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STEM Productive Learning of Lower Secondary School in Southern Zone, Malaysia

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Abstract. Sciences, Technology, Engineering, Mathematics Productive Learning (STEMPL) is an initiative of the Ministry of Education (MoE) to promote creative teaching and learning among STEM teachers, with the ultimate goal of producing students who can think creatively, systematically, and logically in problem-solving. Therefore, this study aims to identify the level of STEMPL practices among STEM teachers in lower secondary schools in the Southern Zone, Malaysia. The differences in STEMPL practices are also examined according to the subjects taught and the relationship of STEMPL practices based on the teaching experiences of the STEM teachers. A survey design was used in this study, applying a quantitative approach. A total of 556 STEM teachers who teach Science, Design and Technology, Computer Science, and Mathematics at the lower secondary level were selected using stratified random sampling techniques. Data were collected using a questionnaire developed by researchers, proven valid and highly reliable for measuring STEMPL practices among STEM teachers. SPSS 23 was used to analyse the data. The findings showed that the overall level of STEMPL practices among STEM teachers were moderate. The analysis also found significant differences in STEMPL practices based on the subjects taught and no significant relationship between STEMPL practices and teaching experience of the STEM teachers. These findings provide input to stakeholders that the STEMPL practices of STEM teachers need improvement in order to realise the education aspirations in Malaysia. Suggestions to improve existing practices are also provided to guide stakeholders in planning, implementing, and evaluating effective strategies.

Keywords: STEM Productive Learning; STEM; Higher-Order Thinking Skills; 21st Century Learning; Lesson Plan

1. Introduction

As the 21st century progresses, the fields of science, technology, engineering, and mathematics (STEM) have become increasingly significant to countries such as

Malaysia (Chua & Choong, 2020). Ong et al. (2017) found that the STEM phenomenon has caused economic, social, and technological activity to occur at a faster rate, resulting in significant changes in the work force. As competition for jobs becomes more fierce, young people need to have a high level of knowledge, skills, and values in STEM in order to meet future challenges. The World Economic Forum (2018) study found that 65% of students who are currently enrolled in primary education will work in new STEM-based fields. However, traditional learning methods are no longer relevant to meeting current needs. Therefore, a shift in the practices of teaching and learning by teachers is needed to guide students towards various competencies, critical thinking, and problem-solving abilities. The Ministry of Education Malaysia (MoE) has taken the initiative to strengthen STEM learning through the Malaysia Education Blueprint (MEB) 2013–2025 (MoE, 2013). STEM refers to any subject under these four disciplines. Faizah dan Ruhizan (2022) argued that STEM learning should be implemented through the integration of two or more subjects using real-world examples.

The empowerment of STEM subject learning aims to increase student achievement in *Trends in International Mathematics and Science Study* (TIMSS) dan *Programme for International Students Assessment* (PISA) and to attract students to the highest level as early as primary school. Norlizawaty et al. (2018) found that a creative approach to teaching and learning can improve students' achievement in STEM subjects. It is also to overcome the fall in the number of students taking STEM subjects, which is causing the loss of 9000 potential students yearly in Malaysia (Chua & Choong, 2020). This finding highlights the need for STEMPL practices among STEM teachers in the classroom to develop students' knowledge, skills, and values.

El-Deghaidy and Mansour (2015) highlighted that teachers are a significant determining factor in the implementation of STEM education in a country, playing an indispensable role as agents of realisation for these aspirations. A study by Hume and Cooper (2019) found that one of the factors limiting the effectiveness of teachers is their content knowledge in the subject they are teaching. Serafin (2016) found that only 15% of students were satisfied with the quality of the teacher's delivery of science instruction, and nearly 60% reported that the science instruction in their school was not interesting enough.

The MoE has conducted various special training programs under the STEM provision in an effort to produce more creative teachers to conduct the STEMPL. Nur Fatahiyah and Siti Nur Diyana (2020) stated that teachers' knowledge increased due to exposure provided by the education department at this time. Teacher involvement in professional development also affects teachers' effectiveness in implementing STEM education (Rukoyah et al., 2020).

However, as Azieyana and Christina (2018) found, there is limited use of STEMPL practices because teachers often rely on traditional approaches. A recent study by Syafril et al. (2021) also found that teachers are faced with three main challenges when teaching STEM subjects: difficulties integrating STEM into lessons, lack of knowledge about STEM teaching methods, and lack of confidence in selecting effective teaching methods for STEM.

