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The Impact of Using the Integration Approach between Science and Math on Acquiring the Skills for Solving Scientific Problems for Fourth Grade Students

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ABSTRACT

This study aimed to investigate the impact of using the integration approach between science and math on acquiring the skills for solving scientific problems for fourth grade students of Basic Education in the Sultanate of Oman. The study sample consisted of 117 fourth grade students selected from one Basic Education school. The sample was divided into two groups: an experimental group, which consisted of 59 students who studied scientific activities integrated with mathematical knowledge and skills through the teacher guide which was designed specifically for the purpose of the study. The second group was the control group, which consisted of 58 students who studied the same activities through the conventional method of teaching. The experimental group students were taught by a cooperating teacher who had received training on how to employ the integrated activities. Both groups studied the same topics for eight weeks during the second semester of the academic year 2008/2009.

To answer the research question, a posttest for scientific problem-solving skills with a reliability value of (0.88) was prepared and administered for both groups. Results revealed that there was a statistically significant difference at ($\alpha = 0.05$) between the two groups in scientific problem-solving skills in favour of the experimental group. The study also showed that there was a statistically significant growth of scientific problem-solving skills in the experimental group. Accordingly, the study recommends training students to use integrated activities which require implementation of mathematical skills and processes in order to solve scientific problems in science.

Keywords: Integrated Science and Math; Problem Solving Skills; Fourth Grade.

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INTRODUCTION

In the 21st century, humans are faced with rapid change in all aspects of society, including economic, educational, cultural, scientific, technological and other systems. Titi and Abu Shrikh (2007) noted that these transformations necessitate responses from these systems in order to ensure the advancement of quality of life. Because the educational system is considered to be the catalyst for these responses, there is an urgent need to develop appropriate teaching methods, especially for children in the early years of education, as these represent a formative stage in which the first seeds of the human personality must be planted. In the same context, Butres (2007) pointed out that if we do not link the concepts that should be presented to children in an integrated structure, this may delay their maturity and impede their performance. Many educators note that a curriculum that does not come together at the level of objectives, knowledge, and teaching methods may lead to psychological conflict and impede the integration of the student's personality (Mubarak, 1986; Sumaan & Labib, 1982).

Consequently, the idea of integrated curricula was one of the ideas to be suggested for improving curricula and developing teaching methods and techniques. Despite the fact that the process of curriculum development and organization in countries all over the world, including Oman, are subject to higher educational policies, there are opportunities for educational experiences and practice which reflect a broader range of topics and possibilities for linking science and mathematical concepts together (Stinson, Sheats, Meyer & Stallworth, 2009). The implementation of the integration idea is often accomplished by creating relationships between the two subjects and promoting them with issues that have meaning for students, as well as society in general.

The relationship between science and math has a long history; their relationship is unquestionable (Hurley, 2001). Furthermore, math and science share similar characteristics, such as beliefs in the importance of understanding; the interaction between imagination and logic; idealism and openness; and the importance of critical thinking as a part of global knowledge and the key to all discoveries (American Association for the Advancement of Science (AAAS), 1990).

Trowbridge, Bybee and Powell (2004) assert that math is the main language of science, because it provides science with laws, rules and equations. These things are used in the analysis of ideas and scientific data in a quantitative way while seeking a new relationship and verification. Therefore, it is difficult to understand science without understanding mathematics, as any progress in science relies on a broader understanding of math; this is what strengthens the call for integration (Abed & Ambusaidi, 2002). In this matter, boundaries for teaching and learning math have been cited in the USA, which stipulates that math contributes to the development of science and technology and vice versa. The development of science and technology often stimulates mathematical innovations by creating new types of problems to be solved. At the same time, mathematical topics often require further deep analysis to link them to scientific concepts (AAAS, 1990). Therefore, science and math have been considered as two sides of one coin and cannot be separated from each other. The idea of integration between science and math has emerged as one of the development proposals that were discussed during several conferences and adopted by many projects funded by international educational and scientific institutions such as School Science and Mathematics Association (SSMA) and the National Science Foundation (NSF) in the USA. In 1991, the NSF funded the Wingspread Conference in which different images and forms of integration between science and math were discussed. The conference also recommended supporting and expanding projects that address the integration between the two subjects (Momani, 2004; House, 1990).

