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Investigating the Relationship between the Frequency of Laboratory Activities and Academic Performance in Science among Secondary School Students

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ABSTRACT

This study investigates the relationship between the frequency of laboratory activities and academic performance in science among secondary school students in Malaysia. It also explores students' perceptions of laboratory-based learning and how these perceptions relate to their academic outcomes. Guided by John Dewey's experiential learning theory and Kolb's learning cycle, the study emphasizes learning through experience, reflection, and active engagement which are the core principles of laboratory-based instruction. This research used a quantitative survey method involving 234 students from Form 3 to Form 5 in a secondary school in Selangor. Data was collected through a structured questionnaire and analyzed using descriptive and inferential statistics, including Spearman correlation analysis. The results revealed that the frequency of laboratory activities varied among students, with some experiencing adequate hands-on sessions and others fewer practical work throughout the year. Students generally had positive perceptions towards laboratory activities, acknowledging their role in enhancing understanding, skills development, and application of theoretical knowledge. The study found no significant relationship between the frequency of laboratory activities and academic performance. This study provides valuable insights for educators and policymakers to emphasize the quality and meaningful integration of laboratory activities in the science curriculum.

1. Introduction

Laboratory activity refers to the hands-on activities that provide the students with the opportunity to question, manipulate, observe, synthesize, and experiment with the existing knowledge that was learned in the classroom [1]. Laboratory activities also include any experiments or tasks that were done in the school laboratories [2]. The science education curriculum in Malaysia aims to teach students about scientific concepts, develop skills, and apply them in a scientifically minded environment [3]. Laboratory activities are very crucial in teaching and learning science subjects in

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schools [4]. It able to produce highly capable, science-literate students who are proficient in applying scientific knowledge in order to resolve problems and make judgements in the context of everyday life [5]. According to Fadzil and Saat [6], practical work or laboratory activities are needed, especially in learning science subjects as the evidence from the theoretical knowledge learned in class. Other than that, students are able to observe, measure, predict, interpret, and experiment during the laboratory lessons conducted at school [7]. This teaching method can be seen as a tactic that could be used to make the process of teaching easier to explain to the students rather than giving lectures, showing videos and so on [5].

The importance of laboratory activities in science education has been emphasized since the 18th century, when many researchers proved the various advantages of conducting laboratory experiments for students. By completing the laboratory activities, students can enhance their understanding of the theories learned and improve their scientific knowledge and laboratory skills [4]. Based on Dokumen Standard Kurikulum dan Pentaksiran (DSKP), students are given the opportunity to design the experiments instead of following the textbook procedures. Students should be able to plan the experiments, collect and analyze the data, discuss the results and conclude their findings. Hence, these laboratory activities can enhance the student's scientific skills and encourage them to collaborate with fellow students.

The government strongly supports the efforts to improve science or STEM education by proposing huge funds for this sector to empower science education in Malaysia [8]. For example, in terms of providing infrastructure that is conducive to a science laboratory to make it easier for students to conduct experiments. Students gain a better understanding of the science concept and construct new knowledge based on their understanding by doing laboratory activities [3].

Practical works are designed in the standard curriculum to give students opportunities to experience hands-on activities in the laboratory. Chu [9] stated that hands-on activities like laboratory work are able to improve students' understanding of science concepts. Nonetheless, laboratory activities are given the least attention in science education based on past studies, and recent research in 2020 also proved that laboratory activities are not emphasized enough [6]. Students are also not able to justify the concepts and theories that they have learned in the classroom. Without the laboratory activities, practical skills are not well developed among the secondary school students [10].

However, the data of the frequency of the laboratory activities in science among secondary school students in Malaysia is absent. While our neighbour country like Indonesia and Vietnam already conducted the study on the utilization of practical works for science teaching and learning [11,12]. There was only the data on the frequency of laboratory activities in biology conducted in Malaysia. According to the findings, 47% of Malaysian students agreed that science teachers use the lecture teaching method most of the time, and only less than half of the lessons were taught using the laboratory works or experiments method despite having adequate facilities and materials [6].

