Development of STEM Teaching Module for Rural Primary Schools in Sabah: Need Analysis with Justification and Key Features

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Abstract

This paper reports on part of a bigger scale study related to STEM education at primary level. Several education officers have been interviewed to obtain information related to the implementation of STEM education in rural schools. The interview session involving education officers from different fields of job specification and experienced in teaching science in primary and secondary schools. Mixed-research method was implemented including collection of quantitative (survey on needs analysis that was validated and reported earlier) as well as qualitative (observation and interview to be reported in this article) data. A protocol has been prepared by the researchers to focus on questions related to the appropriate science topics to be integrated in STEM, the module features expected by teachers in rural schools, STEM activity suggestions to be included as well as the expectations of rural teachers in implementing STEM teaching. Random sampling technique has been used in selecting the subjects. Results from the interview showed that three out of five subjects could not describe 5E Instructional Model (engage, explore, explain, elaborate and evaluate) accurately even they have been used the phases in the model in their science teaching. Several topics have been proposed by the subjects to be included in the to-be-developed Year 4 and Year 5 STEM module. Some of the problems identified through interviews are short period in science teaching, lack of complete laboratory that able to support STEM teaching, no compilation of STEM teaching manual in rural school and limitation of STEM teaching reference in the context of schools in Malaysia. From the need analysis, teachers claimed that the exposure to STEM must be done at the earliest level of education such as kindergarten. Further research involves the development of STEM modules by considering the needs of rural science teachers. The success of this model is seen through the improvement of students' achievement and positive attitudes to STEM learning.

Keywords: Need analysis; Module development; STEM education; 5E instructional model; Rural schools

Introduction

Background and Rationale

A total of 909 rural primary schools were built in Sabah with a number of 184,160 students

(*Kementerian Pendidikan Malaysia*, 2019) making Sabah one of the states with the largest rural primary school in Malaysia. In the Malaysia Education Development Plan (MEDP) from year 2013 to 2025 *(Pelan Pembangunan Pendidikan Malaysia*, 2013), the first shift is providing equal access to quality education of international standard. To ensure justice in education in Malaysia, the government does its best to provide all the same and equal facilities for all schools regardless of the school's location and student background. This is important in ensuring equality in education to all Malaysian citizens.

In facing the challenges of education in the 21st century, the Government of Malaysia has formulated the MEDP 2013-2025 which lists 11 strategic and operational shifts. The improvement in quality of Science, Technology, Engineering, and Mathematics (STEM) Education is covered in shift 1 showing that the Ministry of Education is always concerned in promoting Science and to improve the quality of student achievement in science subjects. Malaysia has spent billions of Ringgit and even increased the allocation in annual budget, however the results obtained still do not reach the target. The target is 60% of the student participation in science and it is still unattainable in 2012 (Phang, Mohd Salleh Abu, Mohammad Bilal Ali, & Salmiza Salleh, 2014). The government's intentions have not been met which in the 10th shift in MEDP stated in maximizing student achievement in ever spent budget allocation. The main problem that needs to be solved is related to the decreasing number of students choosing science streams in secondary schools in Malaysia.

Actions have been taken in upgrading the science laboratories, modified technology in teaching and learning (Nincarean, Phon, Ali, Dayana, & Halim, 2013), revised contents in science textbooks in giving the right scientific concepts that allow students understand the concept well (Peters & Abdullah, 2017). In addition, the standard of science curriculum was reviewed as well as education policy being updated for improving students' science achievement and their interest (Suhanna Zainudin, Lilia Halim, & Zanaton Ikhsan, 2015).

Problem Statement and Aim of Study

Basic infrastructure problems in rural Sabah such as electricity, water, internet and safe roads hinder the success of the government's aspirations. The intention of the government to overcome the electricity problems is by installing the solar PV systems at schools in rural Sabah and it was reliable (Mahmud & Blanchard, 2016). However, teachers in rural schools are still the main source of knowledge and the dependence of rural schools on teachers is still observable.

Recognizing the importance of rural teachers, we strive to produce appropriate STEM modules for them in order to teach STEM effectively in rural primary schools. In identifying the needs of rural primary school teachers in teaching STEM, one phase in this study that is needs analysis has been conducted.

