difference between students' conceptions of the scientific knowledge by gender and grade. According to the mean values of both male and female students, female students have a greater mean value, which means that female students have better scientific knowledge than male students. Moreover, the scientific knowledge of the students was different regarding the grade level: 12 = 10 = 11 > 9. So, higher grades have better scientific knowledge than the lowest grade. However, there is no difference between students' conceptions regarding their nationality.

1) Demographic results related to gender

The demographic results on this research study depend on 3 factors:

a) Gender:

Table 10: Gender differences

Statement	Mean	Std. Deviation	Test Statistics
Gender	Male = 3.57 Female = 3.90	Male = 0.24 Female = 0.32	Independent sample t-test t = -5.169 P-value = 0.000

From the t-test we can conclude that there is significant difference between students' conceptions of the NOS by gender. From the mean we can conclude that female students, with a mean = 3.9, are more agreed with the NOS concepts than male students, with a mean = 3.57.

b) Nationality

Table 11: Nationality Differences

Statement	Mean	Std. Deviation	Test Statistics
Nationality	Emirates = 3.74 Egypt = 3.74 Jordan = 3.58 Oman = 3.57 Syria = 3.24 Bahrain = 3.70	Emirates = 0.33 Egypt = 0.32 Jordan = 0.32 Oman = 0.27 Syria = 0.00 Bahrain = 0.08	One-way ANOVA F= 0.833 P-value = 0.530

From the test we can conclude that there is no significant difference between students opinions on NOS by nationality.

c) Grade Level

Table 12: Grade Level Differences

Statement	Mean	Std. Deviation	Test Statistics
Grade	9 = 3.64 10 = 3.66 11 = 3.68 12 = 3.26	9 = 0.36 10 = 0.21 11 = 0.28 12 = 0.33	One-way ANOVA F= 3.814 P-value = 0.013

From the test we can conclude that there is a significant difference between students' conceptions of the NOS by grade level. By using Tuckey, we can order the grades as per the following: 12 > 11 = 10 = 9

4.2 Qualitative Results

The qualitative analysis provided data based on the responses of the participating students to the third part of the questionnaire. There are two open-ended questions included in the questionnaire to present students' conceptions of the main aspects of the nature of science, such as: scientific theories, scientific knowledge and the main scientific concepts, how they learn science and how it affects their understanding and their 21st Century skills, in addition to revealing their abilities to connect science phenomena with the real-world activities. The following are examples of supportive responses of the open-ended questions that students provided.

Q1) What is science? How does science work?

According to responses of the female students from grades nine, 11 and 12, it is obvious that only a small number of them have good background information about science and the nature of science. They know the basics of the science but actually they do not have any idea about how it works. The students' responses showed that there is a big gap between the correct understanding of science and how it works, and the students' understanding of it through their science learning process. One student responded that "Science is basically the answer of any question, it is the life", so it is obvious that she knew the definition of science but she does not have the proper concepts to define it. Other students wrote that "science is everything around us and it is basically the whole life."

Furthermore, some respondents noted that "science works as scientist's work", "Science is the portion of the earth that supports life, and we can find it everywhere", "Science is based on the experiments and investigations to check the laws and rules of life", and "Science is the study of the nature of the world". However, other students showed that their understanding of science is better than others through their responses: "Science is the study of the structure and behaviour of the physical and natural world through observations and experiments, science works on experiments and investigations", "Science is the key to better future, and most of other subjects have a connection with it", as well, another student who found that "Science is the study of different disciplines (chemistry, physics and biology) in order to understand the changes of the environment, science works by questioning the presence of absence of an object".

According to the responses of the female of the secondary levels, all of them have the same understanding and knowledge of science and how it works regardless the grade level.

Moreover, the male students' responses revealed their basic understanding of science and its work. Some students answered the first question stating "Science is the study of life, everything about science affects our daily life and activities. Science works through the experiments and hypothesis that scientist's set and study", "Science is the whole life, and we use it to discover the world", "Science is the study of scientist and their work, and the nature of everything in the world, it works with scientists and technology", "Science is about all living and non-living things in the world, it works through the discovery of the nature of everything"; actually there were a lot of responses that agreed with this latter statement.

However, one student tried to explain a definition of science based on his learning experience through the following response: "Science is the study of how the life works based on theories and hypothesis of the world", "Science is the study of everything and it works by gathering information and evidence to explore something new or to prove a theory". Another student responded that "Science is the study of the different disciplines based on facts and experiments, its work starts by asking questions about any phenomena in the world"; also, there are many comprehensive answers, such as: "the Science is the study of everything connected to our life such as: space, humans life, animals, plants an earth. Science work depends on experiments, beliefs, and knowledge" and "Science studies and revolves around living things to identify their structures; science works to develop the understanding the world". In addition, there was a good response which showed a student's understanding of the tentative characteristic of science "Science is the study of the life; science has no ending like the observations and evidences".

These were the responses of the male students of grades nine, 10 and 11. Those reflect a good understanding and experience of science. Engaging students with scientific experiments and activities provided them with adequate understanding of science and its nature in general. The students' responses indicated their engagement in scientific experiments, but also it showed that they do not have a deep understanding of science, and that they are not familiar with science concepts.

Q2) How do scientists do their work?