Berlin and Lee (2005) demonstrate, through historical analysis and accounting of documents that have been produced by international institutions and specialized organizations over different periods of time, a body of evidence that demonstrates the pursuits of those institutions toward the goal of integration between science and mathematics, such as American Association for Advancement of Science (AAAS, 1989; 1993; 1998), the National Council of Teachers of Mathematics (NCTM, 1989; 1991; 1995; 2000), the National Research Council (NRC, 1989; 1990; 1996), and National Science Teachers Association (NSTA, 1992; 1997).

The lack of consensus on a unified definition for integration between science and math forced the NSF and the NSTA in the USA to halt their attempts to define the integration between the two subjects and instead describe its forms (Momani, 2004). Both Hurley (2001) and Steen (1991) proposed five aspects of integration between science and math:

1- Sequenced Integration: a curriculum is designed in such a way that science and math are taught in succession, considering the necessary coordination between the two subjects. This aspect of integration helps to achieve a double benefit reflected on the themes where students will be able to see mathematics in a non-abstract form, making it easier for them to understand. On the other hand, students will see science advocated by mathematical proofs, promoting deep understanding and increasing the value of scientific knowledge, thereby helping learners to develop a better appreciation of the role of mathematics in solving problems and to carry out more investigations connected with the real world (Marsteller, 2010).

2- Parallel integration: concepts in both science and math taught in parallel while remaining separate subjects.

3- Partial integration: science and math may be taught in the same class as a single unit in some instances, and as separate units in others.

4- Enhanced Integration: Curricula are designed so that one of the topics is the foundation, while the second appears automatically while explaining the basic concepts of the topic, as follows:

- Teaching math completely, with science as its foundation to give logical justification for the learning of mathematics and deeper understanding of the scientific concept, with emphasis on the need for impartiality by the teacher for the two subjects. Numerous studies showed the importance of this form of integration, for example a study by Hussein and Maxmus cited in (Abdel-Rahman, 1994), where the researchers developed a new concept of integration which they named "Mathematizing Science".
- Teaching science completely, with mathematics as its foundation, considering science as a basic application for mathematics.

5- Complete Integration: science and math are taught together as one unit, taking into account the proper coordination between the two subjects in order to reach the full benefit from each other without losing their independence.

The current study used the "enhanced integration" approach in order to build up the integrated activities in the Teacher's Guide. The subjects and the units of Light and Simple Machines of the science textbook for fourth grade were the primary basis, while the concepts and skills of mathematics were the stimulating factors provided to enhance a better understanding of scientific problems.

Several studies have been conducted to explore impact of integration between science and math on students' problem solving skills. Ventura (2008), a teacher of math and language arts to 6th graders, encouraged her students to detect the patterns of petals numbers (even-odd) in different types of flowers, sparking the curiosity of students and prompting them to visit a plant nursery to conduct an extensive exploration on the number of petals of different types of flowers. This was done while the students were also reading a book entitled "I Can Count the Petals of a Flower." During the discussion that took place, students realized that math can be found in nature and everywhere around them.

Wallace, Dickerson and Hopkins (2007) tried to overcome seven grade students' difficulties with estimating the size of the earth, the sun and the moon relative to each other, rather than the measurements of the dimensions that separate them. Because of this, these students had trouble arranging the positions of the three objects and drawing the path of solar radiation in straight lines in order to explain the full-moon phase. After the application of the integrated approach between science and math, the students were able to draw the earth, sun and moon in the correct order and proportional sizes, which was reflected by the accuracy of their illustrative drawings of the solar radiation path and the emergence of the full-moon phase. The results of this study were confirmed later by the results of a study by Stinson et al. (2009). In this study, Stinson et al. (2009) sought to answer the question, "What examples of math and science teaching do teachers in grades five to eight identify as integration? The study sample included middle school science and math teachers. The results showed that the topic of the solar system was tended to be identified more frequently as integrated.

The study of Laconte (2007) confirmed that the integration of a light unit with concepts in engineering improved students' abilities to draw the falling and reflected light rays, determine the correct angles and identify the images formed in the mirrors using the concept of lines and levels of symmetry. This study agreed with an older study by Luft (1997), which found that teaching light and its properties supported by mathematical information and skills contributes positively to helping students to acquire the corresponding scientific knowledge.

