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Norms and Profiles of Stem Teachers' Productive Learning Practices

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Abstract

The Science, Technology, Engineering and Mathematics Productive Learning (STEMPL) Practice is a process of teaching and learning based on results to develop mastery of cognitive, psychomotor and affective domains among students by integrating content using real-world examples. There is research on teacher practices in STEM subjects, but the constructs of productive learning are not conceptualised in detail. As such, no norms and profiles of the teacher's STEMPL practice level could be compared. Therefore, this study aimed to identify the differences in their STEMPL practices in terms of teaching experience, relationship with gender, academic qualification, and the subject taught. The mean difference in teachers' STEMPL practices based on teaching experience was also studied. The development of instrument involved three phases; i) conceptualisation, ii) construction and iii) validity. proven to have psychometric characteristics i.e. content validity, construct validity and high reliability. Using the multi-level random sampling technique (cluster and strata), 556 samples of lower secondary school teachers in the Southern Zone were selected. The data collection is analysed using SPSS software version 23. Norms and profiles based on teaching experience found that the level of teachers' STEMPL practice with more than 15 years of teaching experience was at a low level. There was no significant mean difference in teachers' STEMPL practices based on teaching experience. This study suggests norm-based targeted interventions for experienced teachers to improve productive learning competencies in STEM in Malaysia.

Keywords: Productive Learning, Stem, Teaching Design, Hot's, 21st Century Learning

Introduction

Kong and Mohd Effendi (2020), stated that the empowerment of STEM subject learning aims to improve students' achievement in Trends in International Mathematics and Science Study (TIMSS) and Programme for International Students Assessment (PISA) as well as attracting students to the highest level at the earliest level at primary school level. Norlizawaty et al. (2018) found that a creative approach in teaching and learning can improve pupil achievement in STEM subjects. It is also hoped that this will outstrip the dwindling number of students taking STEM subjects which causes Malaysia to lose 9000 potential pupils each year (Chua & Choong, 2020). These findings underscore the need for teachers' STEMPL practices in the classroom to be developed effectively so that knowledge mastery, skills improvement and the nurturing of pupil values are generated to the maximum.

El-Deghaidy and Mansour (2015), stated that teachers are an important factor in the implementation of STEM education to achieve the nation's aspirations. A study by Hume and Cooper (2019), found that one of the factors limiting the effectiveness of teachers is the knowledge of the content of teachers only in the subjects they master. The situation makes it impossible for them to optimally integrating different disciplines of knowledge. Serafin (2016), found that only 15% of pupils were satisfied with the quality of teacher delivery in science teaching, and almost 60% reported that teaching science in their school was less attractive.

In the context of STEM learning, Ministry of Education Malaysia (MoE) has taken the first step by emphasing the STEM education element within the framework of the National Education Policy (MoE, 2017) . The emphasis is thus enabling the curriculum and content to be adjusted according to international educational standards by inspiring the National Education Philosophy (MoE, 2013). This preparation is a long-term step designed as a strategic step to meet more challenging circumstances. The World Economic Forum (2018) report has estimated that 65% of pupils currently enrolled in primary education will have to work in a new field based on STEM. Therefore, the shift in learning practices and teacher facilitation is needed to guide students towards a wide range of competencies, critical thinking and improvement of problem-solving capabilities.

According to Faizah and Ruhizan (2022), STEM subjects include Science, Foundumental of Computer Science, Design and Technology, and Mathematics taught at the lower secondary school level. Various professional trainings have been introduced to STEM teachers to enhance their efficiency in effectively implementing the teaching and learning process. However, students' interest and achievement in STEM subjects is still low, so it still does not reach the National Science and Technology Policy of 60 Science and 40 art (60:40) (Chua & Choong, 2020). Azieyana and Christina's (2018), study found that teachers' STEMPL practices are still limited, and even difficult to compare when there is no teacher's STEMPL practice based on the experience factors that can be compared. According to Aminah and K Han (2020), and Hassan and Mahamod (2019), stated that the teaching experience factor is important as it can be an example of good practice to foster interest in STEM among various groups with different levels of teaching experience. Therefore, Odell et al (2019), is of the view that studies can identify the tendency of interest and exposure of knowledge and skills to STEM fields to develop in tandem with the duration of teaching services, ultimately influencing decisions on STEM-related educational or career development for implementation in teaching and learning sessions.

Constructively structured productive learning practices are essential to produce capable and highly skilled pupils. Aminah and Crispina Gregory (2020a), assert that, active interaction in the classroom triggered benefits both teachers and pupils. According to them, pupils acquire benefits with the construction of a higher meaning and understanding. This perspective is shared by Goble et al. (2019) who argues interactions like active questioning, allow teachers to collect a variety of different feedbacks. According to them, teachers also benefit by obtaining the necessary reflections by exploring the traits and abilities of pupils.

