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PHYSICS TEACHERS' PERCEPTIONS ON SUSTAINABLE PHYSICS EDUCATION

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Abstract. *The United Nation 2030 Agenda for Sustainable Development advocates teachers as the key in, and for, sustainable development. Surprisingly, while physics teachers have long been recognized as important agents in equipping students with necessary physics knowledge and scientific inquiry skills, nonetheless less attention is paid to explore physics teachers' perceptions on sustainable physics education (SPE). The absence of robust research that explores physics teachers' perceptions to SPE has informed this research. A total of 248 Malaysian physics teachers were involved in a survey consisting of both close and open-ended questions to capture their perceptions of SPE. In examining the differences in physics teachers' perceptions of SPE, with regards to teaching experiences and educational background, the one-way ANOVA was utilized. Whereas thematic analysis was used to analyze responses from the open-ended questions. The main finding of this research is the novice physics teachers expressed more positive views of SPE, where they posed better understanding and greatly valued physics competencies when compared to the other teaching experiences groups. The understandings of sustainability among physics teachers were largely dominated by environmental foci. This research provides vital information to design effective teacher professional development targeting novice physics teachers in order to implement SPE effectively.*

Keywords: *physics education, education for sustainable development, physics teacher, teachers' perception.*

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Introduction

Education is the key element to realizing one of the most aspiring Sustainable Development Goals (SDGs) vision primarily SDG 4 agenda on establishing inclusive and equitable quality education for all learners. One of the 10 targets of SDG 4 outlines the educational objectives of strengthening learners' knowledge and skills required for sustainable development. In this regard, physics education (PE) bears great potential in providing an excellent opportunity to drive and shape sustainable development for the future world. According to Bao and Koenig (2019), PE not only fosters high-end reasoning skills and improves students' scientific literacy competencies, but also produces technically literate, skilled workforce to support sustainable development.

PE inherently is deployed to excite students' interest, curiosity and initiative for learning science as well as boost students' enrolment in science-related courses towards achieving Malaysia global goals in becoming fully developed country. Supporting this vision, Malaysian physics teachers are committed to educate the younger generations to become responsible citizens who practice sustainable lifestyles. In that account, Malaysian physics teachers have utilized a variety of physics hands-on activities, inquiry-based experiments, and simulation-based learning to promote more students' participation by nurturing a deep and meaningful physics learning (Saleh, 2014).

Literature has argued that physics teachers play significant roles in ensuring quality PE in meeting the SDG 4 targets (e.g. Thi To Khuyen et al., 2020; Wang et al., 2011). However, teaching practices among physics teachers are strongly affected by their perceptions (Thibaut et al., 2018). Teachers who have positive views in sustainable development have greater inclination and aptitude for sustainable physics education (SPE) (Jauhariyah et al., 2019). Previous researchers have also indicated that experienced physics teachers express more positive views to integrate sustainable notion in physics teaching than novice physics teachers (Bao & Koening, 2019). Reflecting on similar idea, many researchers have further analyzed physics teachers' difficulties in implementing pedagogical and curriculum practices (Bess, 2018; Henke & Höttecke, 2015; Krzywacki et al., 2017). Based on previous argument, it is therefore important to explore physics teachers' perceptions of sustainability from various contexts related to teaching in order to promote SPE.

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However, review of literature on physics teachers' perceptions on SPE has revealed a shortfall in this particular area of research. Furthermore, inconsistencies in physics teachers' perceptions from demographic standpoint deserves more investigation (Mansour, 2013). Driven by these identified gaps, this research categorized physics teachers based on their teaching experiences and educational background to examine if there is any difference among them in terms of perceptions towards PE. The key research questions which guided this research are: 1) What are physics teachers' perceptions of PE, 2) Is there any difference in physics teachers' perceptions between different teaching experiences groups, and 3) Is there any difference in physics teachers' perceptions between different educational background groups?

The Relation Between PE and Sustainable Development Goal

The terms "sustainable" or "sustainability" are widely defined as the ability of a system to sustain and be in balance. On the other hand, the term "sustainable development" has been popularized by the World Commission on Environment and Development in 1987 where the idea of sustainable development has its root way back at the late 1960s and early 1970s. Through its report entitled Our Common Future, the term "sustainable development" has been defined as the capacity or ability of a society to meet the present needs of all citizens, without compromising the ability of future generations to meet their own needs (Brundtland Report, WCED 1987). Despite scientific and technological expansion, the unprecedented industrial growth has caused extensive damage to the global environment endangering the survival of human race and the planet. The anxiety caused by the negative consequences observed on environment has received massive media publicity which has given rise to various green movements led by environmental non-governmental organizations (NGOs). In the struggle to find the best solution to address the issues, education has been recognized as the key in achieving most if not all 17 Sustainable Development Goals (SDGs). The fundamental role of education is brought to attention particularly at the United Nation World Summit in Johannesburg in 2002 as greater emphasis is given to reorient current education system towards achieving SDG 4: Quality Education.