Thus, this study aims to identify the STEMPL practised by STEM teachers based on the following questions:

1. What is the level of STEMPL practices among STEM teachers in lower secondary schools in the Southern Zone of Malaysia?
2. Is there a significant mean difference in STEMPL practices among STEM teachers in lower secondary schools in the Southern Zone of Malaysia based on STEM subjects?
3. Is there a significant relationship between STEMPL practices among STEM teachers in lower secondary schools in the Southern Zone of Malaysia and STEM teacher teaching experience?

2. Literature Review

STEM Productive Learning (STEMPL) is a critical challenge for the 21st century, and teachers need to seriously commit to improving the teaching of related STEM subjects. Schueler and Roesken-winter (2018), Gess-newsome et al. (2017), and Isrihan et al. (2019) all found that the selection of structure, content, and learning approach must be aligned to the needs of the students who are learning. Teachers play a crucial role in creating a positive learning environment by designing instruction and sparking students' curiosity. Systematic and careful planning is needed to optimize students' mastery levels according to its standards. According to Lillejord and Dysthe (2008), productive learning practices are those that emphasize measurable results. They add that productive learning practices are accountable to teachers, who use all the knowledge and skills they have acquired to generate creativity, curiosity, and a desire to learn from and with one another. Tanggaard (2011), on the other hand, argues that the concept of productive learning focuses on the relationship between process and the product that needs to be achieved. This approach sees productive learning as a concept that links together ideas related to aims, activities, and outcomes. Therefore, the learning process needs to be understood more broadly, not just as the activities that take place in the classroom between teachers and students, but as a productive process that encompasses objectives, pedagogies, and assessments.

According to Swanson and Collins (2018), most classroom learning processes are unproductive when learning is treated simply as a product that can be acquired and transferred. They argue that learning processes need to focus on actively developing cognitive, psychomotor, and affective skills. Schueler and Roesken-winter (2018) found that productive learning practices can optimize students' levels of knowledge, skills, and values. According to the said study, teachers are the key to creating a constructive learning environment, by designing exploratory processes that spark students' curiosity. Therefore, Isrihan et al. (2019) and Gess-newsome et al. (2017) emphasized that STEM teachers' knowledge and skills are cultivated through the selection of appropriate teaching and learning structures, content, and approaches, based on students' learning needs. Kong and Mohd Effendi (2020) highlighted that this can spur STEM teachers' creativity in encouraging students' cognitive, psychomotor, and affective skills. Loughlin et al.

(2020) added that, by linking objectives, processes, and products in learning activities, based on the constructivist theory, there is potential to redefine existing learning patterns to create a more creative and constructive learning environment that generates new understanding and skills. It can be concluded that STEM productive learning practices by teachers are those where there is a relationship between objectives, processes, and products, in order to optimize cognitive, psychomotor, and affective skills among students.

Setyawan et al. (2018) suggested that teacher activities must be in line with the objectives of learning and assessment processes. Like Lyon et al. (2019), effective teaching requires careful planning and the use of materials and knowledge of students' abilities and experiences to form teaching that ensures mastery of content, skills, and values. Chutrtong et al. (2019) argued that to facilitate student knowledge building, teachers should provide assignments that require active involvement by students. His suggestion of activities is directed towards the construction of new ideas and results, based on existing experiences and knowledge. STEMPL practices can help students to learn more effectively in the targeted cognitive, psychomotor, and affective domains, by integrating real-world examples.

To increase high-order thinking skills (HOTS) among students, Widoretno and Dwiastuti (2019) suggested for students to interact with their teacher on a regular and ongoing basis, including through questioning and explanations, the content of the lessons, and teacher-student relationships. Setyawan et al. (2018) suggested that teachers give specific instructions to students so that their skills are optimized when completing tasks given. Additionally, Garcia et al. (2019) and Kussmaul and College (2017) suggested for teachers to design lessons concisely, which can help students to develop creative thinking and critical thinking skills. The teacher should create experiences that can help students to learn and grow academically. Hero and Lindfors (2019) and Murphy et al. (2018) believed that experiential learning can help students to develop high-level thinking skills by involving students in real-life tasks. However, Brame (2019) argued that active learning should involve students in meaningful activities that link the knowledge learned in class. As suggested by Murphy et al. (2018), the minds of students can be stimulated to develop creative and critical thinking skills through teacher-led questioning appropriate for the subject matter being taught. Rau et al. (2017) believed that using an integrated teaching approach will enable students to develop high-level thinking skills by connecting different teaching materials.

