Effectiveness of Integrating STEM Education into Grade 8 Science Teaching and Learning Process

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ABSTRACT

Key elements of STEM education are integration of Science, Technology, Engineering and Mathematics into curriculum. The lowest mean score was achieved for sub-skill synthesis at a science national test in Sri Lanka. Therefore, the aim of study was to investigate effectiveness of STEM integration into science teaching learning process of selected schools in Wattegama Education Zone. Mixed methods approach and purposive sampling was done with 136 Grade 8 students. Quantitative data were collected from pre and post-test and analyzed using SPSS. Qualitative data were collected using activity sheets, interviews and analyzed thematically. Results showed STEM integrated activities enhanced student's performance in school B and C ($p < 0.05$) except A ($p > 0.05$). Independent sample t test showed post-test marks of experimental and control group of school A and C were not significantly different. Post-test marks of control and experimental group of school B were significantly different. Highest performance of students was shown in school B and it was not at a significant level in A and C due to crowded classrooms. There was no difference of science performance in school A, B and C ($p > 0.05$) due to similar socio-cultural setting. The highest performed were male (B mean = 98.77),

second highest was female (C mean= 97.94) and lowest was A (mean male =95.71 & mean female = 91.80) students respectively. So, male students and low number is influential, and Integration of STEM is successful to become professional teachers, expert students as lifelong learners.

1. INTRODUCTION

A quality school Science Education is an essential element to build a scientifically literate population in Sri Lanka. According to Tularam (2016), traditional teaching approach (usual method of teaching) is teacher-directed and non-traditional teaching uses social constructivism. Thus, many countries have already recognized value of STEM education as a nontraditional teaching method. Nguyen et. al. (2020), state STEM education is a learner centered approach combining four disciplines of science, technology, engineering and mathematics for designing solutions to real-world problems. Research conducted by South Asia Human Development Sector showed that there was a seven percent decline (from 55 % to 48 %) in the GCE O/L student pass rates in science subject from 2002 to 2009 in Sri Lanka. In here, sub-skills of knowledge, comprehension, application, analysis and synthesis were tested and there was an improvement in mean scores of students in all these five sub-skills. But the lowest mean score was achieved in sub-skill synthesis. The main reason for this decline was that students were not able to apply their knowledge to everyday situations (Aturupane et al., 2011). In the mid-1980s, BSCS received a grant to conduct a design study for a new science and health curriculum for elementary schools and 5E Instructional Model was introduced. It consists of the following phases: engagement, exploration, explanation, elaboration, and evaluation (Bybee et al., 2006). Even though the main aim was to develop efficiency and effectiveness in classroom teaching learning process, many drawbacks were found in this system. As an example, even though it was an innovative approach for constructive classroom, most teachers adopted lecture-based teaching due to time constraints resulting from overloaded syllabi. So new teaching methodologies are needed to increase teacher effectiveness and student-teacher interactions to achieve learning outcomes in science subjects. Therefore, STEM education establishes a connection between a real life problem and content and prepares them for the challenges of the 21st century workplace (Burton et al., 2014). All these existing conditions are facilitating to integrate STEM education in science teaching and learning process in Sri Lankan schools to apply knowledge concepts within the subject discipline or to real or new situations in STEM education. So that this study selected the section from Grade 8 Science syllabus on Soil Erosion and relates issues which are applicable to day-to-day real life activities with hands on experiences. Moreover, most of the teachers are engaged in linear teaching and learning activities with the usual method and STEM is a good alternative to overcome drawbacks of this system through authentic learning approaches. However, students can develop their abilities to be applied to solve day today upcoming problems with the support of science teachers. Then it was possible to start this study with STEM education opportunities for science teaching learning process in Wattegama Educational Zone. Furthermore, outcomes of this study can be applied as suggestions and recommendation to promote STEM integrated teaching learning activities in science teaching learning process for betterment of the science education for both students and teachers overcome existing drawbacks in the usual method of teaching to align with the economic development goals to build a STEM literate workforce.

Aim of this study was to investigate the effectiveness of integrating STEM education in to Grade 8 Science teaching learning process.

1.1 Research objectives

1. To examine the student performance in science when teaching a lesson while integrating STEM education in a usual method of teaching.

2. To identify different teaching strategies which can be used by science teachers to teach soil erosion and its effects by integrating STEM education.