In the STEMPL practice context, teachers need to act as More Knowledgeable Others (MKO) who possess high knowledge and skills in STEM as recommended by Azlina et al. (2018). MKO needs to be benefited through guidance so that students are helped to develop a better understanding of STEM concepts and develop deeper STEM concept understanding capabilities. According to Dewsbury (2020), in this process teachers as MKO will guide students to the Zone Proximal Development (ZPD) to master STEM knowledge and skills that were previously difficult to find. Macdonald et al (2019), also added that learning that contextual activities using the example of existing resource materials can foster critical thinking and create new knowledge in pupils through stimulated kinestatic senses. Therefore, STEMPL practices of teachers with high levels of STEMPL practice need to provide support and assistance to teachers with low levels of practice. As a result, more students can be developed and nurtured into ZPD.

Various studies in Malaysia such as Aminah and Crispina Gregory, (2020a), Faizah and Ruhizan (2022), Muhammad Jubri et al (2020), and Noor Lela et al (2019), show that despite the MOE's efforts to promote productive learning practices, the implementation is still limited. Azieyana and Christina (2018) found that the majority of teachers still rely on traditional and passive teaching and learning. This has raised concerns over the development of pupils' potential such as critical thinking and problem solving. Rau et al. (2017) argues that if critical thinking and problem-solving skills are ignored, the ability of pupils to make evidence-based and logical decisions, systematically assess and solve problems and build sound arguments based on facts and information will be affected. Less productive and widely practiced teacher teaching and learning have created significant obstacles in the transition towards meaningful learning practices.

Hence, the research questions for this study as below,

1. What is the level of STEMPL practice norm profile of lower secondary school teachers based on their teaching experience?
2. Is there a mean difference in teachers' STEMPL practices based on their teaching experience?

Literature Review

Shamsuddin (2021), found that the initiative to strengthening STEM education was introduced through the Malaysian Eeducation Blueprint (MEB) 2013-2025 enables various professionalism trainings to be given to educational staff, especially STEM teachers. The study of Jamunarani and Siti Raihamah (2021), and Nursyahirah and Denis (2020), shows that there is a significant positive relationship between the readiness of teachers and their knowledge and attitude towards STEM education. Julian and Mohd Izham (2020), added that professionalism training can improve the quality of teachers to enhance the development of students who are the main focus areas in the MEB 2013-2025 framework. Teacher quality refers to the effectiveness of creative teaching and learning practices, while pupils' is an outcome that can be assessed holistically through classroom assessment (MOE, 2020). Ilminza et al. (2021) found that the creativity of teachers in conducting teaching and learning has a significant impact on the increase in pupils' mastery as a targeted end product. He added that the creativity of teachers when delivering content should be a set of continuous teaching and learning practices so that the level of mastery of students can be improved if implemented productively. Therefore, productive learning practices are teaching and learning that need to be nurtured to achieve STEM education goals as envisaged by MOE.

Teachers' STEM Productive Learning Practices (STEMPL) are a critical challenge for the 21st Century and teachers need to make a significant commitment to improving STEM subject teaching. Tanggaard (2011), and Lillejord and Dysthe (2008), have asserted that teacher STEMPL practice is a teaching and learning approach that is result-oriented and measurable by emphasising on active, collaborative and pupil-centered learning. They added that teachers are responsible for using all the knowledge and skills gained to generate creativity so that they produce meaningful, relevant and applicable learning in the daily lives of students. Swanson and Collins (2018), affirm that productive learning practices are concepts that connect ideas related to goals, activities, and outcomes. Hence, the views of some of the researchers mentioned clearly show that productivity in learning is a complex concept encompassing various aspects of knowledge mastery, skills empowerment and holistic value nurturing and it is in line with the MOE's aspiration.

Some researchers such as Isrihan et al (2019), and Gess-newsome et al (2017), suggest that the teaching and learning process should be constantly improved. This can be done among others, through the selection of structures, content, learning approaches and assessments tailored to the learning needs of the pupils. Therefore, it is important for teachers to link between goals, processes and products in teaching and learning to optimize cognitive, psychomotor and affective mastery among students. Chua and Choong (2020), and Ong et al.= (2017), agreed that systematic teacher guidance can encourage students' minds to gain a deep understanding by engaging assessment, criticism and submission activities. Therefore, students' thinking skills can be nurtured and trained to a higher level critically analytical funds when actively stimulated.

