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Integration of STEM Approach in Teaching Science to Indonesian Islamic Boarding School Students (Malaysian Pre-service Teachers' Experience)

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The research objective is to look at the effectiveness of STEM integration in science learning in Islamic boarding schools based on the experience of PSTs in teaching practice. It's based on qualitative research, with an explanatory approach. The participants of this study were 65 Islamic boarding school students in Tasikmalaya, West Java, Indonesia. The focus of the school local curriculum is based on religion rather than formal learning, especially science. Learning is carried out using the STEM approach, for 2 months including A non-test research instrument in the form of a questionnaire. In addition, semi-structured interviews were conducted as the main source of data incorporating various documents, notes, and diaries. Data processing was completed through data collection and data reduction . The results of the study in the form of response analysis showed that the STEM approach could be integrated into science learning at the Islamic boarding school-based high school . The STEM approach used by PSTs received a good response, namely 71%, while student using this approach were higher at 83%. The STEM approach has been able to inspire half the student population to become scientists and work in the field of technology.

Key words: *STEM, Science, Islamic Boarding School students, ITP, PSTs.*

Introduction

The STEM education reform movement was driven by study reports which showed that there was a shortage of candidates to fill employment in STEM fields, a significant level of illiteracy in the community regarding issues related to STEM, and the position of high school student achievement in TIMSS and PISA (Roberts, 2012). Other problems include lack of support from the school system, inability of teachers to imagine integrated STEM learning and not enough knowledge about the content and standards of STEM subjects other than those taught (Honey et al., 2014; Ejiwale, 2013; Stohlmann et al. , 2012). In the context of basic and secondary education common in many countries including Indonesia, only science and maths subjects are part of the conventional curriculum, while technology and engineering play only a minor role or are even absent from the curriculum.

Within these four disciplinary fields. educational reform fosters the level of work of STEM fields, develops STEM literate citizens, helps the next generation of students to solve real-world problems and increases global competitiveness in science and technology innovation (Burrows & Slater, 2015; Bybee, 2013; Hanover Research, 2011). Thus, integrated STEM education is quickly becoming a meta-discipline, focusing on innovation, designing solutions, and utilising technology (Kelley & Knowles, 2016). Students are expected to be involved in a rigorous curriculum, with instructions and assessment in mathematics and science as well as engineering design (Kelley & Knowles, 2016). There is hope that such an approach will motivate more students to pursue careers in STEM (Stohlmann et al., 2012).

STEM education is widely recognised as a national priority (Honey et al., 2014). Excellence in STEM education can affect employment, productivity, and competitiveness in various sectors including health, technological innovation, manufacturing, information distribution, political processes and cultural change (Asunda., 2014). Empirical evidence supports the idea that the engineering design process can be an effective way to facilitate and maintain the integration of concepts from various STEM disciplines that students must master (Estapa & Tank, 2017; Guzey et al., 2016; Moore et al., 2014). STEM education will not be meaningful by only strengthening the practice of education in separate fields, but rather by developing an educational approach that integrates science, technology, engineering, and mathematics and by focusing the educational process on solving real problems in daily and professional life (National STEM Education Centre, 2014).

Some opinions and research results that have been presented show how important the integration of the STEM approach is to students. As a result, STEM needs to be developed, so that responses that are indicative of concerns related to the understanding and definition of STEM currently available in the education community are more focused on the need for clarity of STEM deficiency (Kelley & Knowles, 2016; Moore et al., 2014; Stohlmann et al.,

2012). Large-scale longitudinal studies have shown that the integration approach encourages student motivation and engagement while disciplined learning is supported by many research studies (e.g., Estapa & Tank, 2017; Glancy et al., 2014; Grubbs & Strimel, 2015; Guzey et al., 2016).

The challenges facing the world today call for a multidisciplinary global society and may require the integration of several STEM concepts to solve them (Wang et al., 2011). Therefore, it is considered important to train and prepare a diverse STEM-literate workforce with the ability to understand the world of technology (Merchant & Khanbilvardi, 2011). Mathematics, physics, chemistry, and biology lessons are identified as STEM disciples that attract the most successful students of those who have representational competence (Suprapto, et al., 2018). It is assumed that the term STEM is used to both show and emphasise points of connection and overlap between science, technology, engineering, and mathematics. This research is designed to explain the numerous factors that need to be considered by teachers in integrating STEM into learning.