1.2 Research questions

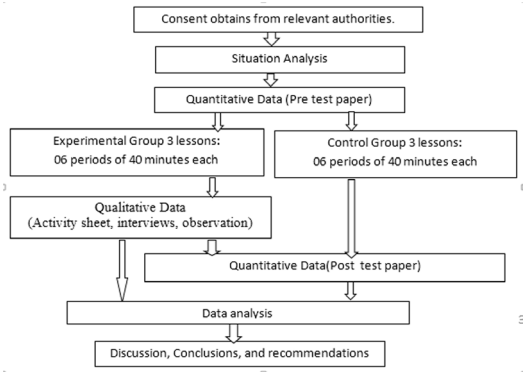
01. How the integration of STEM education into science teaching will change student performance compared to the usual method of teaching?

02. What are the different teaching strategies that science teachers use to teach in integrating STEM to teach soil erosion and its effects?

2. MATERIALS AND METHODS

This is an experimental research and a quasi-experimental research design. Grade 8 science students in 1C schools (A, B and C) in Wattegama Educational Zone in Kandy district. 136 students were selected using the convenience sampling process. It was conducted for 12 months (from June 2018 to July 2019). Soil erosion (subunit 15.3) was selected as the topic under Natural Disasters (Unit15) of Grade 8 science textbook. Mixed method approach was used for data collection. Pre and post-test papers were quantitative data collection instruments and qualitative data were collected using observations and interviews. Quantitative data were analyzed using descriptive and inferential statistics and qualitative data were analyzed thematically.

2.1 Theoretical framework \



2.2 Results

2.2.1 Quantitative results

Pre-test marks of control and experimental groups

Results showed that mean values of control and experimental groups in schools A, B and C, had no significant difference in pre-test marks ($p > 0.05$ at 95% confidence level)

Descriptive analysis of pre-test and post-test marks of students in control and experimental groups in schools A, B and C

According to following graphs, the highest difference between post-test marks of control and experimental group was found in school B (29.54) followed by school A (5.00) and C (3.29).

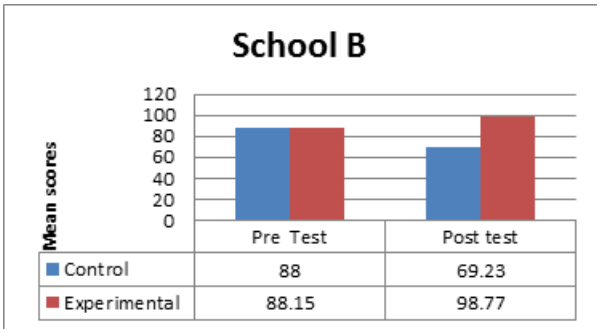


Figure 1: Mean pre and post-test marks of students in control and experimental groups in school B

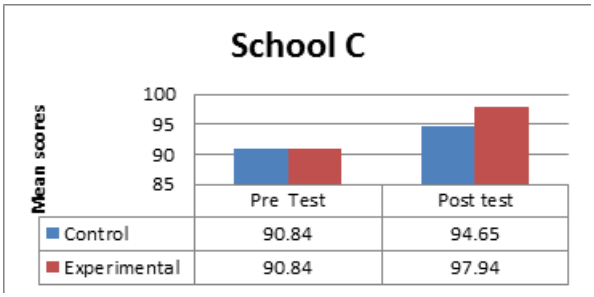


Figure 2: Mean pre and post-test marks of students in control and experimental groups in school C

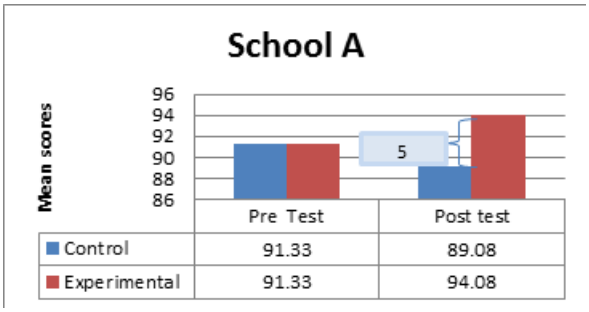


Figure 3: Mean pre and post-test marks of students in control and experimental groups in school A

Difference in pre-test and post-test marks obtained by students in schools A, B and C

Results of paired sample t-test showed that there was a significant difference between pre and post-test marks in experimental and control group of school B and C($p<0.05$), except in A ($p>0.05$)

Compare post-test marks of students in control and experimental groups in schools A, B and C

Results of Independent sample t-tests showed that in school A and C were not significantly different($p>0.05$) and in school B was significantly different ($p<0.05$).

