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EFFECTS OF METACOGNITIVE SKILLS ON PHYSICS PROBLEM-SOLVING SKILLS AMONG FORM FOUR SECONDARY SCHOOL STUDENTS

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Abstract. *A number of studies have demonstrated a connection between metacognition and the ability to solve problems. Therefore, this study aimed to examine the effect of metacognitive skills on Physics problem-solving skills among Form Four secondary school students in Sabah, Malaysia. This study included 248 students from 13 secondary schools in the Kota Kinabalu district. Physics Problem Solving Skills Test and the Metacognitive Skills Questionnaire were used as research instruments. The research found that Form Four students have high monitoring, regulation, and evaluation as measured aspects of metacognitive skills. Meanwhile, students' Physics problem-solving skills for "understanding the problem" and "devising a plan" are moderate, while "carrying out the plan" is good and "looking back at the solution" is low. The independent sample t-test reported that, in general, male students have better Physics problem-solving skills than females but found no gender differences in metacognitive skills. Furthermore, the linear multiple regression results revealed that monitoring and regulation skills are significant predictors of Physics problem-solving skills. This research helps school teachers better design teaching strategies in Physics, considering the student's gender and metacognitive skills. Furthermore, this study provides secondary school students with learning insights for developing better techniques to improve their performance in Physics.*
Keywords: *gender differences, Malaysia, metacognitive skills, Physics problem-solving skills, secondary school students*

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Introduction

To produce a generation that is highly skilled and capable of facing the challenges of the 21st century, metacognitive skills are important in the teaching and learning of Physics so that students can apply those skills to solve problems in everyday life and improve their efficiency in solving Physics problems. Physics is a subject that is important not only in the advancement of technology and the media but also in aspects of the global economy and human well-being (Edmunds, 2008). The goal of Physics education is to educate and guide students so that they can apply what they have learned in Physics to solve problems in their daily lives (Niss, 2012). Specifically, Demkanin (2013) asserted that teachers should incorporate the following goals into the physics education curriculum: societal attitudes toward science; scientific methods; pieces of knowledge for the development of scientific methods and societal attitudes toward science; and pieces of knowledge related to the quality of life and general scientific culture. The third learning objective of the Physics subject in the Malaysian Standard Curriculum for Secondary Schools (KSSM) focuses on the skill of problem solving (Malaysia, 2002). However, students are still exposed to fewer non-standard Physics problem-solving questions as suggested by KSSM in exercises, test questions, and internal examinations. The majority of students, particularly in Malaysia cannot solve problems involving higher-order thinking skills (HOT) and Science, Technology, Engineering & Mathematics (STEM) questions (Baharin et al., 2018). Inadequate mathematical proficiency prevents students from applying Physics concepts to STEM-related problem-solving (Campbell Jr, 2002; Smith et al., 2009). In fact, Physics is regarded as a challenging subject not only by upper-secondary students but also by college students (Erdemir, 2009). Physics is also a challenging subject, particularly in terms of problem-solving (Ogunleye, 2009). This assertion is supported by the findings of a study conducted by Soong et al. (2009), who concluded that the primary reason students refuse to study Physics is because they find it difficult to solve Physics problems. Byun et al. (2008) also reported the findings of the same study, namely that students perceived Physics to be a difficult subject due to difficulties in solving Physics problems. Indeed, problem-solving is an essential component of Physics classes (Gerace & Beatty, 2005).

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In 2014, HOTS questions were first included in the Malaysian Certificate of Education (SPM) exam paper. The SPM questions were also changed so that the level of problem-solving mastery among Physics students could be evaluated. The percentage of HOTS questions assessed in the SPM Physics Paper 2 question paper is approximately 20% (Council, 2020), and students must have strong problem-solving and metacognitive skills to answer these questions. Students must master Physics problem-solving skills and be proficient in answering a variety of questions, including non-routine and higher-level thinking skills questions (HOTS). HOTS questions assess a candidate's ability to solve problems, make decisions, innovate, and create something by applying, analyzing, evaluating, and creating skills (Council, 2020). According to Council (2020), only 36.83% of SPM 2019 candidates had excellent ability in answering HOTS questions based on the quality of answers taken from a sample of 278,904 candidates. HOTS mastery is measured by the candidate's ability to answer exam questions that contain HOTS elements. Overall, 56% of SPM 2019 candidates have a strong understanding of HOTS, compared to 61.10% of candidates in 2018. According to this report, there is a 5.10% decrease in HOTS mastery among SPM 2019 candidates when compared to the previous year. The findings of this data show that the level of problem solving skills for SPM 2019 candidates is moderate rather than excellent. Swanson (1990) discovered that students with a high metacognitive level solve problems more efficiently than students with a low metacognitive level. Based on this correlation, it can be concluded that the level of metacognitive skills of SPM 2019 candidates is also moderate rather than excellent.