According to Croy (2017), active participation is important for productive learning in tasks oriented towards 21st-century learning. Auerbach et al. (2018) propounded that teachers should use active activities such as discussions, presentations, and critiquing sessions to assess students' level of mastery. Furthermore, according to Song (2019), by integrating technology into constructive student activities, they would be able to explore learning independently. In fact, research carried out by Abdul Hanid et al. (2022) has proven that technology is not only a teaching aid but can also be integrated to solve problems in teaching and learning. The resulting behaviour makes it easier for teachers to measure how students transfer knowledge and skills to solve problems (Reynders et al., 2020). According to Beagon et al. (2018), a project-based learning has been shown to be more effective than traditional learning in terms of knowledge, engagement, and enthusiasm. This activity helps to develop teamwork skills, communication skills, and creative thinking, as well as to encourage self-directed learning.

In this study, STEMPL practices refer to the teaching and learning activities implemented by lower secondary school STEM teachers who teach the subjects of Science, Fundamentals of Computer Science, Design and Technology, and Mathematics based on three dimensions: Teaching Plan (LP), Higher-order Thinking Skills (HOTS), and 21st-Century Learning-oriented Task (CLT). The LP dimension consists of five elements: Induction Set, Learning Objectives, Content Development, aAssessment Methods, and Closure. The HOTS dimension consists of four elements: oral questioning, written questioning, deductive approach, and inductive approach. The CLT dimension refers to constructing knowledge constructively, critical thinking, problem-solving, and technology integration. The operational definition of the elements is as set out in Table 1.

Table 1: Operational Definitions

Element	**Description**
Induction Set	Share STEM development information to spark environmental issues and integrate real-world activities for active student engagement.
Learning Objectives	Set learning objectives to plan content constructively through activities that involve students of various abilities as learning owners.
Content Development	Implement active learning using student-centred strategies by fostering group collaboration to complete tasks that require creativity and healthy competition.
Assessment Methods	Provide appropriate instruments to perform self and peer assessment.
Closure	Formulate learning and provide specific feedback on student learning achievement with support, appreciation, and reinforcement.
Oral Questioning	Build strategic thinking skills by evaluating information, making assumptions, and providing arguments with evidence to justify decisions.
Written Questioning	Allow students the opportunity to demonstrate their understanding in a systematic way.
Inductive Method	Conduct practical discussions in which students relate phenomena to concepts learned for everyday life.
Deductive Method	Conduct discussions in which students give examples to explain the concepts.
Knowledge Transfer	Use the infographic to interpret information in order to link old knowledge to new knowledge.
Critical Thinking	Give students the opportunity to engage in discussion and provide critical feedback, which helps to build and justify their learning.
Problem Solving	Give students opportunities to make suggestions in solving real-world problems.
Technology Integration	Digital learning provides students with opportunities to explore information sources.

3. Methodology

This study applies a quantitative approach using a cross-sectional questionnaire survey design. Teachers who teach lower secondary STEM subjects in the Southern Zone, Malaysia (Negeri Sembilan, Malacca, Johore) were selected as the study population. Statistics on basic teacher information up to 30 June 2022 obtained from the School Management Sector, Southern Zone Education Department show that the number of STEM teachers in the three states is 6786 (Negeri Sembilan = 1155, Malacca = 951, Johore = 4680). Krejcie and Morgan (1970) and Research Advisors (2006) suggested that at least 360 samples are needed to represent the population. Creswell (2014) indicated that the number of samples should be increased by 10%. Thus, it was decided that for this study, a minimum of 400 samples were required. A simple random sampling technique for high-coverage populations is used as a list-based method (Couper, 2000).

The questionnaire (PLSTEMQ) used was self-developed by the researcher. The development of the PLSTEMQ adapted from Du Plessis and Martins (2019) and Miller and Lovler (2018) instrument development process involved three phases: conceptualization, development, and validation. These phases are guided by a conceptual framework that is produced systematically. PLSTEMQ consists of sections A (demography) and B (STEMPL practices). Demographic factors use a nominal scale (subjects) and an ordinal scale (teaching experience), while STEMPL practices use a Likert-type scale of agreement (1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Agree, 4 = Agree, 5 = Strongly Agree). PLSTEMQ has been proven to be valid and has high reliability based on measurement principles such as content validity, construct validity, and reliability to measure STEMPL practices among lower secondary STEM teachers in the Southern Zone, Malaysia. Fleiss Kappa's analysis indicated that PLSTEMQ fulfilled the content validity and the high index value (0.93) obtained (Fleiss et al., 1982). Construct validity was determined by performing Comfirmatory Factor Analysis (CFA), in which 13 elements and 62 items were found to meet the model fit. The Alpha Cronbach test was performed on the 62 items and the reliability value was found to be 0.97 and was at a high level (DeVellis, 2016).