According to Croy (2017), active engagement is essential for productive learning in tasks oriented to 21st century learning. Auerbach et al (2018), believes that teachers should use active activities such as discussions, presentations and criticism sessions to assess the level of mastery of pupils. In addition, according to Song (2019), by integrating technology into students' constructive learning activities, they can explore self-learning. The resulting behavior makes it easier for teachers to measure how pupils transfer knowledge and skills in problem solving (Reynders et al., 2020). According to Beagon et al (2018), project-based learning has proven to be more effective than traditional learning in terms of knowledge, engagement and deep interest. This activity helps develop teamwork skills, communication and creative thinking skills and promotes self-sufficient learning.

Thus, STEMPL practice refers to teaching and learning activities carried out by primary secondary school teachers who teach Science, Foundumental of Computer Science, Design and Technology, and Mathematics subjects based on three dimensions; Teaching Plan (TP), High Order Thinking Skills (HOTS) and 21st Century Earning-oriented Task (CLT). The TP dimension consists of five elements of the induction set, learning objectives, content development, assessment method and closure. The HOTS dimension consists of four elements of oral questioning, written questioning, deductive method and an inductive method. The dimension of CLT refers to knowledge transfer, critical thinking, problem solving and technology integration.The operational definition of the elements is as 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	Allowing 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 giving and examples to explaining the concepts.
Knowledge Transfer	Use the infographic to interpret information to link old knowledge to new knowledge.
Critical Thinking	Giving students the opportunity to engage in discussion and provide critical feedback helps to build and justify their learning.
Problem Solving	Giving students opportunities to make suggestions in solving real-world problems.
Technology Integration	Digital learning provides students with opportunities to explore information sources.

Methodology

This study applies a quantitative approach with cross-survey design using questionnaires survey. Based on the statistical data of the Educational Planning and Policy Research Division (EPRD) of MoE, a total of 6786 teachers who taught STEM subjects comprising Science, Fundumental of Computer Science, Design and Technology and Mathematics from lower secondary school in Southern Zone namely Negeri Sembilan, Melaka and Johor were selected as the study population. Krejcie and Morgan (1970) and Research Advisors (2006) suggest that at least 360 samples are needed to represent the population. However, Creswell (2014) suggested that the number of samples should be increased by 10% in order to overcome outliers and missing value. Therefore, this study determined that at least 400 samples are needed to represent the study population. The simple random sampling technique for the vast population used using google form and e-mail has been used as a list-based method as suggested by Couper (2000).

STEMPLQ was built through a systematic meta-analysis involving 32 scribbled and significant articles tailored to the context of STEM education in Malaysia. The construction of STEMPLQ is guided by the integrated instrument construction model from the Du Plessis and Martins (2019), and Miller and Lovler (2018), instrument construction models involving three phases of conceptualization, construction and verification with seven steps. These phases are guided on the basis of a systematically produced conceptual framework. SSSTEMPL consists of part A (demography) and part B (practice). The teaching experience factor uses an ordinal scale while SSTEMPL uses a Likert (Likert-Type) type scale of consent that has a continuity on an affective domain. SSPPTEM has been shown to have the necessary psychometric characteristics based on measurement principles such as content validity, construct validity and reliability to measure teacher STEMPL practices. Fleiss Kappa analysis and Content Validity Index (CVI) have shown SSSTEMPL meets the validity of content with high index values (Fleiss et al., 1982; Polit et al., 2007). This proves that all field experts agree that SSPPTEM has met the content requirements according to the context of STEM education in Malaysia. The validity of the construct is determined by conducting a factor analysis i.e. Exploration Factor Analysis (EFA) Verification Factor Analysis (CFA). The EFA proved 13 theoretical elements matched empirically, while the CFA found, 13 elements and 62 items had met the model's matching with CMIN/df was 2.6 and RMSEA 0.06 (Hair et al., 2019; Kline, 2005) and supported by the legality of discriminant (Joreskog, 1971). The Alpha Cronbach test was analyse d on 62 items and found that the reliability value was 0.97 which is at a high level (DeVellis, 2016). With the evidence obtained, there is a high degree of confidence that the SSPPTEM instrument can be used in a clear and accurate field to measure the level of STEMPL practices of Southern Zone primary secondary school teachers.