Reeder and Moseley (2006) confirmed, through their study, that teaching middle school students the themes of wildlife through integrated science and math activities had contributed significantly to helping them to acquire the concepts of census and ecosystem. Furthermore, it helped them to acquire scientific skills such as prediction, testing the validity of a hypothesis, and representing data about animals' habits and the factors that affect the population of various species in the wildlife.

A study by Hurley and Normandia (2005) showed that the use of mathematical measuring skills during classifying different fruits according to their growth phases helped middle school students to identify whether the fruit was good to eat or not based on the fact that plants produce chemical toxins through various stages of growth before reaching maturity. The researchers stressed that integration between science and math helps to associate the topic of investigation real life problems.

It is clear from the above discussion that the relationship between science and math is very close and each of them needs the other. However, most of the science and math curricula treat these subjects separately. There are a number of reasons for this, such as a lack of coordination between the designers of curricula of science and math, a lack of coordination between the science and math teachers themselves, and a lack of practical applications in science and math books. Unfortunately, most science curricula present and discuss various phenomena in a descriptive narrative style, despite the fact that most of these phenomena need many mathematical and statistical processors in order to support and interpret them.

In the Sultanate of Oman, the idea of integrating science and math curricula has been in use for quite some time. Alkethiri (1995) tracked, in his study, innovations in the curricula of science and math in the Arab Gulf Countries. The sample used for the study included teachers, administrators and experts in both majors representing all six Arab Gulf countries (Oman, Qatar, Saudi, Kuwait, Bahrain and United Arab Emirates). The analysis of sample responses showed that integration between science and math topics was used in the science curricula of the Sultanate of Oman and the United Arab Emirates at the level of primary and preparatory (intermediate) stages. In Kuwait it appeared in the primary stage only, and it did not appear in the science curricula for Qatar, Bahrain and Saudi Arabia.

With the adoption of the Basic Education System (Grades 1-10) in the Sultanate of Oman in 1998 (Ambusaidi & El-Zain, 2008), science curricula have seen a remarkable and significant development at the levels of learning outcomes, content organization, teaching methods and assessment tools. Despite the fact that the curricula for science and mathematics for grades 1 through 4 are classified as one group because of the multiple similarities between them, in reality, teaching practices and assessment processes indicate that science and math are two separate subjects.

Because of this, integration between science and math is a necessity for teaching fourth grade students. There is a need to train these students to use their mathematical knowledge and skills to understand scientific topics, to solve scientific problems and to carry out science activities. These issues encouraged researchers to conduct this study and seek an answer to the following research question:

What is the impact of using the integration approach between science and math on acquiring the skills for solving scientific problems for fourth grade students?

METHODOLOGY

a- Sample of the Study

The sample of the study consisted of 117 students selected from the 4^{th} grade in one of the first cycles of Basic Education schools (Grades 1-4). The researchers chose this school intentionally because the administration of the school and the science teachers were ready to cooperate in applying the treatment for the experimental group. In addition, teaching materials and resources for the science and mathematics topics were available.

Four classes were selected from the school; the treatments were distributed randomly among them. The sample was divided into two groups. The experimental group consisted of two classes of 59 students who studied science integrated with math as it was cited in the teacher guide for integrated science and math activities which was prepared by the researchers specially for the purposes of this study. On the other hand, the control group consisted of two other classes which contained 58 students who studied science through the conventional method of teaching (i.e. separate science and math).

b- Study Materials and Tools

The study materials and tools included the following:

1. A teacher guide for science activities included in the "Light Unit and the Simple Machines Unit" from the science textbook for 4^{th} grade of Basic Education. The topics of these units were redesigned by integrating the mathematical knowledge and skills that were necessary to achieve the scientific objectives of these two units (see Appendix 1 for an example of a lesson plan prepared by the researchers to integrate science with math). The teacher guide was given to a group of specialists and educators in science education for their comments and suggestions.