Data collection was carried out using the Google Form application as recommended by the Education Policy Planning and Research Division (EPRD), as a viable alternative following the enforcement of the Movement Control Order (MCO) due to the Covid-19 outbreak. A total of 556 samples (Negeri Sembilan = 91, Malacca = 80, Johor = 385) were collected, with 145 (26%) being males and 411 (74%) being females. The principle of representative and homogenous sampling from each region was achieved. The data obtained were analysed using Statistical Package for Social Science (SPSS) Version 23. Normality analysis was conducted first to determine the appropriate statistical test, although Coolican (2019) stated that categorical data (nominal, ordinal) should be analysed using non-parametric. The Kolmogorov-Smirnov test found that STEMPL practices were normally dispersed based on subject and teaching experience. Thus, this study used parametric testing analysis involving a one-way Enova test and Pearson Product Moment correlation. The analysis of normality test findings is as set out in Table 2.

Table 2: One-Sample Kolmogorov-Smirnov Test

		Subject	Teaching Experience
N		556	556
Normal Parameter[a,b]	Mean	2.60	3.29
	Std. Deviation	1.26	1.26
Most Extreme Differences	Absolute	0.22	0.17
	Positive	0.22	0.17
	Negative	-0.21	-0.15
Test Statistic		0.22	0.17
Asim. Sig. (2-tailed)		0.00[c]	0.00[c]

a. Test distribution is normal.
b. Calculated from data
c. Lilliefors Significance Correction

4. Results

Demography

The demographic factors studied included subjects taught (4 groups) and teaching experience (5 groups). Data analysis showed that the subject group was represented by 181 (32.6%) Science teachers, 54 (9.7%) Fundamentals of Computer Science teachers, 128 (23.0%) Design and Technology teachers, and 194 (34.7%) Mathematics teachers. A total of 53 (9.5%) STEM teachers represented the teaching experience group with 0-5 years of experience, 94 (16.9%) teachers from the 6-10 years of experience group, 176 (31.7%) teachers with 11-15 years of experience, 106 (19.1) %) teachers who have 16-20 years of experience and 127 (22.8%) teachers who have more than 20 years of experience. Data analysis is as set out in Table 3.

Table 3: Respondent demographics

Demography		Frequency	Percentage
Subject Taught	Science	181	32.6
	Fundamentals of Computer Science	54	9.70
	Design and Technology	128	23.0
	Mathematics	193	34.7
Teaching Experience	0 – 5 years	53	9.50
	6 – 10 years	94	16.9
	11 – 15 years	176	31.7
	16 – 20 years	106	19.1
	More than 20 years	127	22.8

The Level of STEM Productive Learning Practices

The level of STEMPL practices among lower secondary STEM teachers in the Southern Zone, Malaysia, is categorized based on the mean values obtained and classified using the Normal Distributions suggested by Coolican (2019) and Kline (2005). The interpretation was adapted using Dreyfus Model (2004) and categorized into six levels: Very Low (2.33-2.74), Low (2.75-3.18), Moderate Low (3.17-3.58), Moderate High (3.59-4.01), High (4.02-4.43), and Very High (4.44-4.85) as set out in Table 4.

Table 4: Interpretation of the STEMPL practices

Mean	Interpretation
2.33-2.74	Very Low
2.75-3.18	Low
3.17-3.58	Moderate Low
3.59-4.01	Moderate High
4.02-4.43	High
4.44-4.85	Very High

The level of STEMPL practices among STEM teachers was analysed based on the dimensions and elements studied. The findings show that dimensions Lesson Plan (Mean=3.54, SD=0.43) and 21st-Century Learning-oriented Tasks (Mean=3.50, SD=0.46) are at a moderate low level and Higher-order Thinking Skills (Mean=3.69, SD=0.41) are at moderate high. Nevertheless, five of the 13 elements were at moderate low levels: Learning Objective (Mean=3.46, SD=0.52) Assessment Methods (Mean=3.36, SD=0.50), Closure (Mean=3.44, SD=0.51), Problem Solving (Mean=3.29, SD=0.54), and Technology Integration (Mean=3.43, SD=0.59). Overall, STEMPL practices were at a moderate high (Mean=3.59, SD=0.42). Analysis of the findings is as shown in Table 5.