Methodology

Sampling and Methodological Issues

Responses from 244 teachers; 129 teachers in the urban and 115 rural teachers, as they became the sample of cross-sectional quantitative studies in 18-items questionnaire for STEM integrated education were analysed using Rasch Model. The results of the DIF analysis (a statistical characteristic of an item) to measure items for different abilities of teachers revealed competencies related to ICT integration in teaching showing a significant difference between teachers in urban and rural school teachers. As a result, it is important to set an ICT training

for rural school teachers (Khairani, 2017). In addition to teaching science, rural science teachers are also assigned to teach other subjects as well as doing other administrative work. It makes the prior effort for teachers to be directly involved in the teaching vanish, for teachers are more focus in completing various tasks especially trying to complete the science syllabus within a certain period of time. Such workloads cause teachers in rural areas difficult to maintain the quality of their teaching and in the same time their motivation to improve the quality of teaching decreases (Norhaini Mansor, Fisher, Sattar Rasul, Burhan Ibrahim, & Yusoff, 2012).

Data Collection and Analysis

Random sampling in conducting interview sessions was made among education officers in different parts of services organization. An interview protocol has been designed in identifying the needs of rural teachers, also listing some questions related to 5E Instructional Model, expected modules characteristics and opinions. The subjects involved in the interview were the Head of Science and Mathematics Unit at the District Education Office, state science trainers, outstanding science teachers, experienced science teachers, School Improvement Specialist Coaches (SISC +) and UPSR science examiners.

Prior to conducting the interview session, an appointment was scheduled and a letter of consent have been signed and acknowledged by the subject. During the interview, some questions used scales from 1 to 10 to represent their level of acceptance or understanding. The data from the interview was collected by doing audio and video recordings. To interpret the data, the contents of the interview have been translated to several verbatims. The data coding was readily generated according to the theme or type of questions in the protocol. The importance of coding was to classify and generalise the similarities or differences of feedback through the interpretation from verbatims. Detailed data based on interview was reported. A complete report was prepared in discussing the needs of teachers on the to be-designed STEM modules.

Findings

This section elaborates on the aspects of data analysis from interviews.

Background of Subjects

The subjects in this study consisted of personnel with experience in different areas of service. The subjects were experienced science teachers who had taught science in primary schools in rural and urban schools. In addition, the subjects also known as excellent teachers, who achieved certain service achievement levels, School Improvement Specialist Trainers (SISC +) for Science, and also paper examiners for Malaysian Primary School Achievement Test (UPSR) of science subject. Other subjects were the head of Science and Mathematics Unit as well as the Science Coach for teachers at the state level. Findings showed that 75% of subjects have science teaching experience at all levels; level one (Years 1 to 3) and level two (Year 4 to 6) and have been teaching science for over 15 years.

Needs Analysis and Justification of Modules

Understand STEM and Its Goals. Questions related to the purpose and goals of STEM globally and in Malaysia are specifically given to each subject. Each subject gave a different answer depending on the media they have used such as reading, watching news on television or sharing conversations between friends. Most of the subjects talked about education policy since 1962 which stated about 60:40; 60% of students choose science stream and 40% choose

non-science stream. The education policy was designed to aspire students to be dared in trying something and able to use their knowledge and ideas to create and innovate.

> ".....for me STEM goal is to produce students or generation who have basic knowledge in science and technology, and strive to create something new..." (Madam M).

With the ingenuity to create and innovate, students will be exposed to employment opportunities in the future world.

> "....STEM is to elevate the subject of science, technology, engineering and mathematics and to broaden employment opportunities for students...in this 21st century" (Madam R).

In addition to providing the relevance of STEM goals in career challenges and importance of innovative skills, self-learning should have happened when students are interested in studying STEM subjects as reflected in the following interview excerpts.

> ".…….to cultivate students' interest in STEM fields. I think it's very important...So if they are interested, this would lead to these students tend to learn by themselves...related to STEM subject" (Ms L).

> "... I have never attended any course or talk on STEM....usually I take my students to STEM exhibitions to give them exposure to STEM and to promote self-learning..." (Teacher R).