The integration of STEM in learning science for Islamic boarding school-based high school students in West Java Indonesia has been carried out by Malaysian pre-service teachers (PSTs) in the international teaching program (ITP). Teaching practice is one of the phases for USM students from Malaysia to become professional teachers in the International Teaching Program (ITP) (Kabilan, et al., 2017). Teaching practice for pre-service is a teaching activity to become a professional teacher (Nguyen and Baldauf Jr., 2010). Judging by the Islamic boarding school-based high school learning curriculum, Science subjects, especially Biology only have a teaching opportunity of 2 hours per week. This has become an obstacle for PSTs to improve their knowledge and skills in the field of Science because the STEM approach is highly appropriate to be tested in this school.

Previously, no research specifically described the experience of Science trained teachers from other countries who completed the practice directly for Islamic boarding school students in Indonesia. This is the research context, which is presented with the aim of providing input to teachers and school administrators to integrate STEM into the learning process. Other expectations include improving the quality of education, increasing mastery of skills and enriching experiences while stimulating enthusiasm in students about their learning. A great deal of data was collected including questionnaires and practices conducted by USM trainer teachers who teach students in teaching practice in integrated schools using the local curriculum (Islamic boarding school) and national curriculum. The questions are made openly to broaden the scope for answers in semi-structured interviews, to inform development of learning and responses in the questionnaire. The questions raised in this study include 1) What are the biggest challenges to applying the STEM integration approach in education using a local and national curriculum ?; 2) What support will help to overcome this

challenge ?; 3) What are the recommendations for teacher trainer education that can help integrate STEM more effectively ?

Research Methodology

The research uses a qualitative methodology to discover the effectiveness of STEM integrated science learning in education using a local and national curriculum, based on the experience of prospective Science teacher students during teaching practice. An explanatory approach is used as researchers have little information about the areas to be studied (Creswell, 2012). Respondents in this study were high school students (senior high school) based on Islamic boarding school class X and class XI in West Java, Indonesia, amounting to 65 students. There were a total of 29 male s and 36 female students, while the other participants were trainee teachers from Malaysia consisting of 3 people and a Science teacher at the school. The school's learning process is focused on religious content. The school combines the local and national curriculum , but mostly use the former . Within the Science area, Biology only makes up 2 hours per week. Learning in schools was carried out for 2 months, between March and May 2018. The learning process was conducted by Malaysian pre-service teachers (PSTs), namely from the University Sains Malaysia (USM) who were completing teaching practices in Indonesia in the International Teaching Program (ITP) program. The learning process uses the STEM approach.

Data collection is completed through observation, interviews, documents, and questionnaires. Observations were carried out by observers in class where the learning process took place. The interview method was chosen because it has several advantages in a needs assessment study that provides in-depth information about various topics, permitting an explanation for ambiguous responses potentially obtaining more information. The documents analysed in this study were in the form of interview documents, reflection documents and analysis documents prepared by Malaysia PSTs. Questionnaires were given to students when the learning process had been completed which included questions related to teaching and learning in Science to review the STEM integration process, consisting of 23 items divided into 3 components in learning activities : learning media, learning process, learning resources. Questionnaire statements with choices included (1) Never; (2) Rarely; (3) Seldom; (4) Often and (5) Very Often. Student attitudes towards Science and Technology were summarised in the form of questionnaires, consisting of 9 statements, including (1) strongly disagree, (2) disagree, (3) agree and (4) strongly agree highlighting the relevance of science education. The research data was analysed using a descriptive qualitative methodology by collecting and condensing data and forming conclusions. Prior to making conclusions, order research results were validated.

Research Results

Student Teachers' Perceptions of Instructional Media that Support STEM Learning

The learning process at Islamic boarding High School Amanah tends to be teacher centred and uses whiteboard media. Textbooks are provided in the classrooms that can be used by students as needed . When PSTs from USM conduct learning using technology media (media projectors, visualisers) Islamic boarding school students tend to still like the use of whiteboards. This is evident in the results of questionnaires which indicate that students of the Islamic calendar still like the use of whiteboard media. However, students hope that teachers incorporate the use of the media projector, visualiser and whiteboard in their teaching practice (Table 1).