Field data quotations are carried out using the Google Form application as proposed by BPPDP as an alternative when the Movement Control Order is enforced due to the transmission of the Covid-19 outbreak. A total of 665 samples were successfully cited from each district in the Southern Zone state. A total of 556 samples were successfully filtered through data cleansing of outliers and missing values, with 145 (26%) respondents being men and 411 (74%) being women. The sampling principle that represents the homogeneity and representative characteristics of each region has also been fulfilled. Data were analyse d using Statistical Package for Social Science (SPSS) Version 26 software. Normality analysis has been carried out at an early stage to determine appropriate statistical tests, although Coolican (2019) states that category (ordinal) data should be analysed using non-parametric tests. Tests of dizziness and curtosis conducted found that the data on teachers' STEMPL practices were abnormally scattered based on teaching experience. Therefore, this study used a non-parametric test analysis involving the Kruskal-Wallis test.

Finding

Demography

This study was to identify the level of STEMPL practice of the Southern Zone primary secondary school teachers comprising the states of Johor, Melaka and Negeri Sembilan based on the teaching experience factor. STEM teachers are teachers who teach Science, Foundumental of Computer Science, Design and Technology and Primary secondary school

Mathematics subjects. The teaching experience group is divided into five subgroups, namely teachers with teaching experience of 0-5 years, 6-10 years, 11-15 years, 16-20 years and over 20 years. Table 4.1 shows the analysis of study samples based on respondent demoghrafic.

Table 4.1
Respondent demographics

Demographic Factors	Range	Total	Percentage
Teaching Experience	0-5 years	53	9.5
	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
	Total	**556**	**100.0**

Table 4.1 shows that 53 teachers (9.5%) have 0-5 years of experience, 94 teachers (16.9%) have 6-10 years of experience, 176 teachers (31.7%) have 11-15 years of experience, and 106 teachers (19.1%) have 16-20 years of experience. A further 127 teachers (22.8%) had over 20 years of experience.

Determination of Levels, Norms and Profiles of Teacher
Stempl Practices
Miller and Lovler (2018), defining the norm is a set of scores that show the average performance of the group, as well as the distribution of scores above and below average. This can be used as a reference for the purpose of comparison or interpretation of scores at the individual or group level. Cohen and Swerdlik (2009), added, norm represents the average score of the selected sample group and serves as a reference point for interpretation purposes. It can be concluded that the norm is the average score of a group of test samples selected to represent the characteristics of the population produced to facilitate the comparison, interpretation, and inference of the rating performance of an individual or group. In this study, the sample norm is calculated based on the mean and standard deviation of the study sample. There are four norm subgroups based on the experience of teachers. Teaching experience factor is considered dominant in comparing the performance of STEM teachers as suggested by Aminah and K Han (2020), Hassan and Mahamod (2019), and (Odell et al 2019). According to Kline (2005), demographic characteristics produce corresponding comparisons between subgroups.

Next, the profile analysed based on the sample norm for each subgroup based on the mean and standard deviation. According to Linn and Miller (2005), a profile is a graphic presentation (pictures, text and illustrations) of scores resulting from a study where all scores are reported and compared to norm. According to Cohen and Swerdlik (2009), the purpose of the profile presentation is to clearly demonstrate the strengths and weaknesses of each dimension and element for the purpose of the intervention. The analysis of the norms and profiles of the studies is discussed through the following procedure i.e. a) the calculation of norms and profile sketches for the group as a whole, b) the calculation of the mean and standard deviation for each dimension and element of the subgroup, and c) the sketch profile of each subgroup. This analysis is to answer the question of the first study started by develop a matrix of norms in the form of tables and graphs to produce a profile of the teacher's STEMPL practice. The question of the second study requires statistical analysis to interpret the data collected. Thus, the Kruskal-Wallis test is used to analyse ordinal data.

The Level of STEMPL Practices of Lower Secondary School Teachers

The STEMPLQ uses an interval scale to measure teacher STEMPL practices for affective domains as proposed by Hair et al. (2019) and Miller and Lovler (2018). Krathwohl et al. (1964) added, the level of practice of the teacher can be identified according to the continuity of the hierarchy that includes the attitudes, values, or emotional responses that are regularly practiced. Data from 556 study samples were analysed and the results are shown in Figure 4.1.