One of the important targets of SDG 4 is to promote the mastery of sufficient knowledge and skills among students to support sustainable development (Greig & Priddle, 2019). PE inherently advocates multiple SDGs that focus on inclusive and smart lifestyle through the creation of sustainable technological innovation for example, SDG 4: Quality education, SDG 7: Renewable energy, SDG 9: Innovation and Infrastructure, and SDG 13: Climate change. The role of PE in ensuring the achievement of sustainable development goals are preliminarily sketched along with an extended overview on improving the quality of physics teachers. The sustainable development of PE has the potential to equip students with necessary physics knowledge and scientific skills that allow students to be responsible citizens in promoting sustainable development (Talisayon, 2015). In agreement with this statement, Dou et al. (2018) argued that effective and successful implementation of PE should also be able to increase students' interests in making discoveries related to physical world and pursue long-term careers in physics related field.

As one of the components of SDG 4, quality teachers are essential in advancing education to achieve sustainable development goals (Odell et al., 2020). Likewise, a continuous supply of qualified physics teachers is vital to sustain quality PE. Quality physics teachers depend on their teaching qualifications which refer to the measures of teachers' competencies in relation to their subject-matter knowledge, as well as pedagogical skills attained from both academic and continuous professional development training (e.g. Keller et al., 2017; Kumar, 2013). Therefore, it can be understood that teaching profession requires quality teachers who can continuously upgrade their knowledge, skills, and strategies in order to stay relevant (Ng, 2019). In other words, effective professional development should be necessitated to continuously support the teachers in transforming their teaching practices to benefit the students.

The Current Status of PE in Malaysia

Malaysia's educational achievement in physics subject at both international and national level is very concerning. Despite increasing percentage of students who pass Physics paper in the Malaysian Certificate of Education (MCE) examinations, equivalent to the British O-Levels, this trend of academic record is far from satisfactory. The 2019 MCE examination data reveals a consistent run over several years in terms of percentage of students (Ministry of Education, 2019) who have achieved excellent results in physics paper. Such level of achievement may be explained by the students' lack of interest towards learning physics (Ibrahim et al., 2019). Additionally, students

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usually describe physics as a complex and dull subject (Archer et al., 2020). These students' perspectives are homogenous across all levels of education where increasing number of students at higher educational institutions avoid pursuing any physics-related courses (Stiles-Clarke & MacLeod, 2017).

The objective of the Malaysian physics curriculum is to produce citizens who are creative, critical, inquisitive, open-minded, and possess problem solving and decision-making skills in the context of science and technology. In accordance to this vision, physics curriculum in Malaysia has included various teaching and learning strategies to specifically emphasize on students' acquisition and mastery of physics knowledge and scientific skills. Some instances of teaching approach used are inquiry-discovery, constructivism, science, technology, and society (STS), contextual learning, and mastery learning. Despite great emphasis, physics instruction in Malaysia often occurs deductively as the national textbooks present limited opportunity for experiment and demonstration practices (Effendi & Zanaton, 2007; Salmiza & Afik, 2012; Sulaiman et al., 1996; Syarifah Maimunah, 2003). Physics teachers should also develop a wide range of competencies in order to keep physics' teaching and learning process interesting and relevant (Soko et al., 2017). Moreover, physics teachers' preference for traditional way of teaching combined with students' attentiveness to the teachers' explanation has been coined as the main factor that contributes to low achievement and shallow curiosity in learning physics (Demirci, 2015; Mulhall & Gunstone, 2008; Schank et al., 1999). As a result, students often perceive physics as a difficult and unexciting subject (Guido, 2018; Lumintac, 2014) causing severe lack of interest and motivation to learn physics. As teachers' teaching practices could potentially mediate the impact on students' achievement in physics, it is crucial for teachers to demonstrate good understanding of the PE, expand their physics competencies and recognize problems related to physics teaching.

Physics Teachers' Perceptions of PE

The diversity of pedagogical innovations has been widened to ensure quality PE. Although physics teaching strategies in Malaysia remain didactic, current teaching approaches are slowly transforming to foster student-oriented learning by providing meaningful learning experiences in physics (Goldstein, 2016). This transformation, however, greatly depends on the teachers' preferred instructional design or pedagogical approach that is directly linked to their perceptions towards PE (Denisova, 2019).