Table 1: Responses of Participants to Learning Media

Teaching and Learning Science	*Currently used*					*Ideal* usage (%)				
	Current practice					Expectation				
	Strongly Disagree	Disagree	Doubtful	Agree	Strongly Agree	Strongly Disagree	Disagree	Doubtful	Agree	Strongly Agree
The teacher teaches new content by writing notes on blackboard or transparency	0	0	12.3	23.1	64.6	0	1.5	4.6	10.8	83.1
Teachers teach new nce based content by writing notes on a projector, visualiser or interactive iteboard	3.1	3.1	43.1	26.2	55.4	6.2	0	3.1	29.2	61.5
Teacher solves problems or sums on blackboard or transparency	3.1	3.1	43.1	26.2	55.4	4.6	0	3.1	21.5	70.8
The teacher solves the problem or formulates on a projector, visualiser or interactive whiteboard	1.5	6.2	12.3	35.4	40.0	3.1	1.5	3.1	38.5	53.8

Learning Process

During the learning process of USM PSTs students have participated in the learning process positively , the trainee teacher has considered students' ideas for designing learning, and has led conversations about difficult Science concepts. Islamic boarding school students expect

the teacher to lead more talks. USM PSTs students have held demonstrations to explain the phenomenon and students have a positive view of this activity which is indicated by the opinion of students who expect more frequent Scientific demonstrations Students feel more creative in learning Science and prefer group rather than individual learning in assignments, discussions and Science projects. They do not approve of studying individually and most pupils expect assignments, discussions and Science projects to be conducted in small groups (Table 2).

Table 2: Responses of a participant to Learning Process

Teaching and Learning Science	**Currently used**					***Ideal usage* (%)**				
	Current practice					**Expectation**				
	Strongly Disagree	**Disagree**	**Doubtful**	**Agree**	**Strongly Agree**	**Strongly Disagree**	**Disagree**	**Doubtful**	**Agree**	**Strongly Agree**
Teacher takes into consideration students' idea while planning and during a science lesson	1.5	6.2	12.3	35.4	58.5	1.5	1.5	6.2	33.8	56.9
Teachers lead discussions about difficult Scientific concepts and problematic issues	0	1.5	21.5	20.0	58.5	1.5	0	6.2	12.3	80.0
We discuss difficult concepts and problems in small groups	0	3.1	9.2	24.6	64.6	1.5	0	3.1	24.6	70.8
We solve problems or assignments individually	7.7	9.2	53.8	20.0	10.8	6.2	12.3	33.8	30.8	16.9
We solve problems or tasks in small groups	0	3.1	12.3	27.7	58.5	1.5	0	6.2	27.7	64.6
We complete Science projects in small groups	0	6.2	7.7	26.2	58.5	1.5	1.5	9.2	21.5	66.2

Learning Resources

In this discussion learning sources refer to sources of information obtained by Islamic boarding school students within learning, including books, newspapers, magazines, debates, the presence of experts and study tours. Learning resources used in this school incorporate textbooks to study Science, most students hoping to learn Science through non-fiction books, newspapers, and magazines. Usually, debates are rarely included in the learning process, whereas some Islamic boarding school students expect some debate in class. Experts are not invited to Science classes even though some students expect subject experts to provide information about Science. Visits to industry, museums, exhibitions, Science centres to complete information have not been organised for Islamic boarding school students, yet most boarding school students expect such visits (Table 3).

Table 3: Responses of Participants regarding Learning Resources

Teaching and Learning Science	***Currently used***					***Ideal Usage* (%)**				
	Current practice					**Expectation**				
	Strongly Disagree	**Disagree**	**Doubtful**	**Agree**	**Strongly Agree**	**Strongly Disagree**	**Disagree**	**Doubtful**	**Agree**	**Strongly Agree**
We learn Science by reading non-fiction books, newspapers, and magazines	23.1	20.0	33.8	18.5	6.2	7.7	9.2	24.6	35.4	23.1
We learn Science through textbook reading	1.5	7.7	26.2	43.1	23.1	1.5	7.7	23.1	40.0	26.2
We visit enterprises, industrial plants, and research institutes	73.8	12.3	7.7	6.2	1.5	7.7	1.5	20.0	27.7	43.1
We visit museums, exhibitions and science centres	80.0	7.7	9.2	3.1	1.5	3.0	6.2	20.0	26.2	43.1

We have a debate during Science lessons	24.6	24.6	24.6	21.5	6.2	7.7	4.6	26.2	38.5	23.1
An external expert visits our Science class	18.5	13.8	38.5	24.6	6.2	3.1	6.2	27.7	43.1	20.0

The Relevance of Science Education (RPS)

According to the results of the boarding school student questionnaire , Science is not a difficult subject, only a small percentage of students claim the contrary . Most agree that Science is interesting and easy to learn. They realise that Science learned at school is useful for their daily lives , and learning Science increases curiosity about unexplained problems . Half of the Islamic boarding school students surveyed aspire to work in the field of Science and half Technology. All respondents agreed that Science and Technology are important to society.

