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Needs Analysis in Developing Integrated STEM Intervention in Elementary School: Perspective from Pupils and Teachers

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Abstract
This study aims to examine the needs analysis that was carried out as a preliminary stage in developing the intervention for science teaching and learning that has a characteristic of integrated STEM. The focus of this analysis is to identify the current and the future needs from teachers' and pupils' perspectives. The current needs analyses comprise (i) the selection of difficult science topics, (ii) the teaching practice and learning experience of integrated STEM education, (iii) teaching constraints, and (iv) students' attitudes towards science learning. Meanwhile, the future needs were reviewed in terms of teachers' and pupils' desired intervention in science teaching and learning. A total of 50 science teachers and 160 Year Six pupils (12 years old) from elementary schools in Selangor, Malaysia, were used as respondents. The result shows both teachers and pupils had chosen science topics under the physical theme as the most difficult content to teach and learn. The finding also revealed pupils are less motivated to learn due to a teacher-centred teaching approach. The outcomes from this study provided evidence of the teaching and learning issues and offer a solution generally in developing an intervention of integrated STEM education.
Keyword: *Needs Analysis; integrated STEM; teaching and learning science*

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Introduction

In an era where global interconnectedness and diversity are on the rise, it is crucial for educational reform to cater to the diverse requirements of students with varying cultural, linguistic, and socioeconomic profiles. The current economy is increasingly known as a knowledge-based economy, or k-economy, where success hinges on knowledge and innovation. Qualified STEM professionals are needed to remain economically competitive in the global market and to fill contemporary demands, such as ensuring sufficient and sustainable energy, efficient healthcare, and well-considered technology development (Bøe et al., 2011). As observed, high workforce demand to develop the economy is controlled by four main areas, which are science, technology, engineering and mathematics (STEM). Thus, a country with a society that dominates the four areas will be able to develop their own economy and compete with other developed countries (MPEN, 2010). By the year 2020, with global economic challenges in the years to come, Malaysia is dedicated to becoming a developed and high-income nation. Thus, it is essential that educational systems adapt to develop the human capital with a high literacy in various disciplines, especially in STEM fields.

Still, a new generation that will shape society in the future is becoming less interested in STEM, and their expertise in this field is not as expected. This scenario can be clearly observed through the statistical trends of pupil enrolment in Malaysia, specifically those who choose the science stream in secondary schools and those who pursue STEM-related fields in higher education, both of which have shown a declining trend since 2010 (MOE, 2016). The statistics of a pupil's achievement in science in the National Elementary School Achievement Test (UPSR) exams from 2010 to 2013, respectively, indicate a decrease (Malaysian Examination Board, 2011). The decrease in achievement is in line with the international assessments conducted by TIMSS (2011) and PISA (2009), which show that Malaysian pupils are weak in answering higher-order thinking questions.

To overcome the declining trend in science results in school and encourage pupil interest to enrol in STEM fields in the future, changes in education need to be implemented so that effective teaching and learning in science can be introduced. Previously, the teaching and learning of science were conducted separately within the STEM fields; however, STEM education promotes interdisciplinary learning that integrates these subjects. STEM education is approached to integrate teaching and learning between contents and skills with two or more disciplines of Science, Technology, Engineering and Mathematics (STEM) (Becker & Park, 2011a).

The studies related to the intervention of STEM education show that learning by integrative teaching in the STEM fields resulted positively and increased their interest and learning (Becker & Park, 2011b). The strategy of integrative teaching in STEM fields through project-based learning (PBL) (Han, Capraro, & Capraro, 2014; Olivarez, 2012; Hiong & Osman, 2015), authentic instruction (Blue, 2014), inquiry (Hiong & Osman, 2015) and design-based learning, such as designing science games (Nam & Osman, 2016), not only can improve the performance and skills and promote learning butcan close the gap between different ability levels of pupils. Effects of integrative teaching in STEM education not only have an impact on pupils but also on the teachers because education can improve their knowledge, attitudes, beliefs and efficacy in teaching (Shahali et al., 2015).

To create a knowledgeable society in various knowledge disciplines, STEM education, which is the teaching and learning of science and mathematics through the integration of engineering and engineering design for a technology, is needed. According to Johnson et al. (2015), the implementation of STEM education should begin in elementary school. At this level, the psychomotor, cognitive, and affective pupils are growing, and they have also shown a positive interest in the knowledge. Achieving a more profound understanding of effective and equitable teaching methods through integrative teaching in STEM education will enable us to build a robust base for evidence-informed teaching practices, with the goal of improving student performance.