Comparison of post-test marks of students in experimental groups of schools A, B and C

Results of one-way ANOVA test showed that there is no significant difference (($p<0.05$) among the post-test marks of experimental groups in three schools.

Compare post-test marks of male and female students in experimental groups in school A, B and C

Analysis of post-test marks of experimental groups showed that marks of male students were higher than that in female students. Mean post-test marks of students in experimental groups of school C (Girls) and B (Boys) were 97.94 and 98.77, respectively. Further, mean post-test marks of female and male students in experimental group of school A (Mix school) were 91.80 and 95.71, respectively.

2.2.2. Qualitative results:

Qualitative data were transcribed, and codes were categorized for development of four (04) themes by using thematic analysis process.

Theme 01: Students explored the outside environment.

Integration of STEM education into science teaching learning process is facilitating students for exploring the surrounding environment with authentic learning approaches.

> *"Students observed different locations of soil erosion and they were able to identify control measures to minimize soil erosion."* (Fieldnotes, 2019/03/21)

Both male and female students actively participated. But male students were more enthusiastically involved to explore the surrounding environment compared to female students as mentioned below;

> *"Facilities were provided by science teachers with guidance to observe surrounding. Initially male students were more enthusiastic and leading activity."* (Fieldnotes, 2019/03/18)

Students' involvement in outdoor activities is important to grasp new information with own learning strategies in trial-and-error method.

> *"A student was about to touch eroded place with his hands and tried to take a soil sample. Teacher emphasized to use appropriate tools:"* (Fieldnotes, 2019/03/21)

Theme 02: Student enthusiasm with peer learning

During the video programme on soil erosion, one student explained her own interest regarding video show as "Actually, none of us did not aware until the end of this video show and they asked teacher to repeat video programme. (Fieldnotes, 2019.03.12)"

The Science teacher conducted a small open discussion in which the student teacher interaction was high by giving freedom to express student's own ideas with their peer group. The Science teacher was a facilitator to progress peer learning activities (Fieldnotes, 12/03/2019). Many students said that these activities helped to develop proper attitudes in them which made them aware on basic concepts of soil erosion and to control and minimizing soil erosion. (Fieldnotes, 18/03/2019)

Theme 03: Students' active participation for solving real life problems

Students expressed their findings which were collaborated with previous experiences.

"Students prepared with curiosity and enthusiasm for today's lesson. They already prepared to present their findings on soil erosion with successful field experiences." (Fieldnotes, 2019/06/07)

Many activities were good opportunities to face challenges in finding solutions to real world problems and presented findings as speeches, poems, etc.

> *"They focused more on practical applications of learning concepts and important issues. Students were curious and exposed to real world experiences." (Fieldnote,07/06/2019)*

Students developed qualities like creativity and group sensing at the end of all activities achieving success of fruitful teaching learning process (writing poems) as given below,

"Before happening this hazard - Think properly.

Establishing stone bunds, live fences - You are protecting lives" (Fieldnotes,06/06/2019)

Theme 04: Teachers views on STEM education

STEM education was focused on student's classroom practices as well as outside practical activities with authentic learning environment linking with community activities. They had received a wide range of STEM educational experience and this was different from the school culture, personal characteristics of teachers and students (age, gender, etc.)

3. DISCUSSION

This chapter discusses key findings of data analysis in terms of four research questions.

3.1 RQ1: How the integration of STEM education into science teaching will change students' performance compared to usual method of teaching?

Results of independent sample t test showed that there is no significant difference between pretest mean scores of experimental and control groups in school A, B and C ($p > 0.05$) at the beginning of experiment. The results of paired sample t test illustrated that students who were taught with the usual method of teaching and STEM integrated method showed a significant difference in their performances in school B (Boys) and C (Girls).

However, there was no significant difference ($p > 0.05$) in their performance between pretest and posttest marks of students in control and experimental groups of school A (Mix). This illustrates that knowledge, skills, attitudes have changed in control and experimental group students in school B and C at the end of teaching learning activities with both methods. According to results of comparative descriptive analysis, the highest gap between post-test marks of experimental and control group was found in school B (29.54) followed by school A (5.00) and C (3.29). All positive values clearly show that student performance has increased in experimental groups than control groups. Supporting this Kaleci and Korkmaz (2018) show that there is a significant increase in learning levels of students in STEM integrated group (Experimental group) compared to control group.