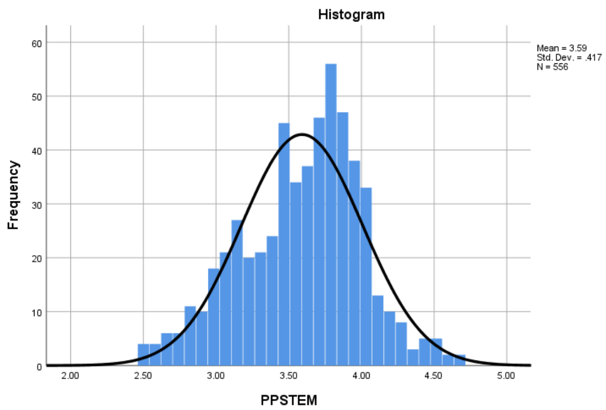


Figure 4.1 Histogram of teacher STEMPL practice

The analysis found that the overall mean value was 3.59 with a standard deviation (SD) of 0.42. Next, Kline (2005), Villeneuve, (2018) and Coolican (2019) propose positive values (+1SD, +2SD and +3SD) and negative values (-1SD, -2SD and -3SD) to be determined using the following formula and calculation:

Formula = Mean ± SD
Formula = Mean + 1SD = 3.59+0.42 = 4.01
Formula = Mean – 1SD = 3.59–0.42 = 3.17
Mean ± 1SD (68.26%) =3.59 ± 0.42 =3.17-4.01
Mean ± 2SD (95.44%) =3.59 ± 0.84 =2.75-4.43
Mean ± 3SD (99.73%) =3.59 ± 1.26 =2.33-4.85

The value of the range obtained from the calculation is used to determine the level teacher's STEMPL practice. The teacher's STEMPL practice level is categorized based on the mean values obtained and classified using the Standard Normal Distribution as proposed by Kline (2005), Villeneuve, (2018) and Coolican (2019), while the interpretation of each category uses the Dreyfus Model (2004) which has been adapted to six levels namely Very Low (2.33-2.74), Low (2.75-3.18), Medium Low (3.17-3.58), Medium High (3.59-4.01), High (4.02-4.43) and Very High (4.44-4.85). The interpretation of the teacher's STEMPL practice level is formulated as per Table 4.2.

Jadual 4.2
Mean and range Teacher's STEMPL Practice Level

Indicator	Mean	Range	Level
Mean - 3SD	2.33	2.33 - 2.74	Very Low
Mean - 2SD	2.75	2.75 - 3.16	Low
Mean - 1SD	3.17	3.17 - 3.58	Medium Low
Mean + 1SD	4.01	3.59 - 4.01	Medium High
Mean + 2SD	4.43	4.02 - 4.43	High
Mean + 3SD	4.85	4.44 - 4.85	Very High

The level of teacher STEMPL practice has been analyse d based on the dimensions and elements studied. The findings showed that the dimensions of TP (Mean=3.54, SD=0.43) and CLT (Mean=3.50, SD=0.46) were at medium low level and HOTS (Mean=3.69, SD=0.41) at medium high level. However, five of the 13 elements are at a moderately low level; Learning Objectives (Min=3.46, SD=0.52), Assessment Method (Mean=3.36, SD=0.50), Closing (Min=3.44, SD=0.51), Problem Solving (Min=3.29, SD=0.54) and Technology Integration (Min=3.43, SD=0.59). Overall, STEMPL practice is at a moderately high level (Min=3.59, SD=0.42). Analysis of the findings is shown in Table 4.3.

Jadual 4.3
STEMPL Practice Levels of STEM Teachers by Dimensions and Elements

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

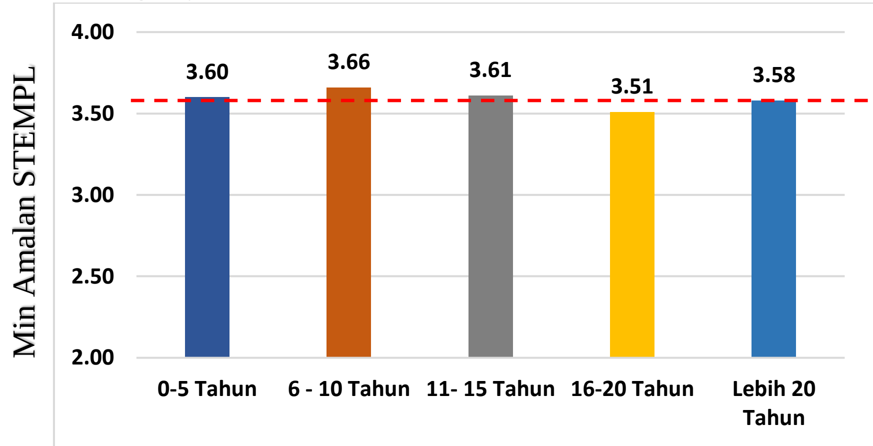
The formula, it is found that only one dimension and eight elements are at the Medium High level, instead two dimensions with five elements being at the Low Medium level. The implications of the findings of the teacher's STEMPL practice level are discussed in detail based on teaching experience.

