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The Effectiveness of Teaching a Science Subject Unit Designed Based on the STEM Approach on Developing the Scientific Concepts Among the Fifth- Grade Pupils at Al Iman School – Kingdom of Bahrain

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Abstract

The current study aimed to investigate the effectiveness of teaching a science unit designed based on the STEM approach on developing scientific concepts for fifth grade students at Al Iman School School-Kingdom of Bahrain. The study sought to verify the hypothesis stated that there are statistically significant differences between the mean scores of the experimental group in learning scientific concepts taught using the STEM approach, and the mean score of the control group taught the same content traditionally. The study utilized the systematic approach to design the proposed science unit and develop the required learning material, the experimental research approach with a quasi-experimental research design to test the above hypothesis. The study sample consisted of 40 pupils from the fifth grade of primary school who are studying in Al-Iman schools. This sample was divided into two groups, an experimental group - section (A), composed of 20 fifth grade students, and a control group –section (B), composed of 20 fifth grade students. To assess the impact of the independent variable represented in the teaching method i.e. (teaching a unit using the STEM approach versus teaching the same unit traditionally) on the dependent variable represented in learning the scientific concepts included in the STEM curriculum, the study used the following tools (1) An achievement test in scientific concepts (for the third unit of the fifth grade science subject) prepared by the subject teacher (researcher) to measure achievement; (2) The unit developed using the STEAM approach was prepared by the subject teacher (researcher). Data analysis revealed that there were statistically significant differences at ($p \leq 0.01$) between the mean scores of the experimental group and the control group in the post application of the scientific concepts test in favor of the experimental group. Results also showed a notable high degree of interaction from the experimental group who were taught by the new curriculum developed using the STEM approach was also reported. The study recommends adopting the STEM approach for teaching science at the primary level, and the necessity of training teachers to design lessons based on the new curriculum.

Key words: STEAM , NGA

1 Introduction

Many developed and developing countries seek to improve science and technology practices and policies by developing strategic plans for science, technology, and innovation that are appropriate to the specific conditions of our knowledge age; linking them to human development through appropriate education and training programs to achieve the strategic goals for developing teaching and learning processes. One of these modern plans is the STEM approach, which is currently one of the most promising curricula in the United States of America, which are used with pupils at different levels of study. STEM is defined as an integrated knowledge building between the disciplines of science, mathematics, and engineering design with its technological applications. This structure is based on learning through practical activities, digital and computerization activities, expertise-based activities, discovery and investigation activities, manual expertise activities, scientific and logical thinking activities, and decision-making. This knowledge-based structure is based on integrated conceptual experience, problem-centered thinking, intensive application of practical activities, focused on self-directed experience and empirical research in binaries and teams, realistic multidimensional evaluation based on performance, the capacities of scientific, creative, and critical thinking. 3 Bybee (2013) pointed out that the STEM approach aims to achieve scientific enlightenment in society by providing the learner with knowledge, skills, and attitudes in a functional way, enabling him to identify the questions and problems he encounters in his life, to explain what is happening in the world around him, and reach conclusions based on real evidence on the issues surrounding him. In light of the challenges at the global and national levels, developing pupils ability to build up conceptual understanding as a primary goal in the process of teaching, learning and therefore a major goal in the teaching of science, which requires teachers to consider the task of developing the pupils ability to think, understand the terminology of the problems of daily life educational goal, put them at the front of their priorities; because of the development of scientific concepts and introduce it in more