Needs Analysis

Intervention development related to STEM is a newly developed aspect in education in Malaysia. Most of the existing interventions at a elementary school education level in Malaysia did not mention the integration of STEM education. This shortage causes teachers to misunderstand the integration of STEM in teaching and learning, resulting in pupils missing learning experiences that involve real STEM integration. Furthermore, to effectively implement integrated STEM education, teachers must have deep knowledge of the science, technology, engineering, and mathematics content that they teach (Eckman et al., 2016).

In addition to the challenges of finding resources and insufficient teacher knowledge, another major challenge for the implementation of integrated STEM education is the lack of consensus about how integrated STEM learning and teaching should be done (Thibaut et al., 2018). Thus, interventions related to the STEM integration must be developed. But the first step that should be implemented before the intervention of STEM education integration is to do a needs analysis. The aim of needs analysis is to identify the problems or gaps in the teaching and learning of science at elementary school by teachers and pupils and whether the problems and gaps can be rectified by developing an intervention of STEM education integration (Morrison et al., 2007).

The needs analysis identifies several types of needs. The needs analysis in this study is the need of lack, need of felt and need of want (Morrison et al., 2007; Hutchinson & Waters, 1987). Need of lack refers to deficiencies in what a learner knows, need of felt refers to the desire to improve self-performance, and need of want refers to whether they wish for effective teaching and learning of science.

Through this analysis, the needs of target groups, which are pupils learning the unit and science teachers for the teaching unit, were identified for evaluation and access (McKillip, 1987). The goal is to clearly develop the intervention specification for teaching and learning STEM education integration, ensuring it meets the goals and needs of the target group.

Research Questions

The aim of this study was to identify the pupils' and teachers' needs in terms of (i) lack – selection of difficult science topics, pupils' learning experiences and teaching practices; (ii) felt – attitude towards science and constraints in teaching; and (iii) want – necessity in teaching and learning. The result of the needs analysis will be used to determine the learning objective, syllabus content and selection of learning activities in the integrated STEM intervention.

This study is guided by the following research questions:

1. Which science topics are perceived as most challenging to teach and learn at the elementary level?
2. What types of learning experiences do pupils encounter, and what instructional practices are commonly employed by teachers?
3. What is the current level of pupils' attitudes toward science, and what constraints do teachers face in delivering science instruction?
4. What are the expectations and needs of both teachers and pupils regarding the teaching and learning of science?

Methodology

This study employed a quantitative design using a survey research method. The instrument was a two-set questionnaire. The first set of questionnaires for science teachers has four sections, namely: (i) science topics, (ii) teaching practices experienced, (iii) constraints in teaching, and (iv) needs in teaching. The second set of questionnaires was for 6th grade pupils with four sections, namely: (i) fifth grade science topics difficult to learn, (ii) learning experiences, (iii) attitude towards science, and (iv) needs in learning. Face and content validation for each of the instruments was given to two experts, while the reliability of the instruments from the pilot study shows the alpha value is in the range of 0.91-0.98 (high reliability) (Babbie, 2001).

Participants

They are two groups of participants. The first group is science teachers (N=50) with experience teaching science for fifth grade, and the second group is sixth-grade pupils (N=160). Both participants are from different school locations in the state of Selangor, Malaysia.

Instrument and procedures

To determine the guidelines and the characteristics of the STEM intervention in teaching and learning, need analysis was identified in terms of lack, felt and want (Morrison et al., 2007). Instrument needs lack are about (i) difficult science topics and (ii) learning and teaching experience. The list of science topics is based on the fifth-grade content standard in the Malaysian school standard curriculum (Ministry of Education Malaysia, 2014). Meanwhile, the teaching and learning experience is about to identify the frequency of learning experienced by pupils and teaching practices by science teachers. Most constructs in these questionnaires were adopted and modified from 'What is happening in class? (WIHIC)' (Aldridge et al., 2011;

Dorman, 2003; Khine, 2001). Instrument needs are (i) pupils' attitude towards science and (ii) teacher constraints towards teaching science. The questionnaire on attitude towards science was adapted from Murphy and Beggs (2003) and Iksan et al. (2006), while the questionnaire on teacher constraints was referred from Al-Jarrah and Khasawneh (2013), Laidlaw et al. (2009) and Tenaw (2014). Both questionnaires were measured using a five-point agreement of Likert-type responses ranging from "1", representing "Strongly Disagree", to "5", representing "Strongly Agree". Instrument needs focus on the necessity of pupils and science teachers to learn and teach effectively. This questionnaire also uses a five-point agreement scale. Table 1 shows the summary of the type of needs and the instruments used.