Anyolo et al. (2018) found that teachers' perceptions vary according to teachers' educational background and teaching experiences on sustainable education resulting in various teaching practices (Anyolo et al., 2018). Other research studies have identified various influential factors such as understanding, attitudes, beliefs, emotional obstruction, perceived challenges, obstacles experienced and self-efficacy on teachers' perceptions of PE (e.g. Ates & Coban, 2018; Canbay & Berecen, 2012; Munby et al., 2000; Qhobela & Kolitsoe Moru, 2014; Tobin & Mcrobbie, 1996). Due to the scarcity of literature reporting on SPE, this research constructed physics teachers' perceptions of SPE from three components namely, knowledge and understanding of PE, physics competencies, and difficulties in teaching physics.

Physics Teachers' Knowledge and Understanding of PE

There is rich evidence indicating teacher pedagogical content knowledge as a major predictor to achieve quality education (Gess-Newsome et al., 2019). Within Shulman's landscape of teacher knowledge (Shulman, 1987), pedagogical content knowledge serves a prominent role in connecting teachers' knowledge of subject matter and teachers' understanding on teaching the contents. This shows the importance of integrating content knowledge and pedagogy on teachers' professional understanding. Although extensive research has been conducted to determine the impact of teachers' knowledge and motivation on students' achievement, literature related to multi-dimensional teacher expertise that extends beyond formal physics learning to career-oriented perspectives is relatively exiguous (Tsang, 2018). It may appear that the progress of PE in SDG is relatively slow, yet the implementation of SPE should be cautiously addressed as teachers' perceptions of knowledge and understanding on PE can directly influence their teaching approaches. Consequently, this research explored this dimension through 1) the concept of PE in terms of teaching practices of the PE knowledge and skills demanded by careers in physics field, 2) primary instructional approaches in PE that focus on scientific inquiry, constructivism, and contextual learning, and 3) the reference of the term 'sustainability' in PE to achieve sustainable development.

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Physics Teachers' Perceptions Towards Physics Competencies

Woolnough (2000) and Sheppard and Robbins (2009) attributed low students' enrolment rate in physics to their view on this subject as too extensive, mathematical, academic oriented and highly dependent on memorizing the physics concept in the textbooks. These perceptions are largely due to the teaching methods utilized by physics teachers that practice rote learning with little opportunity for open inquiry learning activities (Constantinou et al., 2018). This unconducive way of teaching and learning is worrying as physics requires more than superficial understanding of concepts but also to apply the knowledge in solving community problems (e.g. Etkina, 2010; Ince, 2018; Wiemen et al., 2008). Similarly, Tanenbaum (2016) suggested that a set of physics core knowledge, skills, and thinking in solving complex interdisciplinary problems is highly recommended. Framed by various research consensus regarding physics competencies, several interpersonal skills (e.g. communication, collaboration, problem solving), and intrapersonal skills are recognized. For this research, five categories of physics competencies were studied: 1) skills set relevant for physics careers, 2) critical and creative thinking, 3) decision making and problem-solving skills, 4) ethical awareness, and 5) collaboration.

Difficulties Faced by Physics Teachers in Implementing Physics Teaching

A plethoric amount of literature has reassured that physics is commonly perceived as a difficult and demanding subject (Çetin, 2016; Kessels, et al., 2006; Veloo et al., 2015) among students. Along similar lines, physics teachers report their problematic experiences to effectively implement physics teaching. Some of the problems faced by these teachers are high work load (Buabeng et al., 2017), inadequate professional development training on physics pedagogy, insufficient equipment and laboratory facilities, lack of additional teaching and learning resources, incompetency in unconventional learning such as experimentation, demonstration, and group-work problem based learning (Argaw et al., 2016; Becerra-Labra et al., 2012), as well as limited internet access (Chetty, 2015; Khairani, 2017; Suana et al., 2019). With this in mind, this research categorized the teaching difficulties faced by physics teachers into five categories; namely 1) searching for interesting idea, 2) enhancing physics learning beyond formal national curriculum, 3) judging, assessing and determining students' physics achievement, 4) allocating time for physics learning, and 5) teaching and learning resources.

Factors Related to Physics Teachers' Perceptions of PE

Previous researchers have described that people tend to hold widely differing perceptions due to the complex interaction between personal factors such as the cognition, affect and biology (Siew et al., 2015). Pertinent to this research context, personal factors were reflected upon teaching experiences and educational background.