Results of the independent sample t test showed that posttest marks of experimental and control group of school A and school C were not significantly different. However, posttest marks of control group and experimental group of school B was significantly different. This result also shows the highest students' performance in school B and with this evidence it is clear that knowledge, skills, attitudes has changed at a significant level in school B in both groups students. But in school A and C there could not find any significant difference among two groups at the end of teaching learning activities. This different student performance can be due to many reasons (teacher's role). So need to educate teachers of all experience levels about integrative STEM education (William et all, 2018). One-way ANOVA test results showed that there is no significant difference (P value was 0.111) among the post-test marks of experimental groups in three schools. Main reason for this is similar social cultural setting in three schools. Tsupros (2009) states that various academic concepts link with real world lessons to make connections between school and its community. Descriptive analysis of posttest means scores of experimental groups showed that male students performed higher than female students. Further, School B (boys) achieved the highest mean score (98.77). As a mixed school in A, the mean post test score of males (95.71) was higher than female students (91.80). All these results clearly show the higher performance of male than female students in STEM integrated teaching learning activities. Supporting this study Kaleci (2018), states that significant differences were found between male and female students in STEM disciplines and reveal that men proceed to higher achievements than women. School B consisted of lowest student number (26) and only male students in classroom were leading to the highest performance. But school A consisted of highest students' number (39) and both male and female students in classroom were leading to the lowest performance. But in C, it was included with a moderate number of students (31) and only female students compared to A and B were leading to a moderated performance for post- test mean scores. Smaller number of students in a class facilitates to maintain highly interactive successful teaching learning process for higher performance. Supporting this Gonzalez and Kuenzi, 2012, illustrate that, when student number is small (100 students per grade) it allows teachers to know students well. It was clearly showed that the highest student performance was achieved by school B (Boys). School C (Girls) was in the second highest place and the lowest was achieved by school A (Mix).

3.2 RQ2: What are the different teaching strategies that science teachers used in integrating STEM into teach soil erosion and its effects?

Students received a wide range of STEM integrated teaching leaning activities, such as classroom interactive peer learning activities, face to face

discussions, video programmes and creative independent studies which were highly effective in science teaching and learning process. Some research which was done in Sri Lanka by Polgampola (2016), emphasize that learning becomes more authentic with pedagogical strategies that have a deeper learning process to the real-world application. Supporting this, USA President Barack Obama (2015), states science is more than a school subject or periodic table and it is an approach with a critical way to understand, explore and engage in the world. The classroom environment facilitates students to enthusiastically watch video until the end and students asked for repeating the video show (Fieldnotes, 2019/03/12). It expresses the strength of student's attention, interest on the video programme. Successful STEM education in a student-centered learning climate will ensure the capability of students to generate new ideas. In addition, take home assignments are important to involve them effectively in after school hours. Supporting this, (Gonzalez & Kuenzi, 2012), "STEM education" includes educational activities across all grade levels from pre-school to post-doctorate in both formal (e.g. classrooms) and informal settings (e.g. after school programs). However, high quality learning environments (smart phones) provide a structure to build and explore students 'natural curiosity among teachers and peers. Ejiwale (2013), shows that the environment should be made conducive to learning. Then, Henson (2001), states STEM lab will include an outdoor garden area as an extension of hands-on learning. Male students were enthusiastic in field practical activities than female students (Fieldnotes, 2019/03/18). Supporting this Ejiwale (2013) states attitudes toward STEM education among students, males are enjoyed games in outside than female students. Bardige & Russell (2014), state reflecting teaching and learning process is a key component of intentional teaching and teachers should use environment as third teachers in STEM.

4. CONCLUSION

- The overall results revealed that the performance of students who were taught with STEM integration increased compared to those who were taught in the usual method of teaching.
- Male students performed better than female students, with the STEM integration.
- STEM integration into science teaching provided more opportunities for an authentic experience.
- Appropriate professional development opportunities are needed for teachers to integrate STEM education into science teaching in order to provide meaningful learning experience for students.
- There is a need to integrate STEM into science teaching appropriately, as it enhances student's active engagement in learning, providing authentic experiences and motivating towards science learning.

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