Perceptions on STEM Education in Secondary Schools in Sri Lanka: Trends and Challenges

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Abstract: STEM ensures that today’s students can generate and test new ideas and contribute to the scientific developments and innovations for tomorrow. Effective STEM programs shares the elements of strong leadership, professional capacity of teachers, a student-centered learning climate, and instructional guidance for teachers. Sri Lanka is at the conceived stage of STEM education thus classroom observations of 10 Sri Lankan prospective science teachers from a reputed National College and reflects the existing constraints. Lack of methodology, strategies and technology were some factors exploited from this study. It was also obvious that teachers with a strong capacity to teach in their discipline are essential for the success of STEM practices. Conclusions are drawn that highly-qualified STEM teachers are in high demand.

Keywords: Blended approaches, STEM delivery, Prospective science teachers, Sri Lanka,

Introduction

Science is a constantly evolving field. Research on science education has attracted great attention in recent years. In order to apply innovative teaching strategies and advanced technique into classroom (McLaughlin and Talbert 2006), STEM is a new way to reach students, is not an entirely new phenomenon. There has been a dramatic increase in the number of STEM-focused schools in recent years. STEM infusion is the pipeline into which teachers become no longer of information distributors; this new approach will enable students to be responsible for their own learning (Gasiowski, Eagan et al. 2012). To achieve this goal mastery or perfecting of pedagogy is necessary for educators’ to manage their classroom and deliver effectively. STEM educators must be able to call on a repertoire of strategies and methods for illuminating STEM topics guiding students in scientific inquiry, the design of experiments get more teachers involved in STEM education by alleviating their fears. Focus on in-service programs and provision of specific training for subject knowledge, pedagogy, and classroom management to meet the teacher’s current needs is a great importance. Marginalized perceived perceptions and teachers lacking strong efficacy are main obstacles to enhance STEM in developing countries (Mejia 2011). STEM process skills can harness to meet the challenges of 21st century globally. In the first, theoretical section of this paper, we argue that some consider STEM education to be the improved teaching of the separate subjects of STEM others believe STEM should be taught in an integrative subjects approach. Majority believe it is a combination of both of these approaches. If this is the case what aspects should be considered in the professional development or training programmes and how congruent changes bring forth towards reformed pedagogical beliefs for the majority of participants (Tatto and Coupland 2003). This paper also reviews these factors, presents several aspects of teacher education programs that have been effective, and makes specific recommendations for improving the quality of teaching and provides guidelines for improving the professional development of teachers for a congruent change toward reformed pedagogical . These guidelines furnish a range of alternatives that have been tried in STEM systems imposing the needs of a globalized world of the 21st century on Professional development and efficacy elicits in educators develop new instructional techniques, recruit highly-qualified passionate science teachers, provide opportunities for extracurricular activities, and foster connections with the professional community.

Definition of STEM

On its surface, “STEM” is the acronym of science, technology, engineering, and mathematics. However, when you pull that first layer away, you reveal the most elaborate puzzle in the education world. Most educators know what STEM stands for, but how many really know what it means?

A common definition

STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply
science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy. (Tsupros, 2009)

Creative Definition for STEM to Sri Lankan Context

According to Sri Lankan context with the available recourses and technology, the above definition does not play a significant role. So it can be modified as an integration of science, maths, engineering and technology skills and competencies with one subject matter content

The significance of the Study

Qualified teachers are essential to STEM teaching and professional development is a great need to cultivate knowledge content as well as pedagogical knowledge ability. This study is to identify the related literature on professional development programmes and to find out the opportunities, trends and challengers. Specifically, the study shall be investigating the following:

• How teacher education and professional development in STEM can be an impact on student achievement in STEM
• The role of STEM teacher and how can best be prepared for teaching STEM in the 21st century.
• Issues, implications, and challenges of globalization through STEM education
• How STEM training programmes focus on real-world issues and problems

Teachers need to be actively involved in the changing process of STEM education and update and upgrade through professional training programmes. In order to incorporate the demanding characteristics of professional development programs, this study aimed to explore related literature to find solutions to the above issues.