Furthermore, according to data analysis for SPM 2019 Physics achievements obtained from the Sabah State Education Department, a total of 4655 candidates sat the SPM 2019 Physics exam in Sabah, with only 12.40% (577 people) achieving excellent results. The percentage of candidates who passed SPM Physics 2019 was 99.29%, which was higher than the percentage who passed in 2018 (99.49%). This indicates that the pass percentage has decreased by 0.20% from the previous year. According to an analysis of the 2019 SPM Physics performance by district, Sabah has 23 District Education Offices. The Kota Kinabalu district's 2019 SPM Physics Subject Average Grade achievement is third, with an average grade of 4.24, trailing Kunak (4.12) and Penampang (4.05) districts. According to JPNS (2020) data, the Kota Kinabalu district is classified as urban, while the Kunak and Penampang districts are classified as rural. Although the district of Kota Kinabalu is located in an urban area, the achievement of the average grade of Physics SPM 2019 demonstrates that even if a student attends a school in an urban area, it cannot be used to determine and guarantee that students in the city have high problem-solving skills.

According to Lasan et al. (2017), students are less prepared to actively participate in question-and-answer sessions during teaching and learning. As a result, there is no effective interaction between teachers and students. This situation leans more toward teacher-centred teaching and learning, which is a conventional teaching method. However, the learner-centred approach to teaching and managing inexperienced students is advised (Demkanin, 2018). Several studies in the field of education have found that collaborative learning is beneficial (Demkanin & Ková, 2019). Traditional physics classes begin with a lesson in which the teacher explains how to solve a given problem using the laws and theories that they have taught their students (alşkan et al., 2010). Traditional teaching and learning methods, according to Yusof (2006), result in a shallow learning process that is incapable of developing students' cognitive abilities. This situation is extremely worrisome, as many educators are concerned that today's generation "can't think" (Collins, 2014). The current study is significant because previous research has shown that metacognitive skills can assist students in solving problems, particularly those involving mathematical calculations (Jauovec, 1994; Schoenfeld, 2016; Swanson, 1990). Mestre (2001) asserted that in order for students and teachers to solve Physics problems more effectively, they must be connected to metacognitive skills and strategies. Scaffolding has been identified as a dynamic intervention that is finely tuned to the students' learning process in the context of the interaction between the teacher and the students (Demkanin, 2022). Scaffolding can help students develop their metacognitive skills in a physics lesson by providing them with clear learning objectives, modelling the problem-solving process, and providing opportunities for them to reflect on their own thinking and understanding. This process can help students develop metacognitive skills by encouraging them to think critically and actively engage with the material, leading to a deeper understanding of the subject matter.

Literature Review

Most students are unable to apply the Physics concepts they have learned to solve problems involving real-world situations because they do not fully comprehend the Physics concepts they have learned (Hu & Sanjay

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Rebello, 2013). In addition, according to Calik and Ayas (2005), one of the reasons why students are unable to apply the concepts they have learned to daily activities is because they lack a fundamental understanding of the concept. If a student does not comprehend the theoretical basis of a Physics concept, he or she will be incapable of applying that concept to solve problems in a variety of Physics situations. This statement is supported by Edmunds (2008), who states that students struggle to comprehend the fundamental theories and concepts of Physics and to apply Physics and mathematical concepts to problem solving. For the majority of students, Physics is a subject that contains numerous facts, particularly in the form of physical laws. The physical laws can be expressed mathematically, i.e., in the form of Physics formulas. These Physics equations are used to solve Physics problems. The Physics course requires students to recall a large number of Physics concepts and formulas (Salleh, 1992). Unfortunately, the majority of students do not comprehend Physics concepts. According to Mahda (2003), this circumstance encourages students to solve Physics problems using formulas rather than relying on their knowledge of Physics phenomena and concepts. This circumstance frequently hinders students' ability to solve Physics problems effectively.