Teaching Experiences

In general, mastery experiences are time-dependent and reinforce people's belief on their abilities as well as capacities in executing specific task successfully (de Boer et al., 2016). Teachers' teaching experiences in regard to how long they have been teaching will therefore influence their beliefs and perceptions towards the subject (Caleon et al., 2018). Caleon (2018) calculated a relatively low efficacy scores among novice teachers compared to teachers who have five-year teaching experiences. However, there are inconsistencies reported in terms of teachers' perceptions and teaching years across previous research. For example, Park et al. (2016) found significant differences between teachers' perceptions and teaching experiences, in contrary Margot and Kettler (2019) indicated no differences. Accordingly, for this research, the years of teaching was utilized to explain the differences of teachers' perceptions towards PE.

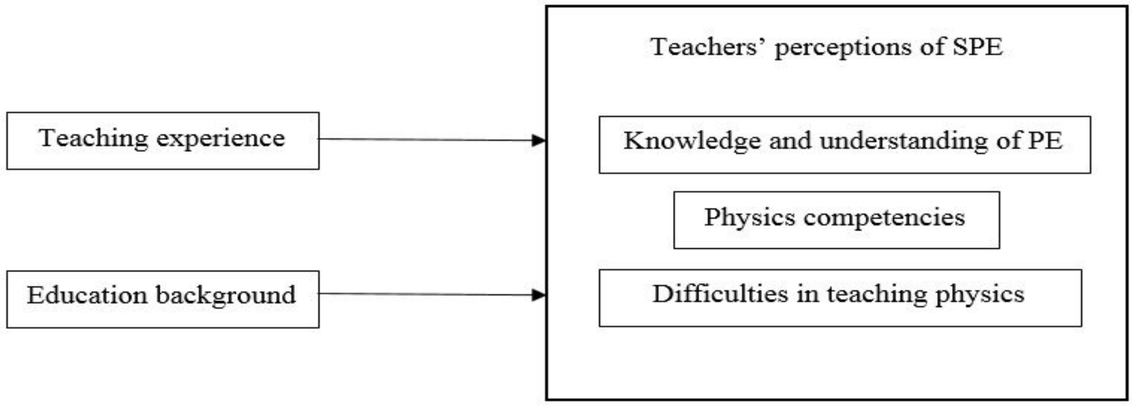
Educational Background

Teachers are usually influenced by what and how they are taught. Debreli (2016) reported that current teaching approaches used by most teachers are strongly influenced by their experience as students during their

https://doi.org/10.33225/jbse/20.19.569

schooling years. Other than being a major contributor to improved students' achievement (Shannag et al., 2013), teachers' educational background also has great influence on teachers' teaching practices as a result of various scholastic instructional models (Ye, 2016). Figure 1 depicts physics teachers' perceptions of SPE and factors utilized to categorize the participants.

Figure 1
Demographic data for categorizing subsamples



Research Methodology

General Background

Survey research design was employed to measure Malaysia physics teachers' perceptions of SPE based on three components, knowledge and understanding of PE, physics competencies and difficulties in teaching physics. Data were gathered for six months (January to June 2019) among physics teachers who were attending professional development training at various teacher training institutions where the first author served as one of the speakers. These training programs were annually organized by both government and private agencies gathering physics teachers from all over Malaysia. The research survey was administered at the end of every training program and consisted of both close and open-ended questions.

Sample Selection

A homogenous convenience sample of 248 physics teachers who voluntarily participated in this research was selected. This sampling approach was adopted due to its easy access for data collection, time-saving quality and cost-effectiveness. Apart from being a positive alternative to conventional convenience sampling, it could also yield clearer and generalizable data for the targeted population (Jager et al., 2017).

Almost 46.2% of the total participants were from rural schools and 53.8% participants were from urban schools. All participants had at least a bachelor's degree (68.5%), while some of the participants (24.2%) had a master's degree and only 7.3% of participants had a doctoral degree. Over half of the participants had 10 years or more in terms of physics teaching experiences. Table 1 illustrates the distribution of participants based on educational background and teaching experiences.