Norm of Teacher Stempl Practice Based on Teaching
Experience
The teaching experience factor is divided into five subgroups: STEM teachers with teaching experience of 0-5 years, 6-10 years, 11-15 years, 16-20 years and over 20 years. A comparison of mean score and standard deviation based on teaching experience factors is shown in Table 4.4.

Jadual 4.4
Norm Teaching Experience

Teaching Experience	N	Mean	SD
0-5 years	53	3.60	0.06
6 - 10 years	94	3.66	0.04
11- 15 years	176	3.61	0.03
16-20 years	106	3.51	0.04
Lebih 20 years	127	3.58	0.04

Table 4.4 provides norm data for a subset of teaching experiences. Overall, the norm subgroup of teachers with less than 15 years of teaching experience showed higher min scores, while teachers with more than 15 teaching experience obtained lower min. Next, Figure 4.2 shows the profile of teaching experience.



Rajah 4.2 Teaching Experience Profile

The comparison was based on the overall mean of 3.59. The profile of teaching experience shows the norm of teachers with teaching experience of 0-5 years, 6- 10 years and 11-15 years is 0.01, 0.07 and 0.02 above the mean compared to teachers with 16-20 years of teaching experience and over 20 years of being 0.08 and 0.01 below the mean. However, the mean calculation for each dimension of STEMPL practice provides detailed findings for five subgroups of teaching experience as shown in Table 4.5.

Jadual 4.5
Norm of Teaching Experience by Dimension

Teaching Experience	DIMENSION						
	N	TP		HOTS		CLT	
		Min	SP	Min	SP	Min	SP
0-5 years	53	3.54	0.43	3.70	0.44	3.50	0.48
6 - 10 years	94	3.62	0.39	3.76	0.39	3.56	0.45
11- 15 years	176	3.55	0.43	3.70	0.40	3.52	0.45
16-20 years	106	3.44	0.43	3.61	0.42	3.44	0.44
More 20 years	127	3.53	0.44	**3.66**	0.41	3.50	0.48

Comparison by dimension shows that teachers in all subgroups of teaching experience outperform the overall min on the KBAT dimension. STEM teachers with 6-10 years of teaching experience obtained the highest min (Min=3.76, SP=0.39), while teachers with 16-20 years of experience obtained the lowest min (Min=3.61, SP=0.42) in the KBAT dimension. Teachers with 16-20 years of teaching experience achieved the lowest min in the RP dimensions (Min=3.44, SP=0.43) and TBP21 (Min=3.44, SP=0.44). The practice level profile for each dimension is described in Figure 4.3 for all five subsets of teaching experience.

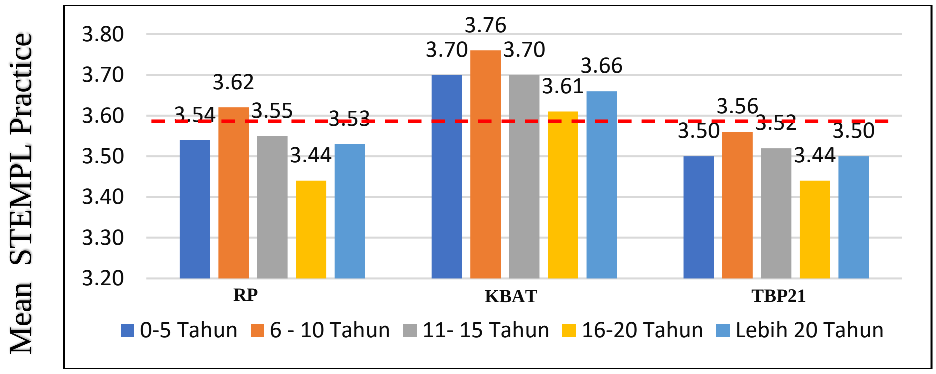


Figure 4.3 Teaching Experience Profile by Dimensions

The profile of teaching experience such as Figure 4.3 shows that with teaching experience 0-5 years, 6-10 years, 11-15 years, 16-20 years and more 20 years are 0.11, 0.17, 0.11, 0.02 and 0.07 above min in the KBAT dimension. All teaching experience subsets are 0.09, 0.03, 0.07, 0.15, and 0.09 below min in the TBP21 dimension. STEM teachers with 6-10 years of teaching experience exceeded the min with 0.03 in the RP dimension, while teachers with teaching experience of 0-5 years, 11-15 years, 16-20 years and more than 20 years were 0.05, 0.04, 0.15 and 0.06 below min.