Table 5: The level of the STEMPL practices among STEM teachers

Dimension/Element	Mean	SD	Interpretation
Lesson Plan	**3.54**	**0.43**	**Moderate Low**
Induction Set	3.77	0.47	Moderate High
Learning Objectives	3.46	0.52	Moderate Low
Content Development	3.65	0.49	Moderate High
Assessment Methods	3.36	0.50	Moderate Low
Closure	3.44	0.51	Moderate High
Higher-order Thinking Skills	**3.69**	**0.41**	**Moderate High**
Oral Questioning	3.63	0.47	Moderate High
Written Questioning	3.61	0.47	Moderate High
Inductive Method	3.72	0.46	Moderate High
Deductive Method	3.82	0.45	Moderate High
21st Century Learning-Oriented Tasks	**3.50**	**0.46**	**Moderate Low**
Knowledge Transfer	3.64	0.48	Moderate High
Critical Thinking	3.64	0.48	Moderate High
Problem Solving	3.29	0.54	Moderate Low
Technology Integration	3.43	0.59	Moderate Low
Productive Learning of STEM	**3.59**	**0.42**	**Moderate High**

The Differences of STEMPL Practices based on Subjects Taught

The One-way Enova analysis was used to identify differences between STEMPL practices and subjects taught. The findings showed that there was a significant difference in STEMPL practices among STEM teachers in the Southern State Zone, Malaysia based on the subject taught. This was indicated by the value of $F = 9.96$ and $p = 0.00$ (<0.05) as shown in Table 6 below.

Table 6: One-way Enova test of difference in STEMPL practices based on subject taught

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.94	3	1.65	9.96	0.00
Within Groups	91.28	552	0.17		
Total	96.22	555			

Differences in STEMPL practices based on the subject taught are detailed out by referring to Post Hoc LSD analysis as in Table 7. The findings show that there are significant differences where STEMPL practices of Design and Technology teachers are higher than the Fundamentals of Computer Science (Mean difference = 0.20, p = 0.01) and Mathematics (Mean difference = 0.24, p = 0.00). Mathematics teachers' STEMPL practices were lower than that of Science teachers (Mean difference = -0.14, p = 0.00). The analysis of the findings is as set out in Table 7.

Table 7: Post Hoc LSD differences in STEMPL practices based on subject taught

I (Subject Taught)	J (Subject Taught)	Mean Difference (I-J)	Std. Error	Sig.
Science	Fundamentals of Computer Science	0.11	0.06	0.31
	Design and Technology	-0.09	0.05	0.19
	Mathematics	0.14*	0.04	0.00
Fundamentals of Computer Science	Science	-0.11	0.06	0.31
	Design and Technology	-0.20*	0.07	0.01
	Mathematics	0.04	0.06	0.94
Design and Technology	Science	0.09	0.05	0.19
	Fundamentals of Computer Science	0.20*	0.07	0.01
	Mathematics	0.24*	0.05	0.00
Mathematics	Science	-0.14*	0.04	0.00
	Fundamentals of Computer Science	-0.04	0.06	0.94
	Design and Technology	-0.24*	0.05	0.00

Effect size is also considered to obtain better results where the value is determined based on the following calculations of eta squared:

$$\text{Eta squared} = \frac{\text{Sum of squares between groups}}{\text{The total sum of squares}} = \frac{4.94}{96.22} = 0.05$$

The Eta squared value for this test was 0.05, indicating that the effect size was small (Cohen, 1988). In conclusion, there was a significant difference ($p < 0.05$) in STEMPL practices of STEM teachers based on subject taught, $F(3, 552) = 9.96$, $p = 0.00$. Effect Size was obtained by using eta squared = 0.05. Post-hoc differences using the Tukey HSD test showed that the mean scores for STEMPL practices of Design and Technology teachers (Mean = 3.71, SD = 0.40) differed significantly from those of Fundamental of Computer Science (Mean=3.51, SD=0.48) and Mathematics (Mean=3.47, SD=0.42). In contrast, the STEMPL practices of Science teachers (Mean=3.62, SD=0.38) differed only significantly from those of Mathematics teachers.

The Relationship between STEMPL Practices and Teaching Experience

The Pearson Product-moment correlation test analysed the relationship between STEMPL practices and the teaching experience STEM teachers. Preliminary analyses were performed to ensure no violation of normality, linearity, and homoscedasticity assumptions. The analysis shown in Table 8 found a p-value = 0.14 (> 0.05). The findings also showed no difference between the STEMPL practices of STEM teachers with teaching experience.