Despite the recognized importance of laboratory activities in science education, their actual implementation in Malaysian secondary schools remains underexplored. While countries such as Indonesia and Vietnam have examined the frequency and impact of practical work, limited research in Malaysia has investigated how often laboratory activities are conducted and whether they influence students' academic performance. Existing evidence suggests that many lessons continue to rely on lecture-based approaches despite the availability of facilities, raising concerns about the meaningful integration of hands-on learning. Addressing this gap is crucial, as understanding the current state of laboratory activity utilization will provide insights into its role in shaping students' scientific understanding and achievement. Such findings are valuable for policymakers and educators in designing initiatives that enhance the quality and impact of science education. Therefore, this

study aims to examine the relationship between the frequency of laboratory activities and students' academic performance in the science subject among secondary schools in Selangor state.

Following are the research questions of this study:

1. What is the frequency of laboratory activities conducted in science teaching and learning among secondary school students in Selangor?
2. What are the perceptions of secondary school students toward laboratory activities in science subjects?
3. Is there a significant relationship between the frequency of laboratory activities and students' academic performance in science?

2. Literature Review

2.1 Theories

John Dewey (1858–1952), an influential American philosopher and educational reformer, is widely recognized for his contributions to progressive education and experiential learning [14,15]. Dewey proposed that effective learning occurs when students actively construct knowledge through direct experience rather than passively receiving information. He emphasized that education should connect theory to practice, allowing learners to interact, reflect, and apply knowledge in real-life contexts [16]. According to Dewey, meaningful learning emerges through social interaction, hands-on activity, and reflective thinking. His "learning by doing" philosophy promotes critical and creative thinking as students engage in problem-solving and inquiry-based activities. In science education, laboratory activities embody Dewey's principles by requiring learners to experiment, observe, and reflect, thereby deepening understanding and fostering lifelong learning.

David Kolb [17] expanded on Dewey's ideas through his Experiential Learning Theory (ELT), describing learning as a cyclical process grounded in experience. Influenced by theorists such as Kurt Lewin, Jean Piaget, and Dewey, Kolb proposed that knowledge is created through transforming experience [17]. His model consists of four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation [18]. Kolb's model highlights that effective learning requires engagement in all stages which are experiencing, reflecting, conceptualizing, and applying. Within this study's context, laboratory work aligns with abstract conceptualization and active experimentation, where students move from theoretical understanding to real-world application. This process reinforces the link between thinking and doing, central to experiential learning.

2.2 Frequency of Laboratory Activities in Teaching and Learning Science

The frequency of laboratory sessions varies across schools depending on resources and teacher readiness. In Indonesia, Mukra *et al*., [11] reported high laboratory utilization due to well-maintained facilities and teacher support. In contrast, Huong *et al*., [12] found low laboratory activity frequency in Vietnamese schools due to inadequate equipment and unqualified teachers, which hindered student engagement and performance. Similar resource constraints are evident in Malaysian schools [8].

Rogers and Fraser [13] observed that students who engaged more frequently in laboratory work demonstrated better attitudes and motivation in science learning. Overall, contextual factors such as

infrastructure, curriculum, and teacher competency significantly influence how often laboratory sessions are implemented.

2.3 Students' Perceptions Toward Laboratory Activities

Laboratory learning enhances students' understanding, motivation, and skills by turning abstract ideas into observable experiences. Studies show that students develop more positive attitudes and deeper comprehension when science lessons include experiments and group activities [19,20]. Conversely, traditional lecture-based approaches reduce interest and engagement [21]. Regular laboratory exposure encourages active participation, collaboration, and critical thinking are the key aspects of meaningful learning.

2.4 Relationship Between Frequency of Laboratory Activities and Academic Performance

Previous studies consistently show a positive relationship between laboratory exposure and academic achievement. Asiyai [22] and Shana and Abulibdeh [4] found that students participating in frequent laboratory sessions achieved higher post-test scores and better conceptual understanding. Similar findings were reported by Ntawuhiganayo & Nsanganwimana [2], confirming that laboratory experiences enhance academic performance compared to conventional instruction. Collectively, these studies underscore the importance of practical work in improving science learning outcomes. A meta-analysis by Mao *et al*., [23] also supported this relationship, revealing that students with more positive attitudes toward science often fostered through laboratory experiences tend to achieve higher academic results.