Table 1: Types of needs and need analysis instruments

Types of needs	Need analysis instruments
Lack	• Level of difficulties of science topics. • Learning and teaching experience by pupils and science teachers.
Felt	• Pupils' attitude towards science • Teaching constraints
Want	• Necesity in learning by pupils • Necesity in teaching by science teachers

Data analysis

The data gathered from the instrument is quantitative. Hence, the analyses of need analysis data only involve descriptive statistics, namely frequency, mean, variance and standard deviation. Data from the needs analysis will be processed and readied in table form for easy analysis and reporting. Results from the analysis will be used to identify the priority needs from pupils' and teachers' perspectives for developing the STEM intervention.

Results

(i) Difficult science topics to learn and teach

There are eleven topics of science in fifth grade. The level of difficulty for the science topics was determined using the mean values presented in Table 2. The higher the mean value means the topics more difficult. From the analysis, the top five difficult topics to learn selected by pupils were the properties of the substances ($\mu = 2.64$), electricity ($\mu = 2.40$), food chains ($\mu = 2.27$), energy ($\mu = 2.26$) and heat ($\mu = 2.21$). While the top five difficult topics to teach by science teachers were the properties of the substances ($\mu = 3.30$), acid and alkaline ($\mu = 3.04$), heat ($\mu = 3.02$), electric ($\mu = 2.98$) and energy ($\mu = 2.96$). A comparison between both pupils and teachers shows their choices of difficult science topics to learn and teach were quite similar. Based on the pattern selected, it was found that four topics should be focused on in STEM education and are suited to developing the STEM intervention for fifth-grade science, namely the properties of the substances, electricity, energy and heat.

Table 2: Level of difficulties of fifth grade science topics by mean

Science topics	Pupils		Teachers	
	Mean	S.D	Mean	S.D
Survival of animals	1.69	0.73	1.51	0.68
Survival of plants	2.02	0.93	1.55	0.68
Food chains	**2.27**	1.13	1.86	0.84
Energy	**2.26**	0.99	**2.96**	0.73
Light	2.06	0.99	2.69	0.68
Electricity	**2.40**	1.09	**2.98**	0.90
Heat	**2.21**	0.97	**3.02**	0.93
The properties of the substances	**2.64**	1.15	**3.30**	1.06
Acid and alkaline	2.15	1.21	**3.04**	1.10
Earth, moon and sun	1.93	1.01	2.59	1.02
Strength and stability	1.85	0.93	2.88	1.01

S.D – Standard deviation

(ii) Pupils' learning experienced

Figure 1 indicates the percentage of frequency of pupils' learning experience doing activities in science. The majority of the pupils stated they sometimes only carry out all the activities rather than often. Learning activities such as doing experiments (30.9%), working in teamwork (32.83%) and science lessons with the interaction of belief, nature and society (33.45%) indicate the percentage frequency of the learning experience that is almost always conducted. However, the percentages remain low at around 30%. Integration of STEM in learning science shows the most activities that are not implemented in class with the percentage frequency 'never' was 26.65%.

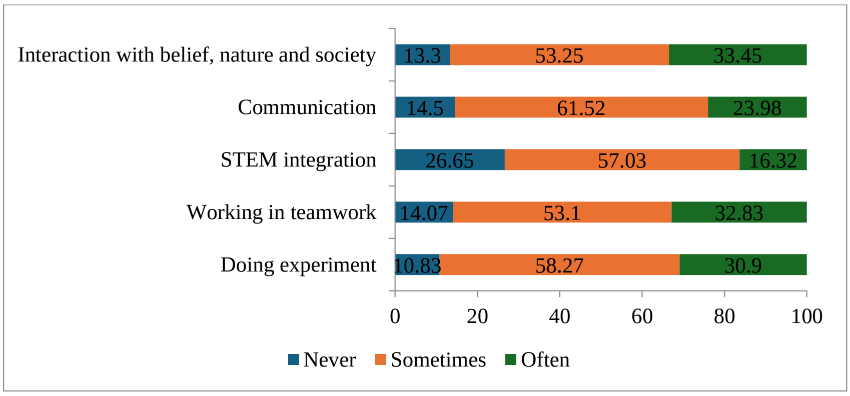

Figure 1: Pupils' learning experienced

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(iii) Teaching practices

Based on the information indicated in Figure 2, most science teachers often practiced a conventional approach to teaching science (39.1%), compared to a learner-centred approach (17.6%). Teaching practices involving the interaction of belief, nature and society were the least common teaching practices, never implemented by science teachers (17%) compared to others. Meanwhile, science teaching associated with the integration of STEM is rarely implemented by teachers (35%). Overall, science teachers only sometimes perform all science teaching practices as described.