Level of Confidence in Achieving STEM Goals. In themes related to the level of confidence of teaching STEM, the answers given were in the rating scale of 7 to 10. This is contrary to the scale given regarding their confidence in achieving STEM goals, which were in lower range between 2 to 7 only.

> "For me ...to teach it can be up to 10" (Madam M)

> "...so if you just tend to write the papers and all the theories on the white board…that STEM objectives cannot be achieved...so my confidence to achieve the goal is only 2 to 4" (Ms L).

> "To achieve the STEM objectives...my confidence level is about 6" (Madam R).

Adequate Guidance and Support from existing Science Documents Curriculum Standards and Assessment. Three subjects stated that the Curriculum and Assessment Standards Document (DSCA) issued by the Curriculum Development Division (CDD) should be enriched in terms of steps of teaching or activities manual.

> "The integration of STEM in the Curriculum and Assessment Science Document Standards needs to be shown clearly or example the STEM skills to be applied .... which at present teachers are not really clear on that ..." (Ms L).

Nevertheless, there are still subjects who quoted that the assistance and support from the Curriculum and Assessment Standards Document (DSCA) is sufficient for teachers.

> "….from the specification in terms of the curriculum...I think at the moment it is very complete to help and enable us to teach STEM in the context of rural schools.....enough for me ...the latest specifications are really adequate" (Madam M).

STEM Teaching Guidance in Rural Primary Schools. The need for support and guidance on STEM teaching methods in rural schools is stated by all subjects. The needs expected by the subject such as conducive STEM laboratory facilities as well as topical STEM teaching manual. The STEM elements to be taught to students should be stated in the learning objectives. In addition, the subject requested that the existing Curriculum and Assessment Document Standards (DSCA) should be reviewed to suit the context of rural schools. Subjects also expected that the materials proposed for STEM teaching are cheap and easy to obtain. Among the opinions shared by the subject is the use of recycled materials to be proposed as learning materials in project-based STEM activities.

> "Mmmm ...I think they need more on the methodology, what are the new ways to teach" (Madam I).

5E Instructional Model Inquiry-Based Learning and Their Understanding. The five phases in the 5E Teaching Model are the engagement of students in teaching, students' exploration of new knowledge and skills on their own with teacher guidance, sharing and providing information on newly acquired knowledge, explaining correct terms or facts and assessment to the students' achievement for the lesson. According to Srikoon, Bunterm, Nethanomsak, and Tang (2018), the integration of 5E and 5P (main phases; persuasion, planning, performance, production, and presentation) showed significant changes in the academic achievement and creative thinking of Grade 9 students in Thailand.

Throughout the interview, all subjects stated that they had heard about the 5E Instructional Model. However, the subject could not accurately explain the meaning of this model. Even so unknowingly, this model has been used for so long to teach science in schools.

Exploration in finding information to generate new knowledge is synonymous with science teaching. Students are guided to find information using the media facilities available at the school. The constructivism approach requires teachers to be facilitators and students need to solve problems by applying their STEM skills. Teachers need to be pro-active in acquiring knowledge and exposure to STEM issues. The subject also stated that assessment at the end of teaching and learning is important in re-planning to improve teaching methods in order to attract more of students' interest.

> "... OK ...in this model it requires students to learn in a situation…involving…minds - on and hands-on constantly occur naturally and teachers become facilitator and as an observer only" (Madam R).

> "...teachers always give students the opportunity to expand their knowledge…. for example….. knowledge about science term either they got it from the project they created, or in the form of a scrapbook. After that the teacher will evaluate the student achievement based on the work shown." (Madam M).

> "...related to the phase in teaching where it starts with the full engagement of students to the teaching and finally there is an assessment…… this helps teachers in achieving their objectives" (Madam I).