3. Methodology

This research used a quantitative design with a survey research approach to identify the frequency of laboratory activities in secondary school setting, students' main perception toward laboratory activities and the relationship between the frequency and academic performance in science.

3.1 Research Instruments

The instruments were divided into three different sections, labelled as Section A, B, and C. Section A consisted of personal information questions, while Sections B and C contained 16 questions related to the research questions. As for Section B, there was only one question which asked on the frequency of laboratory activities in secondary school for the science subject. The item used a multiple-choice question. There were 4 options for this item. Respondents answered based on their experience on conducting laboratory activities during their learning period. The item was adopted and adapted from research by Rogers and Fraser [13]. Section C contained three parts, which assessed students' perceptions towards laboratory activities in different aspects, such as study, skills development, and the practical application of theoretical knowledge. Each questions have 5 sub-questions that focus on identifying the students' main perception of laboratory activities. The type of items in this section was Likert scale items. There were four scales, which were Strongly Agree, Agree, Disagree and Strongly Disagree. To guarantee its validity and reliability, the questionnaire for this section was self-created and examined by two experts who assessed the items' clarity, structure,

and content. They then used their views to improve the questionnaire and make it a trustworthy instrument for gathering data.

The instruments in Section C were analysed for reliability by using the Cronbach's Alpha value. The Cronbach's Alpha value for Part A was 0.767, which indicates a good reliability of the items in this part. Next, Parts B and C also showed a good internal consistency of the items, which scored 0.749 and 0.718, respectively.

Table 1
Reliability analysis using Cronbach's Alpha for item in section C

Items	Perception towards laboratory activities	Cronbach Alpha Value
	Part A: Perception of Students About Laboratory Practical Impact on Study	0.767
	Part B: Perception of Students About Laboratory Practical Impact on Skills Development	0.749
	Part C: Perception of Students About Laboratory Practical Impact on Practical Application of Theoretical Knowledge	0.718

3.2 Research Sample and Population

The target population for this research was secondary school students in one of the schools in Selangor. Students who are in Form 3 until Form 5 were chosen to participate in this study. The simple random sampling approach was used to select the samples. The total number of target population was 625 students where 144 students were Form 3 students, 118 was Form 4 students and 132 students in Form 5. For this research, the sample size was chosen by using the Krejcie and Morgan Table. A total of 234 students were randomly selected and balanced to form the sample and taking into account the total number of students. For example, the number of students in Form 3 was the highest, so the sample size for Form 3 was also the highest compared to other forms.

3.3 Data Analysis Procedures

The collected data were entered into SPSS for processing and analysis. Descriptive statistics, including mean, standard deviation, percentage, and frequency, were applied to summarise the responses, while Spearman's correlation analysis was employed to examine the relationship between laboratory activity frequency and students' academic performance.

Ethical clearance for this study was granted by UiTM's Research Ethics Committee (Approval Code: ED/REC/F/11545), and permission was also obtained from school administrators, teachers, and parents prior data collection. All student participants were briefed about the study, assured of confidentiality, and provided informed consent before completing the survey.

4. Results and Discussion

4.1 The Frequency of the Laboratory Activities in Teaching and Learning Science at Secondary Schools

The data in Table 2 revealed the frequency of science laboratory activities conducted in secondary school settings. 66.7% of the respondents reported conducting laboratory activities between 6 to 10 times a year. Additionally, 17.9% of them indicated conducting laboratory activities 11 to 15 times annually. A smaller proportion, which was 15.4%, reported that such activities were carried out fewer

than five times a year. Notably, none of the respondents conducted laboratory activities more than 16 times a year.