than one form among students give to allow them to discover themselves and the ability to deal with problems correctly, accurately and at the right time (Abdul Aziz, 2007;Hossam El-Din and Abdel-Fattah, 2005). Studying STEM programs and curricula provides the best opportunity to recognize the phenomena of the world we live in and remove artificial barriers between the four domains and provide a model of coherence and cohesion education (Lantz, 2009). Among the studies conducted in the field of science, technology, engineering and mathematics curricula (STEM) to determine the effectiveness of the STEM approach, and showed that effects on some variables, for example, Stephanie Study (2014), which found that fourth graders in Florida gained an understanding of STEM-related knowledge and 4 concepts about robotics, and this study supported the idea of introducing science, technology, engineering, and mathematics to primary school pupils. The National Academy has stressed the need to learn science, technology, engineering, and mathematics in an integrated framework as one of the requirements of the learner's preparation in the 21st century in the hope of creating educational paths and opportunities that provide pupils with high quality educational, conceptual and professional experiences in these disciplines and this in turn, prepares them for better jobs in the future (National Academy of Education, 2009). One of the main objectives that science education seeks to achieve is to create positive attitudes among students towards the study of science because of its importance in their lives. It directly affects their behavior, and the effects of their behavior are evident in a kind of social motive (Habib, 2008 & Abu al-Majid 2013). In the context of global interest in preparing a scientifically and technologically informed graduate who can know, understand, and solve corresponding problems, he was interested in the STEM approach and these sciences require integration into teaching and learning. The comprehensive and interconnected knowledge of related subjects is far from theoretical concepts that are traditionally taught in the classroom (Muhisen and Khaja, 2015).

2. Statement of the Problem

Despite the importance of scientific concepts, they do not receive sufficient attention in teaching science especially in the primary stage, because of using traditional teaching strategies, and the scientific content does not include activities and scientific practices based on the STEM approach that allows the minds of pupils to think and innovate. To address this problem, the researcher tries to answer the following main question:

1. Questions of the study

The current study will try to fulfill the following questions:

What is the impact of teaching a science unit designed based on STEM approach on developing scientific concepts for 5th grade primary pupils?

To answer the above main question, the study is trying to answer the

following sub-questions:

1. What are the basic concepts to be developed for 5th year primary pupils in science?

2. What are the components of the designed science subject unit in light of STEM approach for developing the scientific concepts for 5th year primary pupils?

3. What is the impact of teaching the designed science subject unit based on STEM approach on developing the scientific concepts for 5th year primary pupils?

2. Purpose of the study

This research seeks to achieve the following objectives:

1. Demine a list of scientific concepts for the prosed science subject unit for the 5th grade pupils.

2. Designing a Science Learning Module based on the STEM approach for the Fifth Graders pupils.

3. Detecting the impact of the proposed learning module designed based on the STEM approach in the development of the scientific concepts among fifth graders pupils.

Literature Review

This chapter is mainly intended to explore the importance of teaching Science in general, and the importance of teaching science in the light of the STEM approach. The researcher explores the basic theoretical foundations related to this study and review the related literature. The chapter explore the following topics: teaching science at primary education, problems of teaching science, misconception among primary students, STEM approach, why using STEM approach for teaching science, the role of STEM approach in teaching science concepts, and the previous studies 2.1 Teaching science at elementary school Science is the systematic study of the structure and behavior of the physical, social, and natural worlds through observation and experimentation. It's key to innovation, global competitiveness, and human advancement. The world must continue to advance the field of science, whether it is finding new cures for cancer and other diseases or identifying and exploring new galaxies. The National Academy of Sciences (2008) defined science as: "The use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." Beyond the potential scientific breakthroughs, there are individual benefits to learning science, such as developing ability to ask questions, collect information, organize and test our ideas, solve problems, and apply what we learn. Even more, science offers a powerful platform for building confidence, developing communication skills, and making sense of the world around us, 14 a world that is increasingly shaped by science and technology (Walden University, 2020). Science also involves a lot of communication with other people and develops patience and perseverance in children. Finding answers to their countless "why" questions pushes students to research and form their own opinions instead of taking others' for granted. While it is easy to go along with another student,