Differences in Stempl Practice Based on Subjects Taught

The null hypothesis of this study is that there is no significant min difference in STEMPL practices based on the teaching experience of South Zone lower secondary schools. An analysis was conducted to assess the differences in teachers' STEMPL practices based on the teaching experience of STEM teachers. Data is in the form of ordinal data (1 = 0 - 5 Years, 2 = 6 - 10 Years, 3 = 11 - 15 Years, 4 = 16 - 20 Years, 5 = more than 20 Years). Therefore, Coolican (2019) suggests that the data be tested using two measures of normality, namely skewness and kurtosis. Nanna and Sawilowsky (1998) also assert that data need to be assessed first to determine whether the data are parametric or non-parametric so that appropriate analysis can be determined. The value of skewness and kurtosis for teaching experience from descriptive analysis as shown in Table 4.6.

Table 4.6
Descriptive Statistics of Teaching Experience Data

	Statistics	Std error
Skewness	-0.15	.10
Kurtosis	-.94	.21

Table 4.6 shows that skewness is -0.15 with error 0.10 and kurtosis is -0.94 with error 0.21. According to Hair et al. (2019), the z score value should be between 1.96 and -1.96 with a value of α=0.05 to indicate that the data is scattered normally. The calculation was carried out and the value of the z score obtained was as follows;

$$\text{Z score for skewness} = \frac{-0.15}{0.10} = -1.44 \quad \text{and Z score for kurtosis} = \frac{-0.94}{0.21} = -4.53$$

The z-score is in the range of -4.53 to 1.44, indicating that the teaching experience data is not parametric. With this evidence, the researchers have used the Kruskal-Wallis test because teaching experience is a variable not relying on ordinal scales. The results obtained are as in Table 4.7.

Table 4.7
Kruskal-Wallis test

	Teaching Experience	**N**	**Mean Rank**
STEMPL	0-5 years (N_1)	53	287.69
	6-10 years (N_2)	94	302.03
	11-15 years (N_3)	176	285.58
	16-20 years (N_4)	106	252.10
	More than 20 years (N_5)	127	269.47
	Total	556	

Kruskal-Wallis H	5.80
df	4
Asymp. Sig. (*p*)	0.22

The Kruskal-Wallis value is 5.80 and the p-value is 0.22. However, given that the p-value obtained is much greater than the significance level of 0.05 as proposed by Corder and Foreman (2014), it can be concluded that the null hypothesis failed to be rejected.

In summary, the findings showed that there was no significant mean difference ($H = 5.80$, $p > 0.05$) of the teacher's STEMPL practice based on teaching experience.

Discussion

This study found that teachers' STEMPL practices still lack the desired level of practice. This is evidenced by all dimensions being at low to moderate levels. However the KBAT dimension reaches the Medium High and High levels on each element across the subgroup of teaching experiences, indicating that the mean score is above the overall norm. Mohd Syaubari and Ahmad Yunus (2018) in their study on KBAT issues have acknowledged that teachers are at a productive level for a more effective learning approach. The researchers stressed that training and professionalism workshops related to KBAT have had an impact in raising their awareness to produce students with thinking skills as the end product of productive learning.

The TIMSS 2019 National Report also revealed data on the implementation of professional development programmes organised by MOE at the national level. According to the report, 73% of teachers responsible for teaching Science and Mathematics without taking into account specific demographic factors have undergone professional training related to the subject and curriculum. The report details that the training has resulted in improvements in productive learning practices and improved the effectiveness of STEM teachers (MOE, 2020). However, according to Mustam and Adnan (2019), the training provided was more focused on learning and facilitating teachers as experts in subjects or Subjeck Matter Expert (SME) but failed to adequately address the integration of content using an authentic approach i.e. performing activities and tasks based on the real-life scenario of pupils across the teaching experience. New teachers face the challenges of time and opportunity before becoming an SME while more experienced teachers face obstacles in adopting new approaches and technology integration due to the reluctant mentality to change (Abdul Sani, 2018; Ahmad Zamri et al., 2017; Darchinie Rani & Md. Yusoff, 2020). Ermis-demirtas (2018), and Hume and Cooper (2019) argue that less targeted professional development has resulted in a new and less well-developed group of teachers at the school level until the tradisonal learning method remains.

As stated by Kam et al. (2018), the factor of teaching experience plays an important role in the framework of enabling them to achieve expertise in their respective areas of teaching. Nurul Shahida et al. (2020) further contributed to this understanding by emphasizing that the competence of teachers is developed from time to time through their practice and prevalence in planning and managing the curriculum, ultimately leading to the mastery of content knowledge and pedagogical knowledge as SMEs. To support this notion, Schmidt et al (2009), argues that content knowledge and pedagogical knowledge vary across different disciplines, as they cover both the subject and the teaching methodology to facilitate effective learning practices in the current educational context. Auerbach et al (2018), found that experienced teachers are able to devise a constructive approach to encourage learning objectives to be achieved. In addition, they insist that experienced teachers are well versed in identifying learning targets that fail to be achieved by proposing appropriate strategies to address them.