Constraints of teaching STEM through 5E Instructional Model. Several feedback received from subjects related to constraints using the 5E model in teaching science. This includes the existing facilities in rural schools seemed not really adequate and ready to be used

effectively to teach STEM. Laboratory maintenance and preparation of teaching materials involve expensive costs and sometimes the recommended materials are not readily available in rural areas. Appropriate teaching materials are important in ensuring the successful achievement of STEM objectives. In addition, the use of good resources provides students with the opportunity to independently explore relevant knowledge and learning experiences, hence, to be used in their problem-solving skills. All these constraints stifle teachers' creativity to improve their teaching and as for that students are not interested in following the lessons due to boring and uninteresting teaching methods.

Feedback related to the needs in developing the STEM module. All subjects argued that a specific module for STEM should be developed to help them teaching in rural areas. Such modules can expose teachers to appropriate STEM teaching methods, while making it easier for them to prepare materials and save time in making their daily lesson plan. The subject also regarded that a clear and complete operating manual is important. This module can also become a good reference for new teachers to teach STEM. A clear description in the module helps to enhance the teacher's understanding to carry out the proposed teaching activities. Good time management will give students the opportunity to do activities and complete their assignments in a given time. Through funds provided by Universiti Malaysia Sabah, several studies will be conducted in helping teachers in rural areas to solve their problems in STEM teaching. Therefore, UMS will act as a mediator in creating collaboration between researchers and teachers in rural schools. The collaboration platform provides a quality learning process that is facilitated by university researchers or by other teachers as collaborators, in becoming wider intellectual networks as well as the use of appropriate specialized teaching tools for self-analysis and change (Avalos, 2011).

> "...this will become some sort of guidance to them to plan their lesson and then they will know what steps in the lesson they should use." (Madam I)
>
> "In my opinion, it is necessary to have a module...as a guide for teachers...will not be used totally but just a guide and can be modified...for examples, activities that integrate STEM" (Ms L).

The Key Features of STEM Module in Rural Schools

The subject stated that a good module should meet the following features i.e. user-friendly, the language used is easy to understand and able to show complete procedures for teaching certain STEM topics. In addition, this module should be in line with the science teaching time allocated to teachers. The most important is the content taught in the module must comply the Science Document Standard of Curriculum and Assessment (DCSA). According to Thomas (2000), activities in teaching can attract students' interest. Therefore, the proposed STEM activities must be studied and piloted before applying to the module. Researchers also need to consider the cognitive level of children while designing the proposed activities. According to Tseng, Chang, Lou, & Chen (2013), the selection of teaching materials is important. Researchers need to be aware with the facilities available in the rural school area and teaching materials should be readily available to help teachers save their time in planning and concentrating to the lesson.

A complete STEM module must be systematically compiled including content synopsis, daily lesson plans, appropriate worksheets on each topic to be taught. The teacher must be fully understand the teaching module so that the teacher can deliver the lesson according to the plan. It also helps researchers to examine the development and effectiveness of the module

accurately. The module desired by the teacher is a module that is flexible with the current situation and can be modified depending on the facilities available in the school.

Students need to go through the learning experience on their own by doing the investigations that lead to problem solving via practical methods (George, 2006). STEM activities or experiments should be operated everywhere either in the science laboratory, classrooms or outside of the classroom. The steps in conducting the experiment should be explained in writing not only verbal to avoid confusion of the teachers and also to the students. Detailed and easy-to-understand descriptions can bring the success of STEM activities. Teachers also need to be with students in every activity by providing their support and guidance.

To ensure the safety of our environment, the use of recycle materials are advisable as teaching aids (Yeboah, Asante, & Opoku-Asare, 2016). At the same time, this STEM module helps to promote and instill awareness to appreciate our environments. Subjects also expect guidance in terms of preparation of assessment instruments. Appropriate teaching time allocation needs to be studied so that teachers can deliver their teaching comprehensively. Teachers can also choose proposed STEM activity based on their current school facilities. Subjects also suggested that the development of the module must be done in stages, starting from level one to level two. Preliminary exposure related to STEM should be done as early as kindergarten. A training on STEM module implementation should be done to the teachers to ensure coherence in teaching. STEM skills to be applied in the module need to be clearly defined (Holmund, Lesseig, & Slavit, 2018) to help teachers achieve the learning objectives.