Schoenfeld (2016) demonstrated that metacognition is a crucial aspect of problem solving. In addition to considering ways to solve a difficult problem, students must also assess their own problem-solving abilities. Students with a high metacognitive level are found to solve problems more effectively than students with a low metacognitive level (Swanson, 1990). By applying monitoring, regulating, and evaluating metacognitive skills (Vos & de Graaff, 2004) to the step-by-step problem solving process as found in the problem solving skills of (1) understand the problem, (2) devise a plan, (3) carry out the plan, and (4) look back at the solution (Pólya & Conway, 1957), a person can implement the problem solving process more efficiently and effectively. This demonstrates that a student's metacognitive skills determine his or her success or failure in problem solving (Kassim & Ahmad Zanzali, 2001).

Previous research has examined the link between gender and problem-solving abilities. Blue (1997) discovered no significant difference in Physics problem solving between male and female student groups in the first year of higher education. There was also a previous study that discovered the opposite. Males were found to have better problem-solving skills than females when learning science (Erickson & Erickson, 1984). Furthermore, male students outperform females in Physics subjects at the secondary school level. In fact, male students were found to be superior to female students in terms of applying Physics knowledge and skills. In the context of a study in Johor, Malaysia, Abdullah (2005) discovered that female students have better Physics problem-solving skills and metacognitive skills than male students. Based on the findings of Sulaiman et al. (2007), there is a significant correlation between metacognitive skills and the ability to solve Physics problems among secondary school students in Malaysia. In addition, Mahda (2003) found that training using a metacognitive approach and strategic questioning can enhance students' problem-solving skills in Physics-related courses. Tasir et al. (2008) discovered that students have a high level of metacognitive skills when solving math problems. Students demonstrated an amazing array of control skills, followed by assessment skills and monitoring skills. In the context of a study in Johor, Malaysia, Abdullah (2005) discovered that female students have better Physics problem-solving skills and metacognitive skills than male students. Based on the findings of Sulaiman et al. (2007), there is a significant correlation between metacognitive skills and the ability to solve Physics problems among secondary school students in Malaysia. In addition, Mahda (2003) found that revising using a metacognitive approach and strategic questioning can enhance students' problem-solving skills in Physics-related courses. Tasir et al. (2008) discovered that students have a high level of metacognitive skills when solving math problems. Students demonstrated an amazing array of regulating skills, followed by evaluating skills and monitoring skills.

Malaysia's approach to education in the twenty first century is still in its infancy and has much room for development (Bakar & Ismail, 2020). For instance, it is highly recommended that teachers create methods, activities, models, or modules of learning based on metacognitive strategies to help support 21st-century learning and meet the needs of the modern educational system. Furthermore, there is a lack of in-depth research on metacognitive skills in the classroom (Daher & Hashash, 2022), particularly in Malaysia on the metacognitive skills and Physics problem-solving skills of Form Four students in secondary schools. As a result, the purpose of this study is to see if this phenomenon occurs among students in Kota Kinabalu, Sabah. Therefore, the purpose of this study was to answer the research question, "What factors effect Form Four secondary school students' problem-solving skills in Physics in Kota Kinabalu, Sabah?" Answering this question would then help secondary school teachers and students develop an effective teaching and learning strategy to address the problem in Physics class. In order to answer this research question, the following three research objectives were established:

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1. To determine the level of metacognitive and Physics problem-solving skills among Form Four secondary school students.
2. To determine the differences in Physics problem-solving and metacognitive skills among Form Four secondary school students according to gender.
3. To determine the effect of metacognitive skills on students' Physics problem-solving skills among Form Four secondary school students.

Research Methodology

Research Design

The methodology employed in this study was that of a quantitative cross-sectional and correlational analysis. Quantitative or measurable data on multiple variables are collected and analyzed in a cross-sectional study to uncover correlations or other patterns (Salta & Koulougliotis, 2022). Additionally, since the aim of the current study was to provide an explanation for the correlation between variables, it is more accurately labelled as explanatory research (Creswell, 2002). As study respondents, the researcher utilized only one group of samples, namely form four students from the district of Kota Kinabalu, Sabah. These students are in Form Four and are between the ages of 16 and 17. The students must be enrolled in Physics classes in 2020. Only the 674 students from 13 secondary schools in the district of Kota Kinabalu who were enrolled in the science stream were included in the sample size as targeted population. In this study, the researcher employed a stratified random sampling technique; that is, each respondent was selected at random based on the proportion of strata in the population.

Sampling Technique

In this study, the researcher employed a stratified random sampling technique based on the sampling rate; that is, each respondent was selected at random based on the proportion of strata in the population. Each sample stratum is proportional to the population as a whole. In this study, the study population is divided into multiple strata, and a random sample is drawn from each stratum based on a predetermined proportion. The 13 secondary schools in the district of Kota Kinabalu are divided into two gender-based strata: boys and girls. To calculate the number of student samples according to strata using the stratified random sampling method, the researcher must know both the total study population and the total number of students in each stratum. The sample size of 248 was determined using Krejcie and Morgan (1970) table.