Literature Survey

A prime goal of STEM educational reform is to encourage a shift from teacher centered classrooms where students are passive consumers to student-centered environments where learning is an active process (Smith, Vinson et al. 2014). The NMC Horizon Report: 2015 K-12 Edition examined emerging technologies for their potential impact on and use in teaching, learning, and creative inquiry in schools (Johnson, Levine et al. 2010) boost student interest highly and keep them in the STEM pipeline. But none of these solutions had proven to be a silver bullet and that could be frustrating (Most, 1996). Teacher effectiveness is usually expressed in terms of pupils’ academic achievement hence educators’ active participation strive students to get excited on STEM disciplines through various activities, including hands-on activities (Ejiwale 2012). Successful shifting of the pedagogical beliefs of teachers toward a reformed mindset is essential if professional development is to positively influence teaching in STEM classrooms (Crowther, Ferguson et al. 2009). STEM educators, with a new paradigm shift as “facilitators” and laboratories well-equipped with modules where students will spend most of their time learning, will help students to take what they learn in the classroom and laboratory and apply it to future jobs in the real world (Salmi 2014). These practical applications of the concepts students learn in the classroom and laboratory will help enhance the quality of STEM education (Darling-Hammond 1994, Ejiwale 2012, Ejiwale 2013 Olawoye, 2010). Creative problem solving, product building, collaborative team work, design, and critical thinking (Alemán, 1992; Darling-Hammond 1996) are mandatory skills that are addressed in STEM programs in order to build a culture of interest in science to enable to gap the bridge educators are to facilitate STEM activities of students with reduced input to solutions needed to problem solve or to do hands-on activities (Tytler, Symington et al. 2011). Alemán (1992) described this further: “It is no longer acceptable for the teacher to be the one with the knowledge (Alemán, López, & Solis). Teachers must become comfortable with students as their own teachers working in cooperative groups to solve problems in a culturally, technologically, and socially evolving environment. “Natural curiosity of students that will lead them to bodies of knowledge and means of discovery that teachers can encourage.” (p. 97) (Glasgow 1997). There is a need for investing in the preparation of the potential STEM educator so he or she will be well equipped with the skills necessary to navigate successfully in this new mindset. Researchers (Tschanne-Moran and Woolfolk Hoy 2002) defined educator efficacy as an educator’s judgment of his/her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated. This makes learners more active during the learning process through active participation (Pullias 1994, Glasgow, La Chance et al. 1997). Since facilitative teaching is not an art innate in teachers (Wittmer 1980), STEM educators must learn this skill. Learning is fostered when there is active facilitation of students’ activities and their interactions between with peer learners. Teaching in STEM environment requires competency in pedagogy that ensures active participation in classroom activities by learners. More importantly, educator’s efforts should be geared towards meaningful teaching and learning through practical illustrations and applications (DeJarnette 2012, Sublette 2013). The most common elements of effective teaching have been excerpted from (Heneveld and Craig 1996) which deals specifically with applying factors of school effectiveness and improvement to educational project design. Twenty First Century Science courses
developed at the University of York focus of courses for 14- to 16-year-olds is of students as ‘consumers not producers of science’ (Millar 2006). If teachers are confident and supported in implementing such an approach, young people will be more engaged.

STEM Education in Sri Lanka

Catalyzing STEM education Research and Development in Sri Lanka through networking and international collaboration of the US Association of Science-Technology Centers (ASTC) and the National Science Foundation of Sri Lanka, Its focus is for ASTC to share its wealth of expertise with Sri Lanka in the creation of a science center in Colombo that will engage its people in an accessible science-learning environment and provide its youth with grounding in the scientific concepts and practices and to consider how to develop an ongoing relationship between informal STEM educators in the US and STEM educators to initiate discussions between STEM educators in the South Asia region and the United States, with the goal of developing a long-term relationship between STEM educators in the South Asia region and the United States. Research done on STEM showed that the relationship is more complex than it was argued for. The initial conclusions were that life critical system development and life experience trajectories as determinant factors while technological influences were unavoidable. A further investigation should involve correlations between human centered learning design approach and economical development in the long run. Sahama, Tony R. & Bandara, Deepthi (2014). There has been a lot of concern that Sri Lanka is not getting enough students interested in going into STEM careers so that awareness raising on STEM Education is given priority amidst of numerous obstacles and challenges.