Suggestions of science topics for Module Development. Subjects suggested several topics that were found to be difficult for them to integrate STEM elements. These topics are related to the density of materials, the properties of acid and alkali, solar systems, the properties of materials and the limited human capabilities. Previous topics suggested are in Year 4 syllabus and for Year 5, subjects suggested the Phases of the Moon, Energy and Electricity to be included in the module. The subjects also regarded that they have difficulty to find the most suitable STEM activity to be practised in rural school.

Discussion

The development of STEM modules requires a thorough study of all aspects. These include content selection, delivery methods, appropriate language, attractive presentation, level of understanding of readers or users, consistency and the exchanging opinions between researchers, experienced teachers and external reviewers or experts in producing a good quality module. The success of the to-be-developed STEM module will help the government in providing the facilities that are critically needed in rural schools. It is hoped that the interventions will lead to an increasing in students' interest in learning STEM and can trigger students' creative skills. A pilot study should be conducted to ensure that the time allotted in teaching the module corresponds to the weekly teaching period of the science teachers. It may help to maintain the quality of teaching of the teachers and to reduce their stress. Knowingly that Sabah has a large number of rural schools and constraints in terms of logistics and facilities to be seen, a good planning can help rural schools to get the same educational achievement as in urban schools and in turn bring success to the entire education system. Data obtained from needs analysis are classified into specific themes to facilitate researchers to extract meaningful information. Module characteristics has been obtained from the output theme in the verbatims. A module checklist (Table 1) is created to assess the STEM module. To assess the quality of modules, 80 percent of total tick (**/**) provided by an individual respondent is considerably acceptable.

Table 1
Checklist for STEM Module

No	Module Characteristics	Tick (/) (if any)	Notes
	Module Privilege		
1	User-friendly		
2	Multitasking (school and home)		
3	Self-accessible		
4	Can be modified		
5	Activity not too challenging		
6	Systematic and consistent		
7	Various level		
	Module Content		
8	Comply with the Science Document Standard of Curriculum and Assessment (DSCA)		
9	STEM objective is clear		
10	STEM elements well defined		
11	Clear instructions		
12	Suitable with the science topic		
13	Following the time allocated for teaching		
14	The teaching method is clear		
15	List of tools and materials used		
16	According to the current situation		
17	Hands-on exploration		
18	Use of science lab is flexible		
19	Various activity		
20	Assessment instrument		
21	5”E”training		
22	Procedures of activity/experiment are clear		
23	Lesson plan provided		
24	Guides for concept building		
25	Interesting presentation		
26	Experiment results/findings		
27	Clear pictures and diagrams		
28	Teaching period		
29	Design element		
30	Attracting student interest / fun		
	Material Source		
30	Recycled materials		
31	Cheap/affordable		
32	Easily obtained		
	Implementation		
34	Suitable for existing facilities		
35	Pilot test		
36	Course / Workshop		
37	Involvement of the related personnel from authorities		
38	Timeframe is appropriate		

Conclusion

Limitation and Implications

From the analysis, it is found that teachers and students' exposure to STEM is still inadequate. As a result, the knowledge in STEM integration is hardly implemented by the teachers. Moreover, not all science topics in the syllabus are suitable to be integrated with STEM. In order to improve, guidance is needed to bring forward the ideas on teaching STEM effectively in rural schools. Other limitations include STEM teaching facilities in Malaysia that support STEM education such as internet coverage and appropriate STEM laboratories. This STEM module is limited to Year 4 and Year 5 science only and further improvement such as addition of new content should be taken into consideration.

The implications from this study is in providing options for rural teaching interventions and identifying the needs of teachers in rural areas. The biggest implication seen is in changing teachers' perceptions in teaching STEM and cultivating STEM education in rural areas. The possibility to succeed can only be achieved with the presence of strong collaboration between researchers and rural teachers. The higher adaptation to STEM culture, the easier to increase the number for future Malaysian innovator.

Significance and Future Direction

From the needs analysis, it is found that needs of rural school teachers is important in developing specific, right and qualified modules and study should be done periodically aligning with the curriculum standard or policy. A good need analysis is whenever it can respond towards the gaps that is the difference between what is currently done and what should be performed in helping the teachers and students, thus to cultivate interest in learning STEM in school.

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