2. A scientific problem-solving skills test for measuring the students acquisition of scientific problem-solving skills; the test measured the Initiative and Planning Skill, the Implementation and Note-taking Skill, and the Analysis and Interpretation Skill as cited in the students' learning evaluating document in science for grades 1-4 as issued by the Department of Educational Evaluation, Ministry of Education (2005). Two problem-solving skills tests were designed. The first one was used to verify the equivalency of the scientific problem-solving skills for the two study groups before the treatment for the experimental group was started. The second test was used to measure the effect of using integration approach between science and math on the development of scientific problem solving skills. The latter was administered to both groups after the treatment of the experimental group was finished. It consisted of 17 short-essay questions, distributed as follows:

- 7 questions to measure initiative and planning skill.
- 5 questions to measure implementation and note-taking skill.
- 5 questions to measure analysis and interpretation skill.

The two tests were given to a group experts in science and math teaching to ensure their content validity; their internal consistency was calculated using the coefficient of Alpha Cronbach, which gave the value of reliability coefficient of (0.88) for the pre-test and (0.87) for the post test.

c- Research Design

The study used Qusai experimental designs where the sample of the study divided into two groups; the experimental group was taught science topics using an integrated approach between science and math, and the control group was taught the same science topics through the conventional method of teaching. Both groups were subjected to pre- and post-tests in problem solving skills (Cohen, Manion & Morrison, 2000).

d- Results of the Study

Before presenting the results of the study, Table 1 shows the results of the verification of the equality of the study groups in scientific problem-solving skills.

Table 1. *Independent sample t-test results for calculating the equality of the two study groups in the scientific problem-solving skills (pre-test)*

The skill	group	N	m	St.d	df	t. value	Sig.
Initiative and planning	Experimental Control	59 58	2.47 2.78	1.95 1.96	115	0.834	0.807
Implementation and Note-taking	Experimental Control	59 58	3.08 3.05	1.94 2,05	115	0.067	0.488
Analysis and interpretation	Experimental Control	59 58	2.52 2.57	1.63 1.72	115	0.168	0.478
Total of the skills	Experimental Control	59 58	8.07 8.40	5.24 5.47	115	0.332	0.479

* Number of respondents = 117, Total test mark = 20

From Table 1, it is obvious that the value of (t) is not significant at the level of significance differences ($\alpha = 0.05$) which indicates that there were no differences between the average scores of the experimental group and the control group in scientific problems solving skills as whole and for each skill. This means that the two groups were equal in problem solving skills before the treatment took place.

To answer the study question, "What is the impact of using the integration approach between science and math on acquiring the scientific problem-solving skills on fourth grade students of Basic Education?" the means scores and the standard deviations for both groups were calculated and an Independent Samples t-test was used to compare the two means. The results were as shown in Table 2.

Table 2. *Independent sample t-Test results for calculating the differences between the mean score between the two groups at the scientific problems solving skills (post test)*

The skill	Mark of the skill	group	m	St.d	df	t. value	Sig.
Initiative and planning	7	Experimental Control	3.98 2.66	1.80 1.73	115	4.058	0.001
Implementation and Note-taking	7	Experimental Control	4.47 3.16	1.56 1.74	115	4.287	0.001
Analysis and interpretation	6	Experimental Control	3.54 2.46	1.33 1.26	115	4.516	0.001
Total of the skills	20	Experimental Control	12.00 8.28	4.34 4.46	115	4.578	0.001

*** Total test mark = 20**

From Table 2 it is obvious that there were statistically significant differences between the mean scores of students in the two study groups at the scientific problems solving skills in the post-test as whole and the skills that represent it in favor of the students in the experimental group.

In order to identify the effect size of using the integration approach between science and math on acquiring the scientific problems solving skills for students in the experimental group, the effect size was calculated using eta- squared (η^2) according to the formula:

$$\eta^2 = \frac{t^2}{df + t^2}$$

Where (*t*) is the value of (t) for each scientific problem-solving skill and for the entire total of the skills, while the (*df)* represents the degree of freedom, (Abu-Allam, 2006: 82). The results of eta- squared (η^2) are shown in Table 3.