Table 2
Frequency and percentage of laboratory activities in science classrooms in secondary school

Item	Category	Frequency	Percentage (%)
How often do you conduct laboratories activities during learning process	Less than 5 times a year	36	15.4
	6-10 times in a year	156	66.7
	11-15 times in a year	42	17.9
	16-20 times in a year	0	0

4.2 The Main Perception of Secondary School Students toward Laboratory Activities

Based on Table 3, in Part A, the impact of the study indicated that students perceived laboratory practical as a valuable component in improving their academic understanding of science. The highest mean score (M = 3.42) was recorded for the statement "Performing practical promotes my understanding of the topics better" which reflects strong student agreement on the role of laboratory activities in reinforcing theoretical concepts. However, the statement "Laboratory practical contributes to my academic performance" received the lowest mean score which was 3.13.

On the other hand, Part B assessed students' perception towards laboratory activities on skills development. The highest mean value was recorded for the statement "Practical experiments in the laboratory help develop my observation and interpretation skills", with a score of 3.37. In contrast, students perceived that laboratory practical were less effective in improving their technical skills, like instrumentation operations and reporting, as it recorded the lowest value among the statements, M=3.0.

Lastly, students generally agreed that laboratory practical facilitate the application of theoretical knowledge in real-life contexts. The analysis generally revealed a positive response which a range of mean value between 3.14 to 3.29. Students believed that their participation in laboratory activities aided them to understand and utilize the scientific method, at the same time enabling them to apply theoretical knowledge in real-world situations which recorded mean value of 3.29 and 3.21, respectively. Nevertheless, the lowest mean was observed for the statement "Planning and organising tasks ahead of time is instilled in me through laboratory practical", which scored mean of 3.14.

Table 3
Mean value of perception towards laboratory activities among secondary school students

Part	Category	Mean Value
A: Perception of Students About Laboratory Practical Impact on Study	Performing laboratory practical promotes my understanding of the topics better.	3.42
	Laboratory practical increases my interest in studying science.	3.39
	Laboratory practical helps me bridge the gap between theory and practice.	3.14
	Laboratory practical makes me more confident in applying theoretical knowledge to practical scenarios.	3.23
	Participating in laboratory practical significantly contributes to my overall academic performance.	3.19

B: Perception of Students About Laboratory Practical Impact on Skills Development	Engaging in laboratory practical enhances my problem-solving abilities.	3.25
	Laboratory practical contribute to the enhancement of my critical thinking capabilities	3.37
	Group practical work improves my communication skills and teamwork.	3.33
	Laboratory practical helps me to develop my technical skills such as instrumentation operations and reporting.	3.0
C: Perception of Students About Laboratory Practical Impact on Practical Application of Theoretical Knowledge	Laboratory practicals deepen my comprehension of theoretical concepts.	3.17
	Laboratory practical sessions enable me to apply theoretical knowledge in real-world situations.	3.21
	Laboratory sessions showcase the real-world applications of my studies.	3.19
	Participating in laboratory sessions helps me understand and apply scientific methods.	3.29
	Planning and organising tasks ahead of time is a skill instilled in me through laboratory practical.	3.14

Hence, the main perception of secondary school students towards laboratory activities was the impact on their study. Based on the Table 4, the highest means are mean score for this domain was the highest, M=16.31. Followed by skills development and application of theoretical knowledge with the score 16.15 and 15.99 respectively.

Table 4
Mean and standard deviation of three domains in students' perceptions towards laboratory activities

	N	Mean	Std.Deviation
Part A	234	3.26	0.39
Part B	234	3.23	0.41
Part C	234	3.20	0.37

4.3 *The Relationship between the Frequency of Laboratory Activities and Academic Performance in Science*

The analysis aimed to determine whether there is a significant relationship between the frequency of conducting laboratory activities and students' academic performance in science. The Spearman's rho correlation coefficient was -0.103, suggesting a weak negative relationship between the two variables. The relationship is statistically not significant, p-value 0.115.