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Table 1
Distribution of participants based on educational background and teaching experiences

Variable	*N*	Percentage (%)
Educational background		
Bachelor	170	68.5
Master	60	24.2
PhD	18	7.3
Physics teaching experiences		
<5 years	35	14.1
5-10 years	55	22.2
>10 years	158	63.7

Instrument and Procedures

This research aimed to examine physics teachers' perceptions of SPE in 1) knowledge and understanding of PE, 2) physics competence, and 3) difficulties in teaching physics. Physics teachers' overall perceptions of the knowledge and understanding of PE were gathered and interpreted following their responses to three different items: 1) the concept of physics teaching related to physics career, 2) the primary instructional approaches of scientific inquiry, constructivism, and contextual learning, and 3) the reference of 'sustainability' in PE to achieve SDGs. Each item was rated on a 5-point Likert scale of 'strongly agree' to 'strongly disagree' in order to specify participants' level of agreement. An average score for each item was calculated to understand and describe physics teachers' perceptions of PE. The range of item factor loadings for item 1-3 was from .64 to .78. Next, participants were required to specify their value towards physics competencies based on a 5-point scale anchored with 'no importance' to 'extreme importance'. Five items on physics competencies were devised: 1) skills set relevant for physics careers, 2) critical and creative thinking, 3) decision making and problem-solving skills, 4) ethical awareness, and 5) collaboration. These items recorded factor loadings between .70 and .88. Finally, participants were instructed to provide their responses on a 5-point Likert scale regarding five difficulties in implementing PE: 1) searching for interesting idea, 2) enhancing physics learning beyond formal national curriculum, 3) judging, assessing and determining students' physics achievement, 4) allocating time for physics learning, and 5) teaching and learning resources. The factor loadings across these items ranged from .58 to .73.

This research also presented the results of an open-ended question that required the participants to state three words related to sustainability in order to capture their perceptions of SPE. The responses to this question were anticipated to offer further insight into physics teachers' perceptions of sustainability within PE.

The adequacy of the sampling was verified through the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity. The test score for KMO was at .786 suggesting highly factorable variables. Whereas, the Bartlett's test value indicating the correlation between the variables was statistically significant at $p<.001$. The total variance for the two factors was about 68.4%. The principal component and Varimax with the Kaiser normalization methods identified three components which were knowledge and understanding of PE (item 1-3), physics competence (item 4-8) as well as difficulties in implementing PE (item 9-13).

Data Analysis

The first question was addressed through descriptive statistic data. In answering the last two research questions, one-way ANOVA was employed to compare whether there were differences between subsamples in terms of teaching experiences and education qualification. Next, significant differences were identified through Tukey honestly significant difference (HSD) tests for post hoc comparison. Finally, to determine the effect size of differences between groups, eta-squared value was calculated where as suggested by Lakens (2013) the value of .01 referred to a small effect, while .06 indicated a medium effect and .14 as a large effect.

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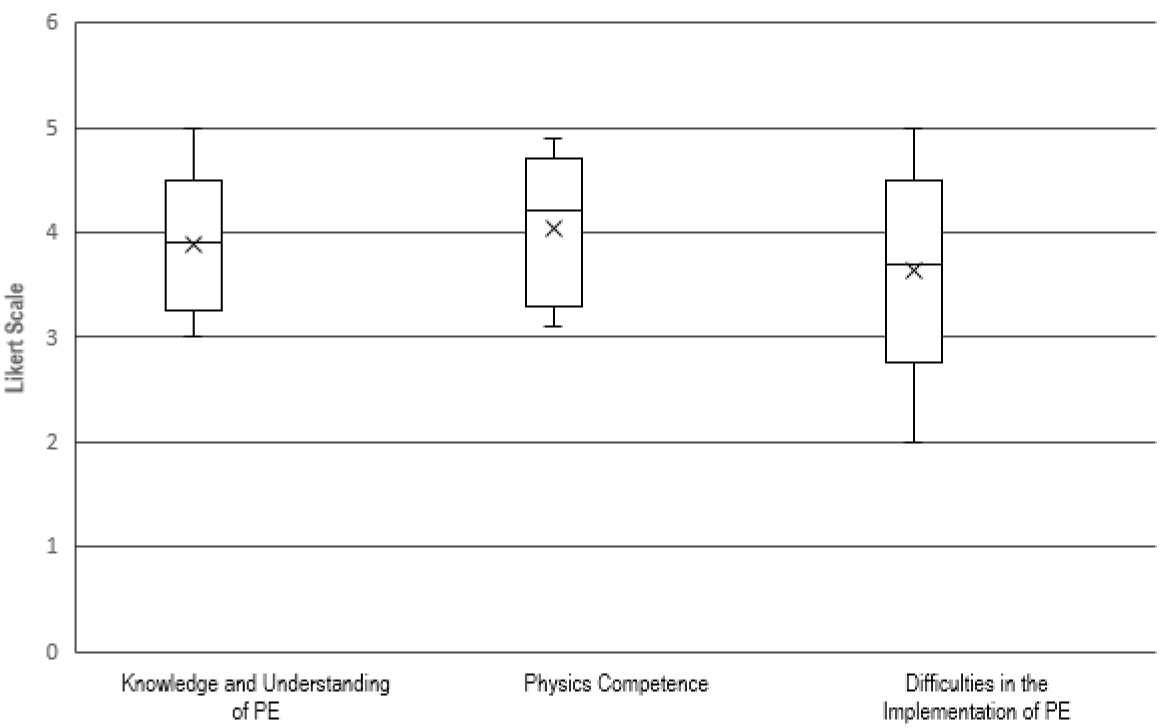
The three words were coded manually by research team members to gain familiarity with the three words. Subsequently, relevant literature was consulted to re-code the words according to the purpose of this research. Data collected were analyzed using SPSS 23.