Starting with female students' responses "They get inspiration first from their experiences, then by testing, questioning, and making theories", "They investigate new phenomena", "Scientists work by scientific theories", "They undergo an experiment and identify the main idea of it", and "They do experiments by using scientific methods". In addition, one student responded by stating that "Scientists work with others on experiments and investigations". All of these answers are correct; however, no one is a comprehensive answer.

Other respondents stated: "Scientists do their work by steps. They have hypothesis that they need test them by experiments and scientific theories", "They keep searching for correct answers", while many students reflected their understanding of the scientist's work with the following response: "Questioning, looking for evidences, and experiments". Others responded by noting: "Testing hypothesis and theories". Regarding this question, higher grade students' responses were better than lower grades, which showed that students' understanding of the scientist's work is improving through their learning process and grades.

There are no differences between male and female students' responses regarding this question. Some male students responded as per the following:

"Scientists use their scientific knowledge to discover new things in steps 1) hypothesis 2) experiments 3) test the hypothesis", "The scientists imagine the case that they observe then they study it for years then come up with conclusion", "They devise a topic to investigate, put hypotheses, test them by experiments and then conclude the results using scientific theories and phenomena", "Scientist gather information and work with them until conclude a new theory or phenomena" , "They ask themselves questions about a phenomena and them try to find correct answers", "They ask questions about something that no one know about it and try to investigate it" and "The scientist do their work depending on their scientific knowledge and through sequential steps".

According to the previous responses of the high school students, regardless the gender, it can be indicated that all students have a brief background of science, the NOS, scientific concepts and knowledge. However, they lack a deep understanding of the NOS and its knowledge. Furthermore, they are familiar with the scientists' work and the scientific process, yet more engagement with scientific experiences is needed to improve students' scientific knowledge, scientific concepts and science understanding. They have good skills to connect science with real-life activities, which are based on their learning process, however, they increasingly need to be qualified enough for future careers.

5. Discussion

According to the importance of the NOS, many countries these days give significant attention to the science teaching and learning process in order to improve it and enhance students' conceptions of the NOS (Carter & Wiles 2017). Furthermore, increasing students' scientific knowledge and 21st Century skills, such as, scientific literacy, problem solving and critical thinking to match the required skills for the future career paths, are the main goals of the countries (Dogan 2017; Aflalo 2018; Nur & Fitnat 2015).

Regarding the data analysis of this research study, the quantitative results showed that all students regardless the gender, grade levels or even the nationality have a positive conception toward the NOS (Herman 2018). However, they have mixed perceptions toward various categories of the NOS (Aflalo 2018). Moreover, quantitative data indicated the positive conceptions of the students towards scientific theories, knowledge, activities and inquiry (Cakmakci 2017).

Moreover, the demographic test conducted regarding the students' gender, grade levels, and nationality showed that, in general, the female students were more familiar with the NOS than the male students (table 6); in particular female students have more positive conceptions of all the NOS clusters except for scientific inquiry (tables 3, 4, 5 and 6). All students regardless their gender, grade and nationality were familiar with the scientific inquiry and have positive conceptions of it (Maurines 2015).

In addition, it is obvious from the quantitative results that the nationality of the students did not affect their conceptions of the NOS (table 8). While the grade level affected the students’ conception positively for high grades regarding the scientific activities and scientific knowledge (table 9), which can be related to the improvement of their abilities of building up their knowledge and connecting the activities with scientific phenomena and concepts in order to develop their science understanding through learning process (Cakmakci 2017; Maurines 2015).

The qualitative results indicated that most students have a good background of the NOS. They were familiar with the general scientific concepts, however, they have good experiences with the scientific inquiry, which provided them with an adequate understanding of the NOS and improved their scientific knowledge (Maurines 2015; Sahin & Deniz 2016). Most of students’ answers on the scientist’s work were to describe the scientific process that scientists use in their experiments, which reflected their experience in scientific activities.

Additionally, most students’ responses to the open–ended questions reflected their brief understanding of science, especially its definition and how it works. However, their responses on the second question indicated that they were familiar with the science activities and inquiry; however, they have to be more engaged with it to understand it deeply and to improve their skills in order to develop their scientific knowledge and understanding of science (Herman 2018; Sahin & Deniz 2016).

6. Conclusion, Limitations, Implications and Recommendations

In this paper, study findings were revealed, assessed and interpreted. This study investigated the students’ conceptions of the NOS. The finding indicates that most students have positive conceptions of NOS and its main aspects. Furthermore, most students were familiar with scientific inquiry and scientific knowledge, which have to improve their science literacy and their conceptions of the NOS. Moreover, it was indicated that there is a significant difference of understanding the NOS between males and females, as well as regarding the grade level. However, there is no significant difference according to the students’ nationality. According to the limited sample of students who completed the questionnaire of this study from one school only in the UAE, the results of this study cannot be generalised to all students in the UAE. Implications of this study are deemed important in identifying whether the science education provide good conceptions of the NOS. As per results of this study, one implication would be reflecting the importance of improving students’ science literacy and nature of science in the reform agendas and policy development. Another implication can be improving science teachers’ conceptions of science and up-to-date science pedagogy. Also, the study suggests that science curriculum has to be supported with NOS in order to foster students’ deep conceptions, regardless of nationality and the gender. As well, science teachers should be provided with PD on NOS as to improve students’ conceptions and scientific literacy. Therefore Future researches might replicate the study and investigate the students’ conceptions of the NOS for large samples of students in multiple schools in the UAE and by using more reliable instruments, or to replicate the study and additionally investigate both students’ and teachers’ conceptions of the NOS.

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