Table 3. *(η^2) value and the effect size of using the integration approach between science and math on acquiring the scientific problems solving skills*

Independent variable	Dependent Variable	η^2 Value	Effect size
Integration between Science and Math Approach	Initiative and Planning	0.121	Medium
Integration between Science and Math Approach	Implementation and Note-taking	0.137	Medium
Integration between Science and Math Approach	Analysis and Interpretation	0.151	Large
Integration between Science and Math Approach	Total of the Skills	0.154	Large

It is obvious from Table 3 that the effect size of using the integration approach between science and math on acquiring scientific problems solving skills was medium in two skills; initiative and planning and implementation and note taking; and large in the analysis and interpretation skill and the whole skills in the test.

In order to identify whether there were any significant differences in scientific problems solving skills between pre and post applications of the scientific problem-solving skills test for both groups, a Paired-Samples t-test was used to calculate the difference in growth of the scientific problem-solving skills for the study's groups (Table 4).

Table 4. *Paired-Samples t – test results for calculating the growth of scientific problem-solving skills for the two groups (pre and post applications)*

The skill	group	test	m	St.d	df	t. value	Sig.
Initiative and planning	Experimental	Pre Post	2.47 3.98	1.95 1.80	58	4.77	0.001
	Control	Pre Post	2.78 2.66	1.96 1.73	57	0.526	0.601
Implementation and Note-taking	Experimental	Pre Post	3.08 4.47	1.94 1.56	58	4.47	0.001
	Control	Pre Post	3.05 3.16	2.05 1.74	57	0.498	0.621
Analysis and interpretation	Experimental	Pre Post	2.52 3.54	1.63 1.33	58	4.04	0.001
	Control	Pre Post	2.57 2.46	1.72 1.26	57	0.583	0.562
Total of the skills	Experimental	Pre Post	8.07 12.00	5.24 4.34	58	4.63	0.001
	Control	Pre Post	8.40 8.28	5.47 4.46	57	0.192	0.849

*** Test degree = 20, n = 117: experimental 59, control 58**

Table 4 shows that the values of (t) for the entire skills measured by the test and each skill were statistically significant at (α = 0.05) between pre and post applications of the scientific problem-solving skills test in favour of students in the experimental group in the post application of the test. The results of the control group students showed no growth in their performance in the post-test from what it was in the pre - test in the test as whole and its skills.

DISCUSSION AND RECOMMENDATIONS

The results of the study showed statistically significant differences between the mean scores of the experimental group and the control group in problem-solving skills in the post-test in favor of experimental group students. This could be due to the effectiveness of using the integration approach between science and math on acquiring scientific problem-solving skills. The results of the current study agreed with a number of studies such as Wallace, Dickerson and Hopkins (2007), Laconte (2007), Reeder and Moseley (2006) and Lee (1997).

The growth of the scientific problem-solving skills (initiative and planning, implementation and note taking, and analysis and interpretation) of the experimental group can be explained as follows:

Initiative and planning skills

The growth of this skill in the experimental group students compared to the control group students may be due to using the integration approach between science and math, which allowed students to apply mathematics skills during each scientific activity. For example, for the activity “form of the rolling objects,” a transparency was shown to the students that pictured a group of contestants with different forms of shapes; the cooperating teacher asked her students to determine the name of each shape as a first step, then she encouraged the students to predict which contestant would win the race. The cooperating teacher also made sure to direct students to determine the purpose of solving the scientific problem, highlighting the relationship between the topic of scientific concepts and mathematical skills.

The students were involved in the planning process in order to address some of the tasks for the implementation of activities, as well as to encourage them to suggest ways to classify and organize information. For example, the cooperating teacher noted that students in the experimental group responded well when they were asked about the best way to organize the data and the measurements that were recorded through the implementation of activities. With the diversity and variety of the integrated activities and the mathematics links in addition to the continuous training, students began to suggest different ways to classify the data (Morrison & McDuffie, 2009). One student suggested designing label cards to classify the rainbow colors while working on the cards, another suggested making the rainbow label cards in different sizes depending on the wavelength for each color, so it will be easier to order them without reference to the readings of color wavelengths. The cooperating teacher helped her students using Venn diagrams in order to determine the color that results from mixing two or more colors, employing graphics to express the change in length of shadows throughout the course of a day; this encouraged the students to make simple predictions using the information. In the control group, the science teachers introduced these activities rapidly so they could cover all activities and topics required in the textbook without attention to whether students were applying their mathematical knowledge and skills. This lead to an unintentional omission in teaching the skill of initiative and planning and its sub-skills; identifying the purpose of solving the problem, planning to address tasks, proposing ways of classifying and organizing information, making simple predictions and identifying difficulties.