Table 8: Correlation of STEMPL practices with teaching experience

		STEMPL practices	Teaching experience
STEMPL practices	Pearson Correlation	1	-0.06
	Sig. (2-tailed)		0.14
	N		556
Teaching experience	Pearson Correlation	-0.06	1
	Sig. (2-tailed)	0.14	
	N	556	

5. Discussion

This study has obtained three essential findings. First, the level of STEMPL practices among STEM teachers is found to be moderate high. These findings indicate that the knowledge of STEM teachers in practicing STEMPL practices is at moderate level (Nur Fatahiyah & Siti Nur Diyana, 2020; Shamsuddin, 2021). Aini Aziziah et al. (2017) found that most STEM teachers lack the skills to integrate content into their lessons. This makes teachers more comfortable using existing approaches as it saves time and effort. The level of STEMPL practices of STEM teachers in planning, from the aspect of learning objective, assessment methods, and closure, are still at a moderate low level. These support the findings of Abdul Halim et al. (2017) that teachers are at moderate level of proficiency in planning various assessment methods. Similarly, the application of problem-solving skills and technology integration was found to be at a moderate low level. These findings are supported by two studies, namely Lai and Ruhizan (2022) and Wilson and Narasuman (2020), which found that teachers' knowledge and design thinking skills were low and that there was lack of technology usage. Therefore, Hanid et al. (2022) argued that the use of currently available technology can help teachers' problem-solving skills in teaching and learning.

Secondly, this study found that STEMPL practices among Design and Technology teachers were better than those of Mathematics and Fundamentals of Computer Science teachers. Similarly, Science teachers were discovered to have better STEMPL practices compared to Mathematics teachers. These findings suggest that courses which emphasize learning by doing are better than rote learning in promoting STEMPL.

Thirdly, this study also found that there was no significant relationship between STEMPL practices and teaching experience. This finding is not in line with the study by Madani and Forawi (2019), which found that experienced teachers are more likely to be able to implement STEMPL practices in STEM subjects. Although the study findings showed that STEMPL practices were moderate overall, there were still aspects not well mastered by teachers that need to be addressed.

The first recommendation requires the commitment of the MoE to promote effective curriculum in order to achieve a successful STEM education in schools. One effective curriculum approach is integrating STEM. Integrated STEM is the combination of the four disciplines of science, technology, engineering, and mathematics in the curriculum (Radloff & Guzey, 2017). On the other hand, Song (2019) suggested that more subjects other than STEM filled can be integrated as well, such as language subjects. In addition, the integration of STEM learning can also be related to a project-based curriculum. According to Shernoff et al. (2017), in order to promote integrated STEM education, a STEM curriculum and supporting program, or some other form of detailed interventions, would be necessary.

A study by Beagon et al. (2018) found that a project-based STEM integration programs are more effective in modifying students' interest levels as a result of the positive group outcomes for STEM career interests. They added that the students involved in the project reported improvement in a variety of skills related to their future profession, with a special focus on teamwork, communication, comprehension of the design process, and self-motivated learning. In addition, the students noted increased confidence and new friendships formed during the course of the project, both of which are valuable assets during the transition from secondary to post-secondary education. Supported by Lesseig et al. (2017), a project-based STEM integration curriculum aims to help students in problem-solving skills that are related to authentic and applicable STEM content. Indeed, the STEM concept is related to the expected outcomes such as increased education, workforce skills, and national productivity (Siekmann & Korbel, 2016). Through the integration of STEM in teaching and learning, there will be a profound impact related to the interest of the subject matter in learning.

The second suggestion is to implement a mentor program for teachers. According to Nolan and Molla (2017), this is done to improve the quality and professionalism of teachers. He also states that the purpose of the mentor program is to: (a) involve participants in investigating their own pedagogical experiences; (b) provide theoretical knowledge, content, and information about alternative practices; (c) incorporate participants' aspirations, skills, knowledge, and understanding into the learning context; (d) help participants gain awareness of their own thoughts, actions, and influence; (e) support early childhood education including children and families; and (f) stimulate critical reflection. Experienced STEM teachers can play the role of mentors to less experienced teachers. Nur Amelia and Lilia (2019) highlighted that experienced teachers can improve the effectiveness of STEM learning for less experienced teachers by serving as mentors.