National Colleges Science Education Programmes

The Science Education Program at National Colleges encompasses both professional teacher education and a professional development program that prepares leaders for science education roles in pre-college and higher education. The guiding principle for these program offerings is that professional science educators should be thoroughly educated in their content discipline and bring modern theories of learning and prepare competent learners for the world.

Teacher training courses conducted in teachers colleges and colleges of education are residential and institutional programs one-year postgraduate diploma courses conducted by three universities are institutional while all the other in-service and pre-service courses are non-institutional either distance or part time teacher education programs.

STEM Practices in National Colleges Science Education Programmes

Based on the literature survey and the useful discussion had with a group of independent people on the subject the following hypotheses were drawn before the analyses of data and conclusions were arrived at based on their results.

1. Ho (Null Hypothesis) - There is no fear in the future of STEM education in Sri Lanka
2. Ho (Null hypothesis): Teaching through STEM will not connect curriculum to life outside the classroom to the real-world application.

Methodology

In social sciences research the data could be collected by a combination of methods, including observation, interviews and questionnaires. All the three methods were employed in this survey to collect necessary information. However, the main focus was the adoption of questionnaires. Personal interviews added weight to the required information to bridge the gaps on the subject. The documentation analyses was done using other publication on the subject along with the circulars released by the Ministry of Education.

Sample details:
- Teacher trainees from NCOE
- STEM learners (students)
- Parents of STEM learners
- Educational Officers
- Tuition teachers

Instruments of Data collection

1. Formal and informal interviews
2. Questionnaire survey
3. Classroom observations
4. Document analyses

Administration of interview questionnaires

The open and closed type questions were included in the interview questionnaire. It was conducted with other stakeholders the parents of STEM learners (40), STEM learners (280), educational authorities (15), and tuition teachers (15). Formal interviews were held for (10) teacher educators, (15) administrative officers and the informal interviews were conducted for the rest of the stakeholders.

Analyses of data

The mass of data those were gathered through the administration of the questionnaires and the interviews were coded. The open ended questions were analyzed qualitatively and the rest were done on as per the guidelines of the quantitative method. Analysis of data was done using MS EXEL and MINITAB 14 software packages. The two hypotheses drawn before data collection were proved or disproved as per the results obtained, and the conclusions were drawn. The analyzed results were interpreted and recommendations were drawn to highlight policy insight based on the results.
No doubt
doubt
100806040200
250
200
150
100
50
0
Scatterplot of doubt vs No doubt
Figure 1: Stake holder’s views on the future of STEM education in Sri Lanka
The following hypotheses were drawn to arrive at conclusions
(1) Ho (Null Hypothesis) - There is no doubt in the future of STEM
Education in Sri Lanka
H1- There is doubt in the future of STEM education in Sri Lanka
Ho is rejected where, p value < 0.05
Ho is accepted where, p value is >0.05
Regression Analysis: doubt versus No doubt
The regression equation is
Doubt = - 9.8 + 2.80 No doubt
Predictor Coef SE Coef T P
Constant -9.77 13.73 -0.71 0.516
No doubt 2.8032 0.2976 9.42 0.001
S = 24.4564 R-Sq = 95.7% R-Sq (adj) = 94.6%
Analysis of Variance
Source DF SS MS F P
Regression 1 53068 53068 88.72 0.001
Residual Error 4 2392 598
Total 5 55460
P VALUE = 0.516
Therefore H 0 is rejected; it means that there is doubt about the future of STEM education in Sri Lanka. The regression analyses and the correlations indicate that there is doubt about the future of STEM education among the viewers.
(2) Ho (Null hypothesis): Teaching through STEM will not connect curriculum to life outside the classroom to the real-world application.
From the scattered plot graph it is clearly shown that there is positive sign in building up national unity through bilingual education.
Teaching through STEM will connect curriculum to life outside the classroom to the real-world application
H1- Teaching in Teaching through STEM will connect curriculum to life outside the classroom to the real-world application
Ho is rejected where, p value <0.05
Ho is not rejected where, p v Teaching in Teaching through STEM will connect curriculum to life outside the classroom to the real-world application value is >0.05
The regression equation is
Will connect = 0.5 + 4.51 Will not connect - 3.5 Not indicated
Predictor Coef SE Coef T P
Constant 0.47 58.45 0.01 0.994
Will not connect 4.509 2.947 1.53 0.223
Not indicated -3.48 15.82 -0.22 0.840
S = 100.395 R-Sq = 83.3% R-Sq (adj) = 72.2%
Analysis of Variance
Source DF SS MS F P
Regression 2 150990 75495 7.49 0.068
Residual Error 3 30237 10079
Total 5 181227
P VALUES = 0.011
Ho is rejected where, p value >0.05
p -value = 0.011