and answer or pull out a Smartphone and do a quick internet search to know why the leaves fall from the trees, a healthy dose of skepticism can take students farther as they explore the world around them and tackle some of its challenging questions. Initially (19th century), science (or science subjects) was included in the school curriculum to provide a background for students to better cope if they chose to study science subjects at university (Fensham, 2008). Teaching science offers pupils the opportunity to increase their overall understanding of how and why things work, it teaches pupils about the world around them. From the human body to methods of transportation, science can explain the mechanics and reasons behind complex systems. This knowledge can be used to understand new concepts, make informed decisions and pursue new interests. Additionally, because science can provide tactile or visible proof of many facts we see on TV and in books, students can increase their understanding and retain information better. Dewey (1987) told us that: an elementary school teacher needs to have a command of 1. The reasoning patterns and pre-instructional conceptions that the students have. 2. The scientists' view that we are working toward. 15 3. The appropriate conceptual goals for the children, given their age. Pupils can develop a healthy dose of skepticism from studying science. Science also instills a sense of intrigue that allows pupils to understand and form questions based on the knowledge they gained. Many pupils find science inspiring and interesting and, thus, pursue new scientific interests. Science can give pupils the belief that they can help solve the world's problems, which is a great thing. Science instills the ability to think logically and solve problems. Almost everything you see is because individuals had a question and used their knowledge of science to solve it. 2.2 Difficulties facing teaching science in elementary school The National Research Council published Taking Science to School: Learning and Teaching Science in Grades K-8 (National Research Council, 2007) reported that teaching science in primary schools has several different issues.

Many primary teachers have not received extra training in teaching science, leading to low confidence in teaching, and less effective science lessons.

Science teachers have low confidence in science teaching because teachers do not have a deep understanding of the topic of the lesson or how to implement it.

Curriculum topics such as the science curriculum need additional time to achieve their goals, which are taught only superficially.

Unavailability of resources and science teaching tools due to the lack of budgets allocated to them, especially materials required in the laboratory.

Traditionally, science is taught as a stand-alone subject, and not connected to other learning areas or the pupils' experiences of life.

• The language difficulty, i.e. when teaching EFL (English as a foreign language), indicates the teaching of English in a non–English-speaking region, since English is the second language, it will be difficult for students to understand scientific concepts in the English language. STEM teachers use STEM skills as part of their everyday lives and volunteer their time to solve all these issues and inspire the students.

2.3 STEM Implementation Criteria the STEM standards of the effective Guide to Practice Guidelines depend on the definition of the combination of behaviors combined with the STEM and expected content of STEM students. These behaviors include participation in inquiry, logical thinking, cooperation, and research. STEM's goal is to prepare post-secondary and labor market pupils for the 21st century. STEM has seven standards in terms of practice (or skills) required to teach students science, technology, engineering, and mathematics. Competencies that have been achieved by the distinguished students in this program and what is expected of them are as follows:

(1) Learning and applying the content of science, technology, engineering, and mathematics. STEM students learn and apply accurate content in the disciplines of science, technology, engineering, and mathematics to be able to answer complex questions and research global issues to develop solutions to global challenges and problems by:

Demonstrate understanding of the content of science, technology, engineering, and mathematics.

Application of science, technology, engineering, and mathematics content.

(2) Integrating the content of science, technology, engineering, and mathematics: STEM's distinguished students integrate science, technology, engineering, and mathematics content appropriately to be able to answer complex questions and research global issues to develop solutions to global challenges and problems by:

• Analyzing links to multiple disciplines in science, technology, engineering, and mathematics.

• Apply the integrated content of Science, Technology, Engineering, Mathematics and other content in an appropriate way to be able to answer complex questions and research global issues to develop solutions to global challenges, and problems.

(3) Interpretation and Linking Information from Science, Technology, Engineering, and Mathematics: STEM pupils interpret, and link information available in the fields of science, technology, engineering and mathematics in an appropriate way to be able to answer complex questions and research global issues to develop solutions to global challenges and problems through: Identify, analyze and synthesize appropriate information from science, technology, engineering and mathematics (text, visual, audio, etc.).

Applying the vocabulary of a specific scientific field in the case of the delivery of the content of science, technology, engineering, and mathematics.

Integrate critical reading and writing of technical information.

Evaluate and integrate multiple sources of information (eg, quantitative data and multimedia video) presented in a variety of ways.

Develop evidence-based opinions and debates.

Communicate effectively and accurately with others.