Table 4: Responses of Boarding School Students regarding the relevance of Science Education

No	Questions	%			
		Strongly Disagree	Disagree	Agree	Strongly Agree
1	Science taught in school is a difficult subject	6.1	63.0	24.6	6.1
2	Science taught in school is interesting	0	4.6	67.7	27.7
3	Science taught in school is easy for me to learn	0	15.4	72.3	12.3
4	Science taught in school is useful in my daily life	0	3.0	61.5	35.4
5	Science taught in school increases curiosity about unexplained phenomena	0	4.6	43.0	52.3
6	I aspire to become a Scientist	6.1	46.1	32.3	15.3
7	I want to work in the field of Technology	1.5	40.0	43.1	15.3
8	Science is important to the community	0	0	61.5	38.5
9	Technology is important to the community	0	0	29.2	70.8

Discussion

The Challenge to Apply the STEM Integration Approach in Education Using a National and Local Curriculum

Indonesia is one of the destinations for the practice of PSTs from Malaysia because teaching in schools within Indonesia appears interesting and the two countries have a lot in common. Although the above two neighbouring countries have similar languages, namely Malay and Indonesian, some terms contain different meanings. This is one of the challenges for USM PSTs students, moreover, the learning process in the classroom uses Indonesian and may also use local languages (Sundanese), so students need to understand Indonesian and regional languages before practicing in Indonesia by conducting cultural immersion. The structured immersion experiences in culturally-different communities (either within the home culture or abroad) will guide teachers to draw upon their students' cultural worlds to develop meaningful learning experiences for all students (Smolcic, EA, & Katunich, J. 2017).

Students who attend Islamic boarding schools study formal education while studying Religion. The learning content is more focused on religion , which is a formidable challenge for science PSTs. Students usually receive lessons in the student centre, on the other hand, the Science Education system administration has recommended ways to understand students from a variety of complex systems. One example is the structure-behaviour-function framework which has been used to support and examine student systems thinking (Bray-Speth et al., 2014; Dauer et al., 2013; Vattam et al., 2011). Known systems of thinking include general system thinking, systems thinking that shows the relationship between structure and function, as well as dynamic system thinking (Jonshon, 2009). In STEM education (Science, technology, engineering, and mathematics) systems are important aspects that are widely adopted as educational innovations so that they emerge as a global movement to bridge the gap between the needs and availability of expertise needed for development in the 21st Century.

The curriculum is a basic guideline in the learning process that is used as a tool to achieve educational goals. As the core curriculum is structured to realise the goal of national education, the national curriculum's focus is to enable e graduates to become full Indonesian citizens (UUSPN no. 2 of 1989, article 4). The National Curriculum in Indonesia is based on 2013 curriculum, wherein its implementation of the learning process uses a scientific approach incorporating learning activities for students and teachers as facilitators (Sinambela, 2017).

Based on the results of interviews with Malaysian PSTs, the national curriculum and the Indonesian and Malaysian curriculum are not very different, so that Malaysia PSTs do not have much difficulty in adjusting teaching materials, including the local high school

curriculum where research is based on studying religion. Student activities begin at 3.30, filled with religious activities. Teaching and learning activities at school start at 7:00 in the morning until noon, then continue with independent and extracurricular learning as well as religious teaching until 21.00. Science lessons, especially biology, are very short, consisting of 2 hours per week. At schools, the teaching of Science is conducted by integrating local and national curriculum. It is a challenge for PSTs from USM to design learning using the STEM approach, including learning cycle 5E strategy. Despite a short amount of time, the PSTs have been able to integrate the 5E cycle model within the STEM approach. PSTs try to use the extra time for discussion and guide the creation of student work after 12 hours of individual study . PSTs use the STEM approach in Environmentally based learning material, including Science: ways to manage material waste, Technology: usage of education tools (jigsaw) in teaching and learning activities, Engineering the invention of new products from waste materials such as used paper, bottles, cans and boxes, and green technology; usage of wastewater materials in teaching tools (giant mind map using newspaper).