Data Collection

The main challenge in conducting this study was distributing the questionnaire. While this study was being conducted, countries around the world, including Malaysia, were hit by COVID-19 pandemic, which made it difficult for researchers to send hardcopy questionnaire instruments to 13 secondary schools in the Kota Kinabalu district. As a result, the researcher has implemented another alternative by creating a questionnaire in the form of a Google Form and then distributing the link to the relevant schools with the assistance of Physics teachers to be delivered to the students involved. The study was conducted in compliance with ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from Ministry of Education Malaysia [Approval Code: KPM.600-3/2/3-eras (8718)].

Instrument

In this study, researchers used two types of instruments to collect data: The Physics Problem Solving Ability Test (PPSAT) and the Metacognitive Skills Questionnaire (MSQ). These instruments were used to measure students' Physics problem-solving skills and metacognitive skills, respectively.

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Physics Problem Solving Ability Test

Problem-solving skills were assessed in this study by (1) understand the problem, (2) devise a plan, (3) carry out the plan, and (4) look back at the solution (Pólya & Conway, 1957). The Physics Problem Solving Skills Test, adapted from Abdullah (2005), was used to assess all four problem-solving skills. This test consists of four Physics questions. The Physics title chosen for this test is Force and Motion I from Chapter 2 of Physics KSSM Form Four. The topic of linear motion is used in the instrument for this study. The topic of linear motion was chosen specifically for this study because it requires understanding of Physics concepts as well as the application of mathematics. Students recognize Force and Motion I as a difficult topic because it is based on Newton's Mechanics and requires mathematical skills (Halim & Meerah, 2002). Mathematics is considered important in the field of Physics (Cassidy et al., 2002). However, in this topic, the mechanical application of mathematics without logic causes students to fail in problem solving due to the misuse of mathematical skills in Physics. Students are only tested in the determination of displacement to ensure consistency of the test. Furthermore, the topic of linear motion was chosen because it is covered in Chapter 2 of Form Four KSSM Physics. The students in this study had already gone through the process of learning this topic at the start of the school year, and they had been exposed to the concept of Physics involved in solving four different types of Physics problems in this test.

All of the formulas and equations required to solve these problems are included in the test. This is intended to eliminate errors in memorizing equations that could interfere with the study's data. There is no time limit for responding to this test. This allows students to answer the test without feeling rushed by the time limit. The researcher assumes that all of the study samples have the same mathematical abilities. As a result, in order to control these external variables, the researcher did not account for mathematical errors in the study sample's answers. This is because the test only captures Physics problem-solving skills. The four types of Physics questions in the test range in difficulty. This is to ensure that the test meets the achievement criteria of various schools in the Kota Kinabalu district of Sabah. Question 2, question 3, question 1, and question 4 are in ascending order of difficulty from easy to difficult. A 3-point scale is used to determine the skill level of participants in all four problem-solving processes during the assessment of problem-solving skills. Cronbach's alpha accounts at .770.

The research employed the content validity for test questions with the help of two expert Physics teachers and an SPM Physics paper examiner with nine years of experience examining SPM Physics papers. Furthermore, as suggested by Macintosh and Morrison (1969), the researcher used the discrimination index, D, and the difficulty index, F, to evaluate the appropriateness of each question in the Physics Problem Solving Test. In order to determine the construct validity of each item, item analysis is performed to determine the Difficulty Index (Facility Index, F) and Discrimination Index (D). According to the results of the item analysis, the first item has a value of F = 43 percent and D = .43, while the fourth item has a value of F = 40 percent and D = .40. The low value of the difficulty index, F, indicates that these two items are difficult and have a high level of difficulty. While a D value greater than .40 indicates that the item is valid, it can be used as suggested by (Macintosh & Morrison, 1969). The second item has a F = 71 percent and D = .05 value, and the third item has a F = 70 percent and D = .16 value. A high value of the difficulty index, F, indicates that the item is easy and straightforward. As suggested by HG and RB (1969), the discrimination index value D, .20 or below, is a weak item that must be improved or removed from the test. Accordingly, the researcher modified the second and third items as recommended by Macintosh and Morrison (1969). The difficulty index, F, and discrimination index, D, is displayed in Table 1 below.