Experienced teachers are a group of More Knowledgeable Others (MKO) who can provide guidance and support to less experienced teachers. Gore et al. (2017) found that teachers who received guidance in certain techniques were more likely to use those techniques more often or more consistently. However, its effectiveness needs to be supported by the use of instruments to improve teaching quality. Therefore, the PLSTEMQ instrument, together with the Malaysian Education Quality Standards 2 (SKPMg2) instrument, can be used to improve the quality of guidance for experienced teachers. Key Performance Indicators (KPIs) can be used to track progress over time to ensure that quality improvements are carried out smoothly.

6. Conclusion

In conclusion, the study on STEMPL practices among STEM teachers in lower secondary schools in the Southern Zone of Malaysia identified that there was a need for improvement in the implementation of STEMPL practices in the region. The analysis found significant differences in STEMPL practices based on the subject taught by the STEM teacher, and no significant relationship between STEMPL practices and the teaching experience of the STEM teacher.

These findings highlight the importance of providing professional development opportunities for STEM teachers, promoting collaboration among STEM teachers from various subject areas, providing adequate resources and facilities for STEM teaching and learning, and emphasizing the use of real-world problems and project-based learning approaches in STEM education.

It provides a starting point for better understanding of teachers' needs in integrated STEM. STEMPL practices can be improved in order to produce students who would be capable of dealing with the challenges of the 21st century and realizing the education aspirations in Malaysia. Effective strategies need to be planned, implemented, and evaluated by education stakeholders to improve the quality of STEM education in Malaysia. Therefore, teachers are advised to implement STEMPL practices that are in line with the current needs and developments in education. Malaysia's goal of becoming a developed nation can be achieved with every dollar spent yielding results in the form of students' success.

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Appendix 1. Sample Survey Questionnaire

Dear Respondent:

Greeting!

The purpose of this study was to explore STEM productive learning among secondary school STEM teachers in the southern zone states of Malaysia.

The data collected in this study is CONFIDENTIAL and will only be used for the purposes of this research. Your participation is essential to the success of this study.

Thank you for your input.

Respectfully yours
MOHD ALFOUZII BIN NASIR
Researcher
Email: alfouziinasir@gmail.com

General Instruction : Kindly provide the requested information in every item. Please select one of the given opinions as your answer. For items with a rating option, please provide your honest assessment by selecting a rating. (Strongly Disagree, Disagree, Somewhat Agree, Agree, Or Strongly Agree)

1. DEMOGRAPHIC INFORMATION

1.1 Sex
____Men ____Female

1.2 Academic Qualifications
__First Degree__Master's Degree ___Doctor of Philosophy

1.3 Teaching Experience
__0 – 5 years __6 – 10 years __11 – 15 years __16 – 20 years
__over 25 years

1.4 Subjects’ taught
__Science (S) __Basics of Computer Science (T)
__Technological Design (E) __Mathematics (M)

2. STEM PRODUCTIVE LEARNING

2.1 INDUCTION SET		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.1.1	I encourage students to share information/views on subject content related to STEM issues					
2.1.2	During the lesson, I associate the concepts learned with STEM issues					
2.1.3	I link the STEM concepts learned with the activities of students' daily lives					
2.1.4	I involve students in the preparation of materials so that they are actively involved in STEM learning					
2.2 LEARNING OBJECTIVES		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.2.1	I use advanced organizer to connect new knowledge with old knowledge					
2.2.2	I carry out activities / practice STEM subjects in laboratories/special rooms/workshops to provide a conducive learning climate to achieve learning outcomes					
2.2.3	I plan STEM learning activities based on students' ability levels					
2.2.4	I guide students to formulate what is learned about STEM concepts through the generation of mind maps					
2.3 CONTENT DEVELOPMENT		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.3.1	I encourage students to use various methods/mediums in presentations to develop creativity and critical thinking					
2.3.2	I assign the role of each group member in each STEM assignment to foster leadership/collaborative qualities					
2.3.3	I use source materials as teaching aids in STEM subjects to create an authentic learning impact					
2.3.4	I plan STEM subject assignments across the curriculum for in-depth knowledge applications					
2.3.5	My assignment specifications require students to compete between groups to increase their motivation in learning					
2.3.6	I share the knowledge of entrepreneurship with the students so that they think about how to market the results from the projects carried out					
2.4 ASSESSMENT METHOD		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.4.1	Each group is required to produce questions along with answers for the weekly / monthly STEM quiz					
2.4.2	I prepare a rubric for each STEM assignment to generate a valid score planned.					