As a result of this learning process, students still like the whiteboard media for learning and expect to use it and available books in the classroom. The use of media technology (projector, visualiser) is new for students, for example using the Kahoot application for evaluation. As a result,, students begin to like technology and expect lessons to incorporate use media technology. The use of technology can motivate students to learn better. USM PSTs have completed the learning process well, using the STEM approach students feel better, more creative in learning Science and hope teacher training leads to improved discussion about these issue. Islamic boarding school students prefer group learning and discussion regarding assignments in contrast to PSTs students who prefer to work in small groups. Islamic boarding school students do not like to learn independently, as they always spend time together in boarding schools. Another challenge is that the main learning resources of Islamic boarding school students are textbooks, rather than fiction , newspapers or magazines. As fiction is not available , newspapers or magazines become the main sources of information in Islamic boarding schools. Furthermore, students of these schools are not allowed to use the internet as a source of information, so information is limited to books provided by the school. Some students hope to use fiction books, newspapers and magazines as learning resources. Limited learning resources are a challenge for PSTs, and they try to provide learning resources which provide knowledge and insights about learning with the STEM approach.

Students are aware of the importance of Science and Technology that is needed by society (Table 4). According to of Maltese & Tai (2011) and Wiebe, et al (2018), at this age level, students tend to assume that Science is needed for their future. This shows that learning with the STEM approach, especially including Technology has a significant influence on participants as half of the student participants want to work in the field of Technology and

Science. The other half do not aspire to become Scientists and Technologists, because most of the school lessons is based on religion , with a tendency towards humanist and social problems. Based on data we can conclude that the STEM approach is influential on participants' understanding that the application of Science and Technology is very important for the community (Table 5).

STEM integration in learning has had an impact on students' mindsets and added self-efficacy, which refers the belief of one's ability to complete tasks and influence events that impact upon their lives (Bandura, 1986). Researchers are increasingly finding that self-efficacy is a predictor of academic achievement (Multon, Brown, & Lent, 1991; Pajares, 1996; Zimmerman & Bandura, 1994). Recent research has emphasised the need to distinguish between general self-efficacy towards task completion and specific self-efficacy towards specific tasks or academic areas (Chen, Gully, Whiteman, & Kilcullen, 2000; Hernawati, et al., 2018). There is also growing evidence in educational research that self-efficacy is a critical factor in the development of student career interests (Betz & Voyten, 2012; Tang, Pan, Newmeyer, 2008).

Support for Overcoming Various Challenges

PSTs from USM received full support in implementing the International Teaching Program (ITP). PSTs received assistance to conduct cultural immersion in order to get to know the regions and cultures of the people of West Java in Indonesia, including food and local languages. The school provides initial time and activities to carry out cultural immersion as students are being taught by, teachers and other officers. PSTs are introduced to teachers, administrative officers and other officials in the boarding school (Islamic boarding school) as well as students who board in the Islamic boarding school. In contrast to Malaysian practice, PSTs are also introduced to activities carried out by students, such as the flag ceremony, religious learning and learning activities which are conducted by students. According to one of the PSTs participants from USM, practicum is still very traditional in the school. During the teaching practicum process, the PSTs were accompanied by school teachers to introduce the curriculum and help design learning, which they do well.

The school also helps to provide the media technology needed by PSTs. They provide freedom of use of technology to support learning. To overcome the lack of time for Science, especially Biology, schools provide additional time to study and use of internet for learning for only 2 hours per week so that they can discuss and guide students in the dormitory in working on projects assigned to them during independent study This support has opened opportunities for students to study Science, especially Biology by using the STEM approach.

Recommendations for Islamic Boarding School Education with STEM Integration

Islamic boarding school-based high schools have very dense learning programs. Students can be overwhelmed by study demand. When teachers teach Science, most students become stop focusing and lack enthusiasm. USM trainee teachers attempt to create stimulating content so students focus on the learning process. Teaching is carried out by the student centre, so students are more active. USM trainee teachers only use whiteboards for a short amount of time when teaching, instead using media technology to help students become more involved in learning Science. Although according to the student questionnaire, students like to learn through the whiteboard media, the STEM approach is more likely to attract students' attention. The use of media with technology makes students engage with and understand the learning material, particularly at the evaluation stage (5E strategy), students compete to answer questions correctly. The STEM approach used by PSTs has made a significant impact on student ideals, resulting in some students aspiring to become Scientists and Technocrats.

When the teaching of Science, especially Biology is only allocated 2 hours per week, the teacher feels the time is insufficient, he or she cannot provide a thorough overview of information. Islamic boarding schools need to improve the curriculum, increase teaching time allocated to Science , include teacher training for teachers so that they can provide students with the experience of knowledge, insight, and motivation to learn to love Science, Technology, Engineering and Mathematics. STEM is needed for the next generation, so they can face life in the digital age.

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