Table 1
Physics Problem Solving Skills Test Item Analysis for Difficulty Index, F, and Discrimination Index, D

Items no.	**Difficulty Index, (F) / %**	Discrimination Index, (D)	Interpretation
1	43	.43	Accepted
2	71	.05	Modified
3	70	.16	Modified
4	40	.40	Accepted

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Metacognitive Skills Questionnaire

The researcher used an adapted version of Abdullah (2005)'s Metacognitive Skills Questionnaire. The original questionnaire has been modified in some way to better fit the needs or goals of the study or research being conducted. The purpose of adapting a questionnaire is to improve its effectiveness in gathering the desired information or data. This questionnaire set is based on the metacognitive skills proposed by (Hong, 1998; Jaušovec, 1994; Vos & de Graaff, 2004), where metacognitive skills are comprised of three constructs: monitoring, evaluation, and regulation. This questionnaire contains 25 questions in total. The first eight (8) items are monitoring components, followed by eight (8) evaluation components, and finally nine (9) regulation components. This questionnaire employed a 5-point Likert scale (1-strongly disagree and 5-strongly agree) to determine the level of agreement. Cronbach alpha values ranged from .694 to .802.

Data Analysis

Descriptive and inferential statistics were used with the SPSS Version 26.0 software to analyze the data. Mean, standard deviation, and percentage were utilized to describe the demographics of the respondents and the variables of the study. Through descriptive analysis, the researcher categorized the results of the mean score based on the percentage of the score that has been established for problem-solving skills, which are categorized into three levels: Good (70–100%), Medium (40–69%), and Weak (0–39%). The classification of mean score results for metacognitive skills is divided into three levels: low (mean 1.00-2.33), medium (mean 2.34-3.66), and high (mean 3.67-5.00). Inferential analysis is used to test research hypotheses regarding gender differences in problem-solving and metacognitive skills, as well as the influence of metacognitive skills on problem-solving skills. This study's inferential statistical analysis is presented as correlation table, *t*-test table, and linear multiple regression table.

Research Results

According to Table 2, the average mean score for all students on the monitoring construct is 4.116 (*SD* = .767), or 82.3%. This demonstrated that Form Four students had a high level of metacognitive skills when learning Physics for the monitoring dimension. The average mean score for the regulation dimension is 4.488% (*SD* = .691), or 89.8%, across all students. This indicated that Form Four students had a high level of metacognitive skills for learning Physics' regulation aspect. The average mean score for the evaluation dimension is 3.857 (*SD* = .835), or 77.1% across students. This demonstrated that Form Four students had a high level of metacognitive skills when learning Physics from an evaluation standpoint.

Meanwhile for problem-solving skills, the mean percentage score to understand the problems for all students is 1.609 (*SD* = .349), which corresponds to 53.6%. This indicated that Form Four students had a moderate level of Physics problem-solving skills with regard to identifying problems. Next, the mean score based on the percentage score for devise a plan for all students is .822 (*SD* = .266), or 82.2%. This demonstrated that Form Four students had a high level of problem-solving ability in terms of planning strategies. The resulting mean score based on the percentage score for carry out the plan for all students is 1.410 (*SD* = .518), which corresponds to 47.0%. This indicated that Form Four students had a moderate level of problem-solving skills in Physics in terms of implementing strategies. According to the percentage score for look back at the solutions, the mean score for all students is .154 (*SD* = .458), or 5.1%. This demonstrated that the level of Form Four students' problem-solving skills in Physics for the reflecting aspect is low.

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Table 2
The Students' Level of Problem-Solving in Physics and Metacognitive Skills

Variables	Dimensions	*M*	*SD*	Percentage (%)	Level
Metacognitive Skills	Monitoring	4.116	.767	82.3	High
	Regulation	4.488	.691	89.8	High
	Evaluation	3.857	.835	77.1	High
Problem-solving Skills	Understand the Problem	1.609	.349	53.6	Average
	Devise a Plan	.822	.264	82.2	Good
	Carry Out the Plan	1.410	.518	47.0	Average
	Look Back at the solution	.154	.458	5.1	Weak

Table 3 displays the Independent Sample t-Test analysis for gender differences in Physics problem-solving skills and metacognitive skills. The results show that there was a significant difference in Physics problem-solving skills based on gender (t = 2.714, p = .007). The mean score for the male students was higher (16.631) than the mean score for the female students (15.453). The results showed that the skill of "carry out the plan" (t = 2.215, p = .05) and "look back at the solution" (t = 2.882, p = .05) are significantly different based on gender. This demonstrates that male and female students had significantly different strategy implementation and reflective skill. The male students obtained a higher mean score of "carry out the plan" skill (5.85) than the female students (5.48), and the male students obtained a higher mean score of "look back at the solution" skill (.95) than the female students (.35). The study's findings, however, showed that "understand the problem" skill (t = 1.558, p = .121) and "devise a plan" skill (t =.198, p = .843) were not significantly different based on gender. This demonstrates that there was no significant difference in problem identification and strategy planning skills between the male and female groups of students.