(4) Integration into the investigation: STEM pupils are involved in investigating and researching global issues, challenges, and problems through:

Asking questions to identify and define global issues, challenges, and problems. • Conduct research to revise questions and develop new questions.

(5) Engage in logical thinking: STEM pupils engage in logical thinking to be able to answer complex questions and research global issues to develop solutions to global challenges, and problems by:

Use critical thinking. • Integration into the investigation: STEM pupils are involved in investigating and researching global issues, challenges, and problems through:

Asking questions to identify and define global issues, challenges, and problems.

Conduct research to revise questions and develop new questions.

Engage in logical thinking: STEM pupils engage in logical thinking to be able to answer complex questions and research global issues to develop solutions to global challenges and problems by:

Use critical thinking.

Evaluate, select, and apply systematic and appropriate methods (scientific, engineering practice, engineering design process, and/or mathematics practice).

• Apply science, technology, engineering, and mathematics content to come up with creative ideas.

• Analyze the impact of global issues and problems at the local, regional, national and international levels.

(6) Cooperation and work as a team: Outstanding STEM pupils collaborate as a team to be able to answer complex issues and research global issues to develop solutions to global challenges and problems through

• Identify, analyze, and implement a specific section of STEM topics.

• Share ideas, and work effectively with a multidisciplinary team (STEM) to achieve a common goal.

• Analyzing employment opportunities in various STEM areas related to the STEM multidisciplinary goal.

Use and application of technology in creative and professional ways: STEM pupils apply technology strategically to be able to answer complex questions and research global issues to develop solutions to global challenges, and problems through:

• Identify and understand the technology required to develop solutions to problems or to create questions for complex issues.

• Analyzing the limitations, risks and impacts of technology.

• Engage in the reasonable and ethical use of technology.

• Improve and create new technology that increases human capacity.

3. Method

The researcher utilized the experimental research approach with a semi experimental design based on a pre-test for two groups, one of which was an experimental group that taught according to the STEM approach and the other 40 was a control group taught in the conventional method (face to face). This design is one of the famous designs and this design is the most appropriate to the requirements and conditions of this study.

5 Exploratory sample: The research tools were applied to an exploratory sample of 5 th grade pupils in Al-Iman elementary schools in the academic year (2020-2021).

Around (30) pupils have participated in the exploratory phase. Their average age is (11 years and a standard deviation of

0.5). The difficulty parameters for the test items were determined, the discrimination parameters for the test items, calculate the test stability factor, calculate the test time, and know the clarity of the test instructions and the meanings of its vocabulary. As well as the reliability and validity of the satisfaction questionnaire with the new curriculum.

The Study Variables

3.5.1 The Independent Variable

The independent variable was the teaching method (categorical variable). Teaching science using the STEM approach versus teaching the same unit traditionally through face-to-face.

3.5.2 The Dependent Variables

This study included one dependent variables: development of the scientific concepts.

3.5.2 The Control Variables In the present study, the control variables were limited to the following:

➢ Pupils` age;

➢ Pupils ` language;

➢ The achievement rate for fifth-grade pupils.

4. Data Analysis, Results & Discussion

The purpose of the study was to explore the impact of using the Effectiveness of teaching a science subject unit designed based on the STEM approach on the development of scientific concepts among fifth-grade pupils. Learning outcomes under investigation included practical concepts to be developed in the unit designed in light of the STEM approach, unit content designed in lightof the STEM approach, and satisfaction with learning using the STEM approach in fifth-grade science education. This chapter presents the results of data analysis starting with a presentation of the demographic and

experiential characteristics of the sample using descriptive statistics including frequencies, crosstabs, and percentages to depict the distribution of values of the independent variables, with interpretations for collapsing categorical data decisions.

Then, the results of the data analysis, using statistical methods, are presented for each research question. The data analysis is based on the data collected from the research instruments described in Chapter III. The results of the questions and the related hypotheses are presented in the way they appeared in chapter one followed by a discussion of the study's results follows in section 4.8. Data analysis was performed using SPSS v26.