The Sofiana and Zamri study (2019), affirms that the reasonableness of teaching experience factors is taken into account when planning a positive impact on 21st Century learning through the active involvement of pupils. However, data from this study tested using the Kruskal-Wallis test showed that the results were otherwise, i.e. there was no significant difference in teachers' STEMPL practices based on teaching experience. This finding is supported by the TIMSS 2019 National Report (MOE, 2020) which reports that teaching experience factors do not have a significant impact on pupil achievement in STEM subjects such as Science and Mathematics. Furthermore, the findings of this study found the fact that teachers who master the content and expertise of the curriculum do not necessarily have a good level of teacher STEMPL practice so can be translated in the context of STEM learning.

According to Ahmad Zamri et al (2017), and Darchinie Rani and Md. Yusoff (2020), new teachers face time constraints and opportunities as they strive to become SMEs, while experienced teachers face resistance to change when it comes to new approaches and integrating technology. Abdul Sani (2018), added that experienced teachers master the knowledge and content of the curriculum, while new teachers regularly adopt the latest learning approaches and conducory based on the use of technology. Therefore, improving the efficiency of STEM teachers in delivering subject content effectively is important, taking into account the strength and experience between experienced teachers and new teachers. Charles et al (2019), argues that teachers who lack support and guidance in implementing learning practices and facilitation will not bring about significant educational transformations. In this context, it is essential that experienced teachers and new teachers work together to play the role of highly skilled and knowledgeable MKO according to their respective expertise by taking on the responsibility of offering the necessary support and assistance, as advocated by (Dewsbury, 2020). As a result, all teachers are able to act on guidance and support by building and nurturing accordingly in the optimal Proximal Development Zone (ZPD).

In short, this study has proven that there are experienced teachers struggling to adapt their teaching and learning approaches according to current developments, despite having received various forms of training. New teachers, on the other hand, face the challenge of time and opportunity to master the knowledge and content of the subjects taught. This phenomenon should be given serious attention by MOE and related agencies so that their professionalism can be improved from time to time.

There are two suggestions for improvement. The first recommendations, norm matrix and STEMPL practice profile can be used to identify the strengths and weaknesses of the teacher's STEMPL practice teacher. This information can be used by administrators and teachers to create reflections and identify the dimensions and elements of STEMPL that need to be improved. The findings of this study are also expected to encourage teachers to be more proactive in enhancing learning creativity and facilitation especially in STEM subjects. The profile graph is expected to assist stakeholders in planning and implementing the Continues Professional Development (CPD) program to improve teachers' STEMPL practices taking into account the teaching experience studied.

The second suggestion is that experienced teachers should be given mentoring courses to make them mentor new teachers based on the findings obtained. Nur Amelia and Lilia (2019) believe that experienced teachers can improve the effectiveness of STEM learning to less experienced teachers by serving as mentors. Experienced teachers are a group of MKOs, who are expected to be able to provide guidance and support to new teachers. The Gore et al. (2017) study found that teachers who received guidance in certain techniques were more likely to use the technique more often. However, he said, effectiveness should be supported by the use of clear instruments so that the feedback obtained can be used to improve the quality of teaching. Therefore, the researchers recommend that teachers' STEMPL practice instruments be used to improve the quality of guidance of experienced teachers. Key Performence Indicator (KPI) can be used to track progress from time to time to ensure that evidence of continuous quality improvement (CQI) is reported based on emperical data from courses or workshops conducted.

Conclusion

In conclusion, the STEMPL practice study of Southern Zone primary secondary school teachers has identified the need to improve teachers' STEMPL practices based on teaching experience. The analysis found no significant differences in teachers' STEMPL practices based on teaching experience. The results of this study emphasize the importance of providing professional development opportunities for teachers in a more specific manner to the target group. This provides a starting point to better understand teachers' need for STEM learning. Teacher STEMPL practices can be improved to produce students who are ready for the challenges of the 21st Century and realize educational aspirations in Malaysia, and effective strategies need to be planned, implemented, and evaluated by stakeholders to improve the quality of STEM education. Therefore, teachers need to practice STEMPL which is in line with current needs and developments in STEM education. This study is proposed to MOE as a reference in constructive drafting of STEM teacher training and services activities to ensure that investments in the field of education achieve the objectives of national expenditure at an optimal level.

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