In terms of metacognitive skills, the research findings in Table 3 show that there is no significant difference in metacognitive skills based on gender (t = -1.887, p = .06). This demonstrates that there was no difference in metacognitive skills between male and female students. Furthermore, it was discovered that only the regulation skill differed significantly between the groups of male and female students (t = -3.556, p < .001). The group of male students had a lower mean score (36.78) than the group of female students (38.818). The study's findings, on the other hand, show that the skills of monitoring (t = -.664, p = .508) and evaluation skills (t = -.229) were not significant. This demonstrates that there was no significant difference in monitoring and evaluation skills between the male and female groups of students.

Table 3
Physics Problem Solving Skills and Metacognitive Skills Based on Gender (N = 248)

Construct	Dimensions	Gender	*N*	*M*	*SD*	*t*	*p*
Physics Problem-solving Skills		Male	111	16.631	3.873	2.714	.007
		Female	137	15.453	2.701		
	Understand the Problem	Male	111	6.54	.970	1.56	.121
		Female	137	6.35	.944		
	Devise a Plan	Male	111	3.30	.870	.198	.843
		Female	137	3.28	.672		
	Carry Out the Plan	Male	111	5.85	1.38	2.22	.028
		Female	137	5.48	1.27		
	Look Back at the solution	Male	111	.946	2.03	2.88	.005
		Female	137	.350	.871		

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Construct	Dimensions	Gender	*N*	*M*	*SD*	*t*	*p*
Metacognitive Skills		Male	111	100.33	10.24	-1.887	.060
		Female	137	102.80	10.20		
	Monitoring	Male	111	32.766	3.448	-.664	.508
		Female	137	33.066	3.612		
	Regulation	Male	111	36.775	4.582	-3.556	< .001
		Female	137	38.818	4.430		
	Evaluation	Male	111	30.793	3.993	-.229	.819
		Female	137	30.912	4.179		

According to Table 4, metacognitive skills for the monitoring dimension have a statistically significant correlation ($r = .205$, $p < .001$) with Physics problem-solving skills. The significant positive correlation showed that students with high metacognitive skills in the monitoring aspect also had high Physics problem-solving skills. This study's findings also showed a negative and significant correlation between the metacognitive skills of the regulation ($r = -.094$, $p < .01$) and Physics problem-solving skills. The negative correlation showed that students with high metacognitive skills in terms of regulation had low Physics problem-solving skills. However, no significant correlation was found between metacognitive skills for the evaluation and Physics problem-solving skills ($r = .056$, $p > .05$).

Table 4
Pearson Correlation Analysis of Metacognitive Skill Dimensions and Physics Problem-solving Skills

Metacognitive Skill Dimensions	Physics Problem-solving Skills
Monitoring	.205**
Regulation	-.094**
Evaluation	.056

Note: $^{**}p < .001$

Table 5 displays the results of a multiple regression analysis examining the influence of metacognitive skills on Physics problem-solving skills. Results indicated that 8.6% of the variance in Physics problem-solving skills was significantly explained by monitoring, regulation, and evaluation skills. Monitoring skill was the strongest predictor of Physics problem-solving skills ($\beta = .279$, $p < .01$), followed by regulation skill ($\beta = -.265$, $p < .01$). However, evaluation skill was not a significant predictor of problem-solving skills in Physics ($\beta =.074$, $p > .05$).

Table 5
Predictors of Physics Problem-solving Skills (n = 248)

Dependent Variable	Predictor Variable	*F*	R^2	*df*	*β*	*t*	*p*
Physics problem solving skills	Monitoring	7.682**	.086	3 (244)	.279	3.765	< .001
	Evaluation				.074	.074	.401
	Regulation				-.265	-3.245	.001

Note: $^{**}p < .001$

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Discussion

This study aimed to examine the effect of metacognitive skills on Physics problem-solving skills among Form Four secondary school students in Kota Kinabalu, Sabah, Malaysia. The results of this study indicated that Form Four Physics students had a high level of metacognitive skills in the areas of monitoring, regulation, and evaluation. In addition, the findings of the study indicated that the level of problem-solving skills in Physics among Form Four students for "understand the problem" and "devise a plan" were moderate, while "carry out the plan" was good, and "look back at the solution" was low. Male students were also found to have higher problem-solving abilities in Physics compared to female students. In particular, male students had a higher skill of "devise a plan" and "look back at the solution" than female students. Regarding metacognitive skills in general, there were no gender differences. However, the male students had less regulation skills than the female students. Finally, monitoring and regulation skills are significant predictors of Physics problem-solving skills among Form Four students in this study.