The growth of this skill among the experimental group between pre and post applications of the test could be due to the continuous training and encouragement that were given to students on how to propose appropriate ways of classifying and organizing information so that they could use them to build simple predictions based on this information. Despite the young age of the students, they performed well when asked to develop plans for solving a problem. Students were also able to identify some of the difficulties they faced in solving problems. For example, some students suggested a plan for the activity “Why do we need rollers?” that required dividing the class into two teams; one team worked with rollers, while the other team performed their experiments without using rollers at all, rather than repeating the experiments with and without rollers. In the same context, some students noted in the activity “Does the wheel size affect its performance?” that the surface they were using was short, and therefore it made the wheels roll and fall at such a high speed that they did not have the opportunity to measure the time it takes to roll in order to determine each wheel speed. Students were fully aware of the difficulty of making the teacher table stand stable at an angle, so they suggested using one of the movable shelves of the classroom library. Some of the students decided to make sure that different wheels sizes have different speeds during their break time using the surface of a skating area in the school garden. The cooperating teacher praised them for their work and encouraged other students to follow their friends in re-testing, which is important for carrying out science experiments (Dinsdale, 2007). All of this took place after making sure that safety rules were available for the materials, tools and places where the study was carried out; thus, the cooperating teacher contributed to encouraging the students to practice the skills of initiative and planning and its sub-skills, which resulted in the growth of these skills for the students in the experimental group.

Implementation and Note-taking skill

The growth of this skill and its sub-skills, such as extracting information from different sources, using tools and simple machines to carry out the measurement, and using different ways to present information (tables, photos, graphics, diagrams etc...) (Morrison & McDuffie, 2009) for students in the experimental group compared to the control group students was due to the integrated activities offered to the experimental groups. In the experimental group, students discussed the phenomenon of refraction and its impact on the daily life, and the reason that objects appear closer under water than they really are. Students were able to extract some information and events that supported their observations. For example, one student said, "I noted that his legs seemed shorter when walking in the pool". Moreover, students did more research about shadows and how the lengths of the shadows could have been used to estimate the time before the invention of the clocks.

The integrated activities also helped the students to deal with various measurement tools that are often used in math, such as rulers, metric tape, protractors for measuring angles, and stopwatches. By using these tools, the students were able to obtain more accurate observations and measurements. According to American National Council of Teachers of Mathematics (NCTM) standards, students should apply appropriate techniques, tools, and formulas to determine measurements (NCTM, 2002). In the same context, students in the experimental group practiced measuring angles, which later helped them in dividing a Newton's disk into seven equal sections for each color of the rainbow, so they got an accurate result. When the control group students divided the disk - as usual - into seven sections for each color of the rainbow, they did not pay any attention to whether the sections were equal or not, so the result that they got from rotating the disc was not as accurate as the result obtained by the students of the experimental group.

Analysis and Interpretation skill

The growth of this skill for the experimental group students compared to the control group students may be due to the integration approach between science and math, which may have enhanced the students' confidence in the results they came up with, because they were supported with mathematical proofs. The researchers noted that during classroom visits to the experimental group, the students were excited about ensuring the validity of their predictions through data analysis. The students were in a hurry to make conclusions and generalizations because of the clarity of the data and measurements that were documented through the integrated activities. For example, most students predicted that small wheels would be faster than big wheels and linked it directly to their ideas and their prior knowledge about the small wheels of race cars. The cooperating teacher asked her students to imagine what would happen if we changed the race car wheels with truck wheels. The students' interpretations were that the race car would be slower. One student even insisted that it would be slower because the big wheels would lift the car up far from the surface of the ground. The researchers noted that the ability of students to determine possible scientific interpretations for a problem depended on the mathematical measurements and estimates students made.