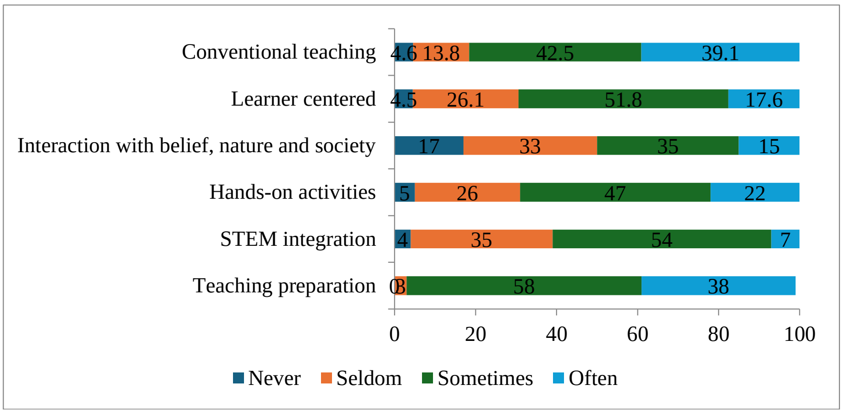

Figure 2: Teachers' teaching practices

(iv) Pupils' attitudes towards science

Mean score interpretations by Nunnally and Bernstein (1994) were used to determine the level of attitude. As shown in Table 3, pupil attitude towards science was measured in terms of enjoyment in learning science, importance of science, perception towards science teachers, perception towards STEM integration, motivation in science and perception towards lessons with the interaction of belief, nature and society. The analysis revealed that most of the pupils show a high and positive attitude towards the enjoyment of learning science (μ = 4.45), the importance of science (μ = 4.19) and perception towards science teachers (μ = 4.25). Meanwhile, three dimensions of attitude were moderately high, namely perception towards STEM integration (μ = 3.58), motivation in science (μ = 3.83), and perception towards lessons with interaction of belief, nature, and society (μ = 3.79).

Table 3: Pupils' attitudes towards science

Constructs	Mean	S.D	Interpretation
Enjoyment of learning science	4.45	0.68	High
Importance of science	4.19	0.58	High
Perception towards science teacher	4.25	0.67	High
Perception towards STEM	3.58	0.67	Moderately high
Motivation in science	3.83	0.79	Moderately high
Interaction of belief, nature and society	3.79	0.77	Moderately high

S.D – Standard deviation

(v) Teaching constraints

Analysis from Table 4 indicates that, overall, science teachers experience moderately low constraints in three specific areas of teaching. They were perceptions towards pupils' interest (μ = 2.37), teachers' professional skills (μ = 2.43) and teaching facilities (μ = 2.74). The finding also revealed that time constraint (μ = 3.87) is considered to be a major problem for science teachers compared to other constraints. Based on this data, the problems faced by the teachers in teaching science should not be reasons for not providing effective teaching strategies in order to meet pupils' needs.

Table 4: Teachers' constraints towards teaching

Constructs	Mean	S.D	Interpretation
Perception towards pupils' interest	2.37	0.51	Moderately low
Profesional skills	2.43	0.51	Moderately low
Facilities	2.74	0.52	Moderately low
Time	3.87	0.93	Moderately high

S.D – Standard deviation

(vi) Necessity in learning

Table 5 shows that pupils demonstrated a strong desire to learn about implementation aspects, including the requirements of hands-on activities (μ = 4.34), teamwork (μ = 4.50), the importance of science (μ = 4.16), STEM integration (μ = 4.24), and science lessons that involve the interaction of belief, nature, and society (μ = 4.34). However, the necessity of learning using ICT is not as great a need as others (μ = 3.76).