4.1 Results related to Subjects Demographic Data and Group Equivalent

The number of participants in the study is 40 pupils. They were divided into two groups, Experimental group, (20) pupils studied using the designed unit (STEM approach). Control group, (20) pupils who studied using the Regular curriculum. Their average age is 11 years and a standard deviation of (0.5 years). As mentioned in chapter three, the school contains four classes from the fifth grade; two classes were chosen randomly (5A and 5B). One of them was randomly chosen to act as an experimental group and its size was (20) pupils studied using the STEM approach, and the other is nominated as the control group consists of (20) pupils studied in the conventional method (traditional face-to-face). Table 4-1 present the study sample group statistics related to the pre-test.

Table 4-1

Study sample group statistics related to scientific concepts pre-test

Group	Mean	N	Std. Deviation	Std. Error Mean
5A	14.3500	20	5.67798	1.26964
5B	13.9000	20	6.14162	1.43436

Table 4-1 presents 5A and 5B classes (study groups), means, standard deviations; standard error means in the pre and post-scientific concepts test. To make sure the two groups (5A and 5B) are equivalent in their scientific concepts' knowledge before the experiment, an independent samples t-test was conducted. Table 4-2 shows independent samples t-test results related to5A and 5B classes achievement in the scientific concepts pre-test.

Table 4-2

Experimental/Control Group Independent Sample Pre-test Results

Variance Type	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.003	.964	.235	38	.816	.4500	1.95555	-3.42783	4.32783
Equal variances not assumed			.236	37.45	.816	.4500	1.955555	-3.42971	4.32971

Levene's Test for Equality of Variances and independent-sample t-test results as presented in table (4-3) shows no statistically significant differences between the two classes i.e. (mean difference =0.450, t=0.235; df=38; no significant at α=0.05 was reported). Therefore, the 5A and 5B classes are equivalent concerning their achievement of the scientific concepts before the experiment. Therefore, the researcher selected 5A class to act as the experimental group and 5B as the control group.

Discussion of results:

The study aims to assess the effectiveness of the proposed scene subject unit designed using the STEM approach on the development of an understanding of scientific concepts. Moreover, it is sought to test the main hypothesis "There are statistically significant differences at the level of (α=0.05) between the average scores of students in the experimental group taught using the proposed science subject unit designed based on STEM approach and the control group taught traditionally. To verify the study hypotheses, the researcher designed a test for scientific concepts. The study instruments` reliability and validity reviewers' suggestions and comments have been taken into account. Accordingly, the test and syllabus content is well designed and organized. After treatment and administrating the study tools, the results of the study revealed that there are statistically significant differences at the level of significance (0.01) between the mean scores of the experimental and control group in the postapplication of the scientific concepts test for the favour of the experimental group, where the computed value of t (7.814) is statistically significant at the level of significance (α=0.01). 5.2 Educational Recommendations: Based on the study findings and conclusion drawn above, the researcher recommends the following:

1. Conducting informational seminars on using the STEM approach for teachers to learn about the importance and methods of using it, as well as conducting training workshops for teachers to develop their competencies to teach according to this approach.

2. Establish departments at the ministry level that include several teachers for science, technology, and mathematics with engineers.

3. Paying attention to teaching scientific concepts for elementary students and do more efforts to develop learning activities that help to achieve this goal.

4. Paying attention to the practical application of materials in solving life problems using STEM-based courses.

5. Take advantage of the proposed plan developed by the researcher to develop the current science curricula and formulate new goals in line with the STEM curricula to prepare students and help them to cope with the era of science and technology and the rapid changes and deal with them efficiently.

5.3 Suggestions

for Future Research Based on the results of the study and the lack of many studies in the Arab world in general and the Gulf States regarding STEM-based learning and its impact on scientific concepts, the researcher suggests the following research studies: 1. Conduct this study on a large number of students in different educational stages with different gender for a longer period to reveal the effect of learning using the STEM approach on the outcomes of science education. 96 2. Conducting similar studies to study the effect of learning using STEM approach on the learning outcomes for other subjects

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