Results of the study indicate that all students possess average problem-solving skills. This study's findings support (Sulaiman et al., 2007) finding that the level of Physics problem-solving skills among Form Four students in the state of Johor, Malaysia is moderate. By implementing a step-by-step problem-solving process proposed by Pólya and Conway (1957), a person can solve problems more efficiently and effectively. The importance of problem-solving skills in Physics subjects suggests that problem-solving skills should be emphasized more during the teaching and learning of Physics (Gerace & Beatty, 2005). Students with problem-solving skills can solve a problem in stages, beginning with identifying the problem. On the basis of the answer scripts, it was determined that the majority of students misunderstood some of the information in the question, and only a few were able to comprehend the problem adequately. This is consistent with the findings of the study, which indicate that students' understanding on the problem skills is at a moderate level. The majority of students are able to use equations or formulas that lead to the correct answer during the next phase, which entails devising a plan. Few individuals failed to list equations or used improper equations when solving problems. This is supported by the findings of the study, which indicate that students' ability to devise a plan are at a high level. Students then enter the stage of implementing a solution strategy, where it is discovered that the majority of students are able to execute a portion of the solution correctly, but only a few can execute the entire solution correctly. This is evident from the study's findings, which indicate that students' abilities to carry out the plan in terms of implementing solution strategies are average. The conclusion of problem-solving skills is looking back at the solution. The majority of students did not reflect on their solutions, and only a few were able to solve the questions correctly, based on their answer scripts. This is evident from the study's findings, which indicate that problem-solving skills in terms of reflecting aspects are lacking. Hence, in order to improve students' performance in Physics, teachers should place greater emphasis on the revision step, rather than simply guiding students to the final answer without revision. It is essential for students to review the solution so that the answers provided are accurate and to correct any errors in the solution work.

Results of this study reported that Form Four students had a high level of metacognitive skills in terms of monitoring, regulation, and evaluation. This finding supports Ogan-Bekiroglu and Dulger (2017)'s finding that students' metacognitive awareness lies between high and medium levels. This study found that students frequently practiced regulation skills, followed by monitoring, and evaluation skills, which is consistent with Leh (2010). The least practiced metacognitive skills, according to Leh (2010) findings, are reviewing the given answers, estimating the time allotted for each question, and asking oneself whether some information is required. Students learn to comprehend a problem in stages, beginning with the monitoring stage, for example, by reading the passage of the question multiple times, asking themselves if they understand the purpose of the question, and not straying from the focus of the problem, as well as allocating more time to comprehend the problem. Students then enter the regulation stage by, for example, recalling past learning experiences by associating them with the solution techniques learned to solve Physics problems; selecting, writing, and organizing relevant information to solve problems; and determining if unnecessary information is required to solve the problem. Students then enter the evaluation phase, in which they assess whether the calculations and answers provided are accurate and logical. Overall, the metacognitive skills of this study's respondents are highly developed. This demonstrates that respondents exercise metacognitive skills such as monitoring, regulating, and evaluating when responding to questionnaire questions.

The findings of this study concur with (Blue, 1997; Erickson & Erickson, 1984). In learning science, male secondary school students tend to perform better in Physics than female students. Male students were found to be superior to females in terms of applying Physics knowledge and skills. This study's findings, however, contradict with Abdullah (2005), who concluded that female students have significantly higher problem-solving skills in Physics

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than male students. The findings of this study, however, contradict those of (Leh, 2010; Tasir et al., 2008; Zakaria et al., 2009) who found no significant gender differences in metacognitive skills.