Table 5: Necessity in learning

Constructs	Mean	S.D	Interpretation
Hands-on activities	4.34	0.58	High
Teamwork	4.50	0.73	High
ICT	3.76	1.06	Moderately high
Importance of science	4.16	0.71	High
STEM integration	4.24	0.66	High
Interaction of belief, nature and society	4.34	0.68	High

S.D – Standard deviation

(vii) Necessity in teaching
Analysis about necessity in teaching as shown in Table 6 found, the majority of science teachers had a high desire in all aspects of needs for teaching science.

Table 6: Necessity in teaching

Constructs	Mean	S.D	Interpretation
STEM integration	4.33	0.63	High
Teaching materials and infrastructure management	4.29	0.55	High
Teaching skills	4.40	0.59	High
Classroom management skills	4.49	0.51	High
Interaction of belief, nature and society	4.50	0.52	High

S.D – Standard deviation

Discussion

This study aims to ascertain the requirement for integrated STEM education interventions through a needs analysis from the viewpoints of teachers and students. Three dimensions of needs were identified: need of deficiency, need of emotion, and need of desire. Research indicates that both educators and students frequently identify topics such as 'The properties of substances,' 'Heat,' 'Electricity,' and 'Energy' as the most challenging subjects in science to understand and instruct. These topics share a commonality since they fall within the realm of physical sciences. This finding aligns with prior research indicating that scientific concepts, especially within the realm of physics, are frequently perceived as abstract and challenging subjects (Duit, 1984; Tsagliotis, 2005; Yuenyong & Yuenyong, 2007). Based on this fact, the development of integrated STEM education interventions should concentrate on these themes, as such interventions can enhance students' performance in challenging disciplines.

Pupil learning experiences indicate infrequent engagement in hands-on activities, including experiments and collaborative tasks. A shortage in these activities results in infrequent communication among students, between students and teachers, and between students and technology to address issues. Research on teachers' instructional methods revealed that science educators predominantly employ traditional, teacher-centered approaches instead of student-centered ones, necessitating the adoption of innovative teaching practices that incorporate the interplay of STEM beliefs, nature, and society.

The findings indicate that students exhibit a positive attitude towards science, characterised by a high level of satisfaction in learning, recognition of its significance, and favourable perceptions of scientific teachers. Favourable attitudes will motivate students to exhibit constructive behaviours, such as engaging actively in science education, and the influence of these favourable attitudes will enhance students' science performance (Osman et al., 2007). Pupils exhibit somewhat high levels of attitudes towards integrated STEM education, the interplay of belief,

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nature, and society in science lectures, and motivation in science. This is likely due to their lack of exposure to the complexities of STEM integration and the interplay of belief, nature, and society in scientific education.

Discovering the limitations encountered by scientific educators indicated that temporal restrictions have consistently hindered the implementation of best practise science instruction. In Malaysia, formal education at national elementary schools designates two hours weekly for science instruction by teachers. The time allotted is insufficient for scientific educators to execute novel pedagogical approaches such as inquiry-based learning, project-based learning, and design-based learning. This leads people to favour traditional teaching methods due to their minimal time requirements.

The needs and wants of teachers and students in the context of teaching and learning science indicate that all construct of want were elevated, except for students' need for ICT in science education. Pupils may believe there is no correlation between ICT and science learning, hindering their ability to understand the application of ICT in this context.

Conclusion

The needs analysis conducted provides a clear picture of the needs and problems faced by teachers and pupils in the teaching and learning of science in elementary schools in the district of Selangor, Malaysia. Overall, teachers and pupils consider science topics in the themes of physical sciences, namely ‘The properties of the substances’, ‘Heat’, ‘Electricity’ and ‘Energy’, to be the most difficult topics to be learnt and taught. The pupil learning experience and teaching that is practised by the teacher give a clear picture of why science is a difficult subject to understand and master for pupils. Whereas the needs of pupils in terms of attitude are high, except attitude under the perception of STEM showed the lowest mean scores. Teachers demonstrated a high-level requirement toward teaching time constraints provided in formal teaching. In terms of desire in science teaching and learning, teachers and pupils both need the STEM integration in their teaching and learning of science since the integration of STEM education intervention can offer more relevant and meaningful educational activity and learning. Based on all of these requirements, science teaching and learning that integrates four central areas (science, technology, engineering and mathematics) effectively should be implemented in elementary school. This interdisciplinary learning undertaken with regard to the findings of a needs analysis will serve to improve pupil achievement in science learning and develop professional skills for science teachers.

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