Research Results

Malaysian Physics Teachers' Perceptions of SPE

The mean value for each component was calculated to understand and interpret the physics teachers' perceptions of SPE on knowledge and understanding of physics (*M*=3.98, *SD*=0.53), physics competence (*M*=4.23, *SD*=0.62), and difficulties in teaching PE (*M*=3.78, *SD*=0.59). Figure 2 illustrates the distribution of each component. For participants' knowledge and understanding of PE, the first quartile (Q1) was 3.45, or more than 75% of physics teachers had adequate perceptions and understandings in PE. Whereas for the second component, Q1 value was 3.89 where more than 75% of the physics teachers perceived physics competencies as important and the median of 4.23 showed that majority participants recognized physics competencies as greatly important. Finally, the interquartile range (IQR) for the difficulties in implementing physics teaching component fluctuated around 4.00 suggesting that most teachers believed the implementation of effective physics teaching was difficult. In overall, Malaysian physics teachers had sufficient knowledge and understanding on PE and highly regarded physics competencies as important. Nevertheless, they faced difficulties to teach physics effectively.

Figure 2
Distribution of each component in the survey instrument



There were five physics competencies and five difficulties in implementing physics teaching. Table 2 outlines the mean, the standard deviation, and the 95% confident interval (CI) for each item in physics competency and difficulties in the implementation of physics teaching. The decision making and problem-solving skills were selected as the most important physics competencies while skills relevant for physics careers (e.g. specific communication skills) were advocated as the least important. Finally, time allocation was regarded as the primary issue in implementing PE and sources for physics teaching and learning materials were assessed as the least difficult.

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Table 2
Means, standard deviations, and the 95% CI level of the importance for physics competence and difficulty in the implementation of PE

Variable	*M*	*SD*	95% CI	
			LL	UL
Physics competence				
(1) skills set relevant for physics careers	3.83	0.76	3.72	4.04
(2) critical and creative thinking	4.42	0.79	4.23	4.53
(3) decision making and problem-solving skills	4.62	0.81	4.45	4.82
(4) ethical awareness	4.15	0.74	3.98	4.27
(5) collaboration	4.00	0.74	3.91	4.18
Physics teaching difficulties				
(1) Searching for interesting idea	3.68	0.79	3.49	4.16
(2) enhancing physics learning beyond formal national curriculum	3.73	0.82	3.65	4.04
(3) judging, assessing and determining students' physics achievement	3.88	0.82	3.58	3.99
(4) time allocation for physics learning	4.22	0.88	3.98	4.37
(5) teaching and learning resources for physics teaching and learning	3.43	0.99	3.26	3.64

Note: CI refers to confident interval, LL refers to lower limit, UL refers to upper limit

Differences in Physics Teachers' Perceptions of SPE Based on Teaching Experiences

One-way ANOVA was employed to examine any difference from subsamples' perceptions of PE. Table 3 illustrates the mean (M) and standard deviation (SD) of each group.