The growth of this skill among the experimental group students between pre and post applications of the tests could be due to the continuous training and encouragement that students were given on how to analyze their data through the implementation of integrated activities. At the beginning of the treatment, the cooperating teacher faced some difficulties explaining this skill to her students, because it requires strong mental abilities for analysis and connectivity that depend on observing numerical patterns and relationships, despite the fact that the students showed a strong level of competition during the implementation process and note-taking, results and measurements. However, this excitement disappeared once they had been asked about the meaning of the numbers and measurements, but through the continuous encouragement, the students gradually began to acquire this skill. The result of the current study disagreed with the findings of Wallace, Pugalee and Douville (2002), which held that the measurement skill and the analysis and interpretation of data skill are the most common skills used in science because it is easier to integrate them with scientific issues and problems. It was noted from the current study that the analysis and interpretation skill developed less compared to other two skills proposed in this study within the experimental group; this notification was supported by Stinson et al. (2009).

In light of the findings of the study, the researchers recommend the following:

1. Holding training courses and workshops for teachers and supervisors in teaching science and math to familiarize them with the educational benefits of using the integration approach in teaching both subjects.

2. Encouraging science teachers and mathematics teachers to:

• analyze science and math books for each grade to find possible opportunities for integration between the two subjects.

• identify methods of cooperation between science and math teachers through the implementation of integrated activities at the levels of scientific content, provision of teaching materials and resources, and designing evaluation tools.

• train students to use mathematical skills and processes for solving scientific problems due to its positive impact on acquisition of scientific problem-solving skills.

3. Conduct a similar study on different grades, and at different levels of achievement.

REFERENCE

Abed, A. & Ambusaidi, A. (2002). High school students' beliefs about math and science and some related variables. *Journal of Educational and Psychological Sciences (University of Bahrain),* 3(3), 127-150.

Abd-al-Rahman, A. (1994). Evaluation of science and math curricula in preparatory school in the light of integration approach. *College of Education Journal*, University of Assout/Egypt, 1(10), 291-316.

Abu - Allam, R. (2006). Effect Size of the experimental treatment and significant differences. *The Educational Colleges/ Kuwait University*, 78(20), 5-150.

Ambusaid, A & Al-Zain, M. (2008). *The Science Curriculum in Omani Schools: Past, Present and Future* in R. Coll and N., Taylor (eds.). Science Education in Context. Rotterdam, Sense Publishers: 85-97.

American Association for Advancement of Science (AAAS) (1990). *Science for All Americans*, Oxford, Oxford University Press.

Alkethiri, A. (1995). *The New Trends in Science and Math Curricula and the Way can Gulf States Benefit from them*, Riyadh, Arab Bureau of Education for the Gulf States.

Berlin, D. F. & Lee, H. (2005). Integrating science and mathematics education: Historical analysis. *School Science and Mathematics*, 105 (1), 15-24.

Butres, H. (2007). *Development of Scientific and mathematical Concepts of Childhood*, Amman, Dar Al-Masera for Printing, Publishing and Distribution.

Cohen, L, Manion, L. & Morrison, K. (2000). *Research Methods in Education*. London: Routledge.

Dinsdale, C. (2007). Pinatas, episodic events and real life applications. *Science Scope*, 31 (4), 50-52.

House, P. A. (1990). Science and mathematics: Partners then partner now. Reading from school science and mathematics, topics for teachers, series number 5, (ERIC Document Reproduction Service No. ED 350169).

Hurley, M. M. (2001). Reviewing integrated science and mathematics: The search for evidence and definitions from new perspectives. *School Science and Mathematics*, 101 (5): 259-270.

Hurley, M. M. & Normandia, B. (2005). A taste of math and science, *Science Scope*, 29 (1), 26-29.

LaConte, J. (2007). Enlightening geometry for middle school. *Science Scope*, 31 (4), 23-27.

Lee, P. (1997). A First Year Evaluation Study of Integrated Math and Integrated Science Curricular Program in an Inner City High School, (ERIC Document Reproduction Service No. ED 415 092).

Luft, J. A. (1997). An illuminating view of mathematics and science integration, *Science Scope*, 20 (7): 18 -21.

Marsteller, P. (2010). Beyond BIO2010: Integrating Biology and Mathematics: Collaborations, Challenges, and Opportunities. *CBE-Life Sciences Education*, 9, 141-142.