Figure 2: STEM curriculum will help the classroom connect to world outside

Trends in STEM in Sri Lanka from the point of tuition masters
Tuition masters show a positive view on the trend .There is a clear future for STEM Education in Sri Lanka. It was found from the interviews held (13/2/2015) with them as well as the questionnaire answered by them. Out of the 15 from the sample 5 has responded positively. It WHICH is 1/3 of the sample. With their experience in the field of STEM they believe the number of students attend for STEM classes are increasing gradually.
Problems faced by the teachers in STEM in schools
Teachers who were in the field of STEM had first hand experiences in the process of teaching They had faced numerous problems. Teachers’ worries had been analyzed by referring to principals, teachers involved in the STEM at present and their views in addition to the views expressed by the STEM learners as well as their parents.
As there was a dearth of competent subject teachers to teach subjects in English medium, English language teachers were allowed to teach STEM subjects. This mainly caused lack of confidence on the STEM .Non availability of continuous development programmes for teachers, had made the STEM teachers were professionally isolated.
Expanding internship programs in particular for STEM disciplines provide work experience to students that would strengthen the relevance of higher education programs. Conclusions are drawn that highly-qualified STEM teachers are still in high demand. It is essential to explore and identify new research questions on STEM education and the role of science teachers as a new model for improving human resource capacities in STEM in developing countries.

**Recommendations**

A central aspect of teachers’ professional knowledge and competence is the ability to assess students’ achievements adequately (Lewin 2004). This principle is appealing to STEM too. Another important field which is closely related to teachers’ competences concerns the question how teachers’ professional development is linked to students’ learning and learning outcomes in STEM. STEM teachers have to develop innovative approaches through blended learning. Continuous Capacity Building of teachers is an urgent need. There is no single best way to prepare and support teachers, so alternatives that had been effective in different contexts. Many challenges can be envisaged. Researches are needed to find out re-imagining in science for future through infusion of STEM since it literate workforce adds value, productivity, and innovations to the economy: STEM-literate workers create a culture of innovation in business and are important contributors to economic development. “Reaffirm the sustainability through STEM to address global education needs” is a timely need. Teaching Practice in school and in college opportunities to practice teaching under supervision with support from experienced mentor teachers is a primly need (Lewin 2004). Suggested areas for future research in STEM education

Since the respondent group to the questionnaire tested was limited to the teacher trainees, it will be useful to conduct a research study with an independent sample of teachers who are already teaching in English medium, covering many area of the country along with an independent sample of school children involved in the bilingual education, to get a broader picture on the subject. Many key factors can contribute to improving a teacher’s performance and hence student achievement. STEM educational blueprint was paramount whatever innovative approaches were put into place, integrating Professional development for STEM teachers should persist over an extended period of time. Surveys of teachers suggest that teachers were most interested in STEM-focused professional development that emphasized career awareness, inquiry based activities, and interdisciplinary activities. Visits and tours or workshop activities were the most preferred modes of delivery. There is a need to increase awareness among parents and students concerning the importance of STEM education. The following three messages are most likely to resonate positively with the community: (1) STEM education prepares all students for the challenges and opportunities in the 21st century economy (2) STEM education improves the impact and overall effectiveness of the K-16 education system; and (3) A STEM-literate workforce adds value, productivity, and innovations to the economy. Technology into the daily educational experience specially trained STEM teachers who knew how to best present these subjects, inquiry-based interactive teaching methodologies and to robust curriculum with adequate knowledge assessment practices is a still a great demand. Policymakers and professionals emphasize STEM education by legislating engineering standards to the existing science standards.

**Limitations**

It is presumptuous to attempt to cover all aspects of teaching and teacher education in STEM in secondary schools in Gampaha District in Sri Lanka and we continuously found ourselves having to limit our work, due to time constraints, and the multiple scenarios of teacher development programmes.

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**Reference Citations**