Table 3
The mean (M) and standard deviation (SD) of each group

Variable	n	Knowledge and understanding of PE				Physics competence				**Difficulty in teaching physics**			
		M	*SD*	*p*	η^2	*M*	*SD*	*p*	η^2	*M*	*SD*	*p*	η^2
Physics Teaching Experience				.043*	.03			.002**	.05			.936	<.01
<5 years	35	3.98	.79			4.28	.56			3.86	.62		
5-10 years	55	3.99	.63			4.05	.62			3.84	.68		
.10 years	158	3.54	.68			3.87	.71			3.81	.61		
Highest education qualification				.001**	.68			***	.19			.021*	.06
Bachelor	170	3.26	.52			3.78	.72			3.65	.86		
Master	60	3.65	.83			3.96	.70			3.45	.64		
Doctorate	18	4.10	.62			4.32	.53			3.98	.52		

Note: $\eta^2 \geq .06$ are in boldface while * $p<.05$, ** $p<.01$, *** $p<.001$

Based on the data analysis, physics teachers with teaching experience of more than 10 years obtained the lowest score advocating physics competency as the least important and faced least difficulties in teaching physics. In order to explore whether there was any difference in physics teachers' perception of SPE based on teaching experience, a one-way ANOVA between groups was employed. There were statistically significant differences in knowledge and understanding of PE scores (p =.043) and in physics competency scores (p =.002) for all physics

https://doi.org/10.33225/jbse/20.19.569

teaching experience groups. Nonetheless, there were no statistically significant differences in difficulties to physics teaching (p =.936). The calculated score for eta-squared which referred to the actual differences in mean scores between groups was very small in understanding of PE (η^2=.03) and difficulty in teaching physics (η^2=<.01). Meanwhile, for physics competencies, the actual differences in mean scores between groups were medium (η^2=0.05). The Tukey HSD test score for the post hoc comparisons showed no statistical significance from the mean scores of three physics teaching experience groups in knowledge and understanding of PE and difficulty in implementing physics teaching. However, for physics competency, the mean scores of physics teachers who had less than five years of teaching experiences were significantly higher than the two other groups.

Table 4
Post hoc comparisons in physics teachers' perceptions of SPE

Demographic Category		Knowledge and understanding of PE		Physics competency		**Difficulty in physics** teaching	
(I)	(J)	Mean Difference (I-J)	*SE*	Mean Difference (I-J)	*SE*	Mean Difference (I-J)	*SE*
Physics teaching experience							
<5 years	5-10 years	-.19	.16	.38	.15	.02	.14
<5 years	>10 years	.26	.14	.51	.14	.04	.13
5-10 years	>10 years	.27	.12	.10	.11	.02	.11
Highest education qualification							
Bachelor	Master	-.31	.19	-.26	.18	-.38	.17
Bachelor	Doctorate	-.68	.33	-.83	.21	-.59	.19
Master	Doctorate	-.38	.14	-.62	.11	-.21	.12

Differences in Physics Teachers' Perceptions of SPE Based on Educational Background

Physics teachers who had doctoral degrees achieved the highest mean scores, whereas physics teachers with bachelor's degrees scored the lowest mean values across all components. Therefore, it was reasonable to conclude that physics teachers with higher education qualification had good knowledge and understanding in physics, advocated physics competency as more important and faced more difficulties in teaching physics. A one-way ANOVA was conducted to determine the influence of physics teachers' educational background on their perceptions of SPE. The results indicated that there were statistically significant differences in PE and difficulty in physics teaching (ρ<.05), and at ρ<.001 in physics competency for all groups. Based on the calculated eta-squared, the actual mean scores differences between groups were moderate in knowledge and understanding of PE (η^2=0.68) and larger in physics competency (η^2=.19). Despite obtaining statistical significance, the actual differences in the mean scores of difficulty in physics teaching between groups were relatively small (η^2=.06). Post hoc comparisons revealed significantly higher mean scores for doctoral group of physics teachers and physics competency compared to the bachelor and master's degree groups. The bachelor group had mean scores in PE and physics competency that had no statistically significant difference from the master's degree group. Employing similar methodology, this research concluded significantly lower mean scores in difficulty to physics teaching of the bachelor group than the master and doctoral degree groups. The mean scores in difficulty to teach physics for the master and doctoral groups revealed no statistical difference.

3 Words Analysis

To further explore physics teachers' perception of SPE, participants had responded to "List three words you think of when you consider the word sustainability". As presented in Table 5, the majority of participants had written environmental-related words (n=756, 67.3% of all words) and some of the examples of words that were coded

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under the "environmental" theme such as 'nature', 'conservation', 'preservation', 'environment', 'habitat'. The "future-oriented" theme was the second most common words reported (n=187, 16.6% of all words) that included words such as 'future', 'upcoming', 'lasting', 'enduring', 'lifelong'. Other small representations of the remaining themes were less than 6% of the total findings.