Ministry of Education (2005). *Students Evaluation Document of Graders 1-4*, Muscat, Sultanate of Oman

Momani, A. (2004). *The effect of using science and math teaching approach in achievement among 8th Grade students of King Abdullah School*, Unpublished Masters Thesis, College of Education, Yarmouk University.

Morrison, J. & McDuffie, A. (2009). Connecting science and mathematics: Using inquiry investigations to learn about data collection, analysis, and display. *School Science and Mathematics*, 109 (1), 31-44.

Mubarak, F. (1986). *An Integration Approach in Building the Curriculum: Theory and Practice*, Cairo, Dar al-Maaref.

National Council of Teachers of Mathematics (NCTM). (2002). Standards for school mathematics: pre-kindergarten through grade 12, Retrieved 3/11/2010 from : http://standards.nctm.org/document/chapter3/meas.htm

Reeder, S. & Moseley, C. (2006). Oh, Deer!: Predator and prey relationships - students make natural connections through the integration of mathematics and science. *Science Activities: Classroom Projects and Curriculum Ideas*, 43 (3), 9-14.

Steen, L. A. (1991). Integrating school science and mathematics: Fad or folly?, Retrieved 4/ 1/2009 from: http://www.stolaf.edu/people/steen/Papers/integrating.html.

Stinson, K., Sheats, S., Meyer, H. & Stallworth, J. (2009). Mathematics and science integration: Models and characteristics. *School Science and Mathematics*, 109 (3), 153-161.

Sumaan, W. & Labib, R. (1982). *Studies in the Curricula*. Cairo, Anglo Bookshop.

Titi, M. & Abu Shrikh, S. (2007). *Integrated Curriculum*, Amman, Dar Greer.

Trowbridge, L., Bybee, R & Powell, J. (2004). *Teaching Secondary School Science: Strategies for Developing Scientific Literacy*, New Jersey, Merrill.

Ventura, J. (2008). Integrating literature, mathematics and science, National Council of Teachers of Mathematics, Retrieved 22/11/2008 from: http://www.nctm.org/resources/content.

Wallace, A., Dickerson, D. & Hopkins, S.(2007). Moon phase as a context for teaching scale factor, *Science Scope*, 31 (4), 18 -22.

Wallace, J.D., Pugalee, D. & Douville, P. (2002). *Examining instructional practices of elementary science teachers for mathematics and literacy integration*. Paper presented at the Annual Meeting of the American Educational Research Association, 1 April. New Orleans, Louisiana

Appendix 1
Example of the Integrated Science and Math Lesson Plan

Unit: The Light	**Activity:** light sources

Science learning outcomes:

By the end of this lesson, students are able to

- Distinguish between self-lighting and non-self-lighting objects.
- Identify the sources of natural and artificial light in the environment.
- Develop an awareness of their duty towards conservation of light sources.
- Respond to the ideas and actions of others and appreciate their contributions.

Math link:

<u>Axis II: Operations on numbers</u>

- Adding natural numbers and estimating the total,
- Multiplying and dividing natural numbers.

Tools:

Varieties of light sources such as: flashlight - candles – illustrations (pictures) of the sun, moon and stars - a mirror – crystals.

Procedures:

Science teachers should follow these steps in order to achieve the learning outcomes:

- Encourage students' discussion about classifying the given light tools (flashlight, candles, etc.) into natural and artificial light sources by emphasizing the difference between them.
- Ensure that students are able to distinguish between the two types of light sources; self-lighting and non-self-lighting (artificial).
- Direct students to put these classifications in a sort of table like this:

Sources	Natural	artificial	Self lightening	Non-self lightening
Flash light				
Candles				
……..				

- Emphasize the importance of both types of light sources, natural and artificial, to human life and examine ways to ration electricity consumption at home, school, etc. through implementing mathematical links as described above by asking students the following questions:

➔ If the sun rises at 5:45 am and sets at 7:10 pm. Calculate the hours of this day?

➔ If you knew that switching off all the light in your home for one hour in a day you will save about 3 O.R per month, how much money you are going to save if you switch them one hour a day for one week (7 days).