2.4.3	I take into account peer assessment as part of a group STEM assignment score					
2.4.4	I carry out *Gallery Walk* activities for the purpose of engaging students in assessment activities					
2.4.5	I conducted a *gamification* quiz for specific STEM titles to assess students' level of mastery					
2.5 CLOSURE		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.5.1	I formulated STEM learning content using mind maps					
2.5.2	I encourage students to formulate STEM learning outcomes individually/in groups					
2.5.3	I provide specific feedback on face-to-face work/assignments to help students master STEM concepts					
2.5.4	I will share the performance of the student quiz/assignment score for each STEM title by providing a histogram graph					
2.6 ORAL QUESTIONING		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.6.1	I encourage students to analyze STEM concepts using thinking tools to answer the questions posed					
2.6.2	I stimulate students to defend the answers given using STEM concepts					
2.6.3	I encourage students to give specific examples in each of their answers to improve critical and critical thinking					
2.6.4	I stimulate students to provide answers/responses to STEM concept questions by presenting facts/evidence					
2.6.5	I encourage students to justify each experiment/activity result rationally/based on different results to what they should be.					
2.6.6	I express questions based on examples of phenomena that occur to stimulate students' critical thinking					
2.7 WRITTEN QUESTIONING		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.7.1	I suggest students write a plan of the STEM assignment to be implemented					
2.7.2	I use written questions to students to determine which STEM concepts are mastered in learning sessions					
2.7.3	I held an *online* forum session on a STEM concept to explore students' understanding					
2.7.4	I stimulate students' minds by providing structured questions to facilitate understanding of STEM concepts					
2.7.5	I use the match-match question technique to stimulate the mind to make process/step recognition in understanding STEM content					

2.8 INDUCTIVE METHOD		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.8.1	I explain a STEM concept by giving authentic examples that occur in real life					
2.8.2	I conducted an intergroup discussion on the concepts of STEM learned					
2.8.3	I act as a facilitator by helping students build an understanding of the STEM concepts learned					
2.8.4	I give STEM assignments that allow students to carry out their respective roles					
2.8.5	I provide enough STEM assignment materials so that they build science process skills					
2.8.6	Students are required to link the STEM concepts learned by giving illustrations in the concept/mind map					
2.9 DEDUCTIVE METHOD		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.9.1	I started the lesson by explaining the definition of the STEM concept followed by examples that fit the title.					
2.9.2	I illustrated the STEM title using a concept map starting from the definition followed by examples.					
2.9.3	By giving examples in real life, I encourage students to increase their examples of STEM concepts.					
2.9.4	I use source material on STEM concepts that are difficult for students to understand					
2.10 KNOWLEDGE TRANSFER		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.10.1	I share data/ information on titles/topics to help students complete given STEM assignments					
2.10.2	I built students' skills to formulate STEM knowledge information in graphic form					
2.10.3	I guide students to label/ plot the resulting STEM assignment data					
2.10.4	I plan learning activities that can link existing STEM knowledge with new STEM knowledge					
2.11 CRITICAL THINKING		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.11.1	I use a variety of strategies that enable students to master STEM concepts critically and critically					
2.11.2	I plan critical/logical/scientific thinking-oriented activities to align with the STEM learning concept					
2.11.3	I stimulate discussion among students about STEM concepts in their real lives					
2.11.4	I develop HOT's students through meaningful with authentic STEM activities/assignments					

2.11.5	The STEM assignment I designed aims to orient students to develop problem-solving/decision-making skills					
2.11.6	The STEM assignment I planned required students to generate new ideas based on data and interpretations of the findings obtained					
2.12 PROBLEM SOLVING		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.12.1	I provide a platform to showcase students' STEM work to the school community					
2.12.2	I plan STEM activities aimed at creating awareness of students on an issue in their daily lives					
2.12.3	I ask students to provide notes/ diaries/ logbooks to write down ideas as a result of the discussion from the STEM assignments implemented					
2.12.4	I ask students to present problem-solving suggestions through symbolic retaliation					
2.13 TECHNOLOGY INTEGRATION		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
2.13.1	I use the simulation/video method to show natural phenomena/virtual labs/animations used to quiz STEM concepts with students					
2.13.2	I give assignments for specific STEM topics through MS TEAMS/Google Classroom for students to complete					
2.13.3	I conducted an online critique session using the zoom/google meet/ MS Team app about a STEM assignment to build students' critical thinking					
2.13.4	I provide current STEM issues in file/ video/ animation/ diagram via *telegram/ whatapss/ Instagram* medium before learning session so that student engagement can be optimized					