Table 5
Physics teachers' perceptions of sustainability as represented by the three words related to sustainability

Theme	Count	% of total	Explanation	Illustrative word
Economic	47	4.2	Dimension of sustainable development goals	Economy
Education	39	3.5	Education for Sustainable principles	Education
Critical thinking	65	5.8	Education for Sustainable principles	Informed judgment
Environment	756	67.3	Dimension of sustainable development goals	Environment
Future-oriented	187	16.6	Education for Sustainable principles	Future
Social	26	2.3	Dimension of sustainable development goals	Community
Political	4	.4	Dimension of sustainable development goals	Governmental effort

Discussion

The findings revealed statistical differences between teaching experience groups, in terms of knowledge, understanding of PE and physics competencies. However, there was no statistical difference among teaching experience groups and difficulties to teach physics. In overall, this research found that most Malaysian physics teachers considered physics competency as being the most valuable. Nevertheless, a comparison between the more experienced teachers and the novice physics teachers (less than five years of teaching) revealed that the latter group's knowledge and understanding of PE were sufficiently better and perceived physics competency as more valuable reaffirming previous research (Caleon et al., 2018). Reiterating Caleon et al.'s (2018) research that reported physics teachers' experiences and their responses on the importance for innovative pedagogical approaches were related negatively, this research also found that physics teachers who accumulated more experience developed less enthusiasm to adopt innovative and new physics pedagogical approaches. Thus, novice physics teachers are commonly viewed to be more optimistic and positive towards improving pedagogical approaches than experienced physics teachers. According to Shahali et al. (2015), teachers' attitudes and beliefs about the effectiveness of particular instructional methods could greatly influence teachers' classroom teaching practices. In accordance to this statement, this research suggests that within the Malaysia education context, novice physics teachers are potentially advantageous in sustaining PE.

Physics teachers with master's or doctoral degree pose more extensive in knowledge as well as understanding in PE and tend to advocate physic competency as more important. The argument that supports this finding is reinforced by the nature of postgraduate studies that largely provide wider exposure and specific learning with regards to the pedagogical innovations and educational change. Therefore, it can be concluded that physics teachers who undertake or continue their studies at higher level such as at master and doctorate level have positive gain on both their professional as well as personal growth (Makovec, 2020). Some teachers report that their ability and competency as teachers are enhanced after pursuing master's degree programs as they are exposed to various pedagogic innovations during their postgraduate studies (Burroughs, 2019). Surprisingly, despite possessing higher educational qualifications, these groups of teachers report higher difficulties to teach physics. However, Sun (2019) convincingly argued that teachers' perceptions on difficulties to effectively teach and desire to engage in new pedagogical practices were irrelevant if teachers put more value on PE. Therefore, this research suggests qualified physics teachers should be viewed from the academic and training qualifications standpoints to guarantee quality PE and SPE.

The qualitative analysis shredded further insights in revealing physics teachers' understanding on sustainability which was mostly dominated by environmental foci. More than half of the '3 words' data were related to the 'environmental' themes (69.1%) suggesting that physics teachers' understandings were constricted to environmental

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notions of sustainability, with notable lack of reference to other dimensions of sustainability (e.g. economic, social, and politic). This way of understanding related to sustainability is unsurprising as the concept of 'environment to sustainability' has been aggressively popularized and widely promoted around the globe. Moreover, the vague definition of sustainability may also contribute to their understanding of sustainability which influences the construct of sustainability image that often portrays environmental components (Salas-Zapata, 2019). Furthermore, scaling down to a school context, the sustainability notion is primarily embedded in environmental school program with discrete attention on school gardens, recycling and tree-planting programs (Emas, 2015). Therefore, it is comprehensible that physics teachers' understandings are positioned in the environmental foci of sustainability.

Conclusions and Implications

This research interprets physics teachers' perceptions of SPE, including knowledge and understanding of PE, physics competence, and difficulties faced when teaching physics. Most participants offer positive views on PE. These findings reflect part of the favorability to sustain PE in Malaysia. To better facilitate the aspiration of PE for sustainable development goals, it is essential to: 1) guarantee a steady supply of qualified physics teachers in both academic and training qualifications in all schools, and 2) meticulously design and meet the professional development needs of physics teachers with greater emphasis on physics thinking and awareness of physics careers.

Some key findings of this research include novice physics teachers have more positive views of PE; perhaps, their access to various sources of advanced knowledge seeking skills through internet has exposed them to informal learning about PE. Secondly, the findings indicate that teachers with higher education qualification pose exhaustive view on PE and report more difficulties in conducting physics teaching. Novice teachers are therefore suggested as a prospective and sustainable resource to implement SPE in Malaysia and further research has to be done to explore the effective ways of supporting both professional and personal growth of the novice physics teachers.

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