Linear multiple regression results also indicate that the metacognitive skill variables for the monitoring and regulation skills are significant predictors of Physics problem-solving skills, where monitoring skills are positively associated with Physics problem-solving skills and regulation skills are negatively associated with Physics problem-solving skills. Previous research has emphasized that metacognitive skills are an important aspect of problem solving (Schoenfeld, 2016) and that they are also factors that can improve a person's problem-solving performance (Abdullah, 2009; Özsoy & Ataman, 2009). This is due to the fact that students with a higher metacognition level solve problems more effectively and efficiently than those with a lower metacognition level (Swanson, 1990). Davidson et al. (1994) propose that metacognition is an important process that contributes to a person's performance in problem-solving by identifying problems, imagining the problem in the mind, planning a solution strategy, and evaluating the solution strategy that is believed to solve the problem. The findings of this study suggest that when students apply the monitoring aspect, such as re-reading the passage of the question, asking themselves if they understand the purpose of the question, and not straying from the focus of the problem, as well as allocating more time to comprehend difficult problems, their likelihood of solving Physics problems successfully is high. In addition, the students in this study utilized the regulation aspect. For instance, if by recalling past learning experiences by relating them to previously learned solution techniques to solve Physics problems, selecting and writing and organizing relevant information to solve problems, and by asking whether there is information that is not needed in solving the problem, a student has a low likelihood of successfully solving the Physics problem, then the student's probability of success is low.

Nonetheless, there are a number of limitations associated with this study. There were only 248 Form Four students from the Kota Kinabalu area included in this study. It is suggested that the population for future studies be expanded to include areas outside of the Kota Kinabalu district. In addition, only thirteen urban secondary schools were included in this study. Previous studies discovered that there was a significant difference between urban and rural students' metacognitive skills and Physics problem-solving skills, with urban students having better metacognitive skills than rural students, but rural students having better Physics problem-solving skills. Therefore, it is recommended that additional research be conducted in rural secondary schools to determine if this phenomenon also occurs there.

Conclusions and Implications

This study is noteworthy because it provides insights into metacognitive skills, which may impact Physics problem-solving skills among Form Four students in Kota Kinabalu, Sabah, Malaysia. This study has shown an ideal framework for understanding the interaction between students and teachers, concentrating on crucial metacognitive skills such as monitoring, in particular is found to have the greatest impact on Physics problem-solving skills. Nonetheless, since the impact of COVID-19 continues to put pressure on most Malaysian secondary school teaching and learning, it is critical for these secondary schools to adopt proper strategy and make effective choices to overcome these obstacles in order to preserve a conducive teaching and learning especially in the Physics course. Notably, this research has contributed to the literature by examining the metacognitive skills' dimensions and discovering that these are things that enhance secondary school students' problem solving in Physics in Sabah, Malaysia. This study can be used as both a reference and a study guide to learn about the role of metacognitive skills in assisting students to solve problems in Physics. If they are favorable, they can contribute to the advancement of science education.

This study has significant implications, particularly for secondary school students and Physics teachers. At school, not only is the student's success a top priority, but also the student's outstanding academic achievement. This study demonstrates that students do not apply problem-solving skills when answering Physics questions, particularly during the reflecting phase. To achieve success, particularly in Physics courses, students must be adept at solving Physics problems based on Polya's Problem Solving Model, which are: understand the problem, devise a plan, carry out the plan, and look back at the solution. Students must be taught metacognitive skills such as monitoring, regulation, and evaluation, in addition to problem-solving abilities. Students have a high probability of achieving success when they employ metacognitive skills in problem solving. In addition, metacognitive skills can be applied to problem solving in everyday life, as it has been scientifically demonstrated that students with a high level of metacognition solve problems more effectively and efficiently than those with a low level of metacognition.

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Teachers should be aware of the significance of metacognitive skills in the teaching and learning of Physics-related subjects, particularly in solving Physics-related problems. The three fundamental components of metacognitive skills should be applied. If these three components are implemented and applied to the solution of Physics problems, it is likely that prospective students will solve Physics problems more effectively and efficiently because it has been scientifically demonstrated that the application of metacognitive skills in solving Physics problems can help students solve Physics problems more effectively and lead to more encouraging Physics results. Hence, Physics teachers should reveal and then apply metacognitive skills in the teaching and learning process, especially when guiding students to solve Physics problems.

The primary research instruments used in this study are quantitative survey research and questionnaires. For future research, it is recommended that this study be conducted experimentally or qualitatively using interview and observation techniques. In addition, it is recommended that additional research be conducted to examine in greater depth aspects of metacognitive skills and Physics problem-solving skills in relation to the efficacy of teaching and learning Physics. Through the findings of this study, interested parties can be guided in the design and development of teaching and learning strategies, resulting in more effective teaching methods for Physics subjects.

Declaration of Interest

The authors declare no competing interest.

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