Table 5
Spearman correlation analysis between the frequency of laboratory activities and academic performance in science. p-value > 0.05

	Academic performance in science	
	r	p value
Frequency of laboratories activity	-0.103	> 0.05

The findings indicate that the frequency of the laboratory activities was moderate to high. Majority of the secondary school students reported they have completed laboratory activities 6 to 10 times a year which aligned with the expectations outlined in the national science curriculum which prescribes the compulsory experiments to be conducted in one year. The result was compared against the Dokumen Standard Kurikulum dan Pentaksiran, it aligned well with the national expectations. According to the DSKP [3], students in Form 3 were required to complete seven core experiments while Form 4 and Form 5 have six core experiments each. In contrast, science textbooks from Form 3 to Form 5 provide twenty to twenty-five experiments in total, combining both compulsory and suggested activities. Therefore, the reported frequency from students suggested the school met or exceeded the minimum requirement, especially if only core experiments were used as the benchmark. This was a positive indication of efforts to promote hands-on, experiential learning in science education which aligned with the theories by John Dewey and Kolb theories [14,15].

Based on Table 4, the main perception of secondary school students toward laboratory activities was impact on study. They agreed that laboratory activities able to improve their understanding on science concepts. This finding is supported by past research by Nicol et. Al [16], where the participants stated that the abstract concepts became clearer when it was associated with a laboratory activity. Students' motivation and attitudes were improved when the laboratory activities in science were implemented. Laboratory teaching dramatically improved students' perceptions of their learning environment [16]. When students have positive attitude towards science, hence it also can improve their perception towards laboratory activities. Secondary school students agreed that completing the laboratory activities can improve their comprehension of the concepts learned in the class. This can be proven in another study where the laboratory activities are able to improve students' performance in science where the post-test results showed higher marks compared to before intervention of laboratory activities during the teaching and learning process [17]. This showed that laboratory activities supported the overall students' study and achievement in this subject.

However, based on Table 5, this study contradicted with the previous research that claimed a positive relationship between laboratory activities and students' academic performance. Based on the Spearman correlation coefficient, a weak negative correlation was found, and this relationship was not statistically significant. This suggests that increased frequency of laboratory activities did not correlate with higher academic achievement. These findings suggested that it is not the frequency of activities matters most, but rather how those activities were implemented and how students perceived it. Simply increasing the number of laboratory sessions without attending to students' interest, prior knowledge or the cognitive demands of the tasks may yield little to no improvement in learning outcomes.

5. Conclusion

In conclusion, this study investigated the relationship between laboratory activities and students' academic performance in science at secondary school level. The results revealed a negative relationship between the two variables which led to another critical finding where the students' academic performance was more strongly influenced by their level of interest in science rather than the frequency of laboratory activities conducted. The findings carry important implications for teaching practices in secondary schools. Laboratory activities should go beyond the procedural execution and involve students in higher- order thinking, problem solving and meaningful reflection. Implementation of high-quality laboratory activities more frequently may help the secondary school students to achieve better in science. By cultivating students' intrinsic interest in science alongside

hands-on experience, teachers can create a richer and more meaningful learning environment that not only improves academic outcomes but also nurtures long-term positive attitudes and aspirations towards science-related fields.

6. Limitations

This study is subject to several limitations that should be acknowledged. First, the research was conducted in a single secondary school in Selangor, which restricts the generalizability of the findings to wider student populations across Malaysia. Second, the study employed a cross-sectional design, providing only a snapshot of relationships between variables without establishing causality. Third, the data were collected through self-reported questionnaires, which may be influenced by response bias or students' subjective perceptions. Additionally, the study measured only the frequency of laboratory activities rather than their quality, duration, or pedagogical approach, which could also affect learning outcomes. Future research should therefore include multiple schools, combine quantitative and qualitative data, and consider observational or longitudinal designs to provide a more comprehensive understanding of how laboratory practices influence students' academic performance and interest in science.

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Author Contributions Statement
S.H.N.H performed data collection and write the manuscript. A.Y.F.K supervised the project and reviewed the manuscript. Both authors contributed to manuscript revision, read, and approved the final version.

Data Availability Statement
All data generated or analyzed during this study are included in this published article. Additional datasets are available from the corresponding author upon reasonable request.

Ethics Statement
This study was conducted in accordance with the ethical standards of the Universiti Teknologi MARA ethics board. Ethical approval was obtained where required, and informed consent was obtained from all participants involved in the research.

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