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Exploration of the Experience of Hands-On Learning and Its Impacts on STEM Learning

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Annotation. The article aimed to assess the effects of hands-on learning on communicating STEM concepts. A survey was carried out involving 47 students at a gifted and talented center in Selangor, Malaysia. It was observed that after engaging in hands-on learning, there was a significant difference in the performance of the students, based on an evaluation of the pre- and post-test scores. The survey analysis shows the variables tested have positively influenced student learning. This paper is instrumental in assuring educators of the effectiveness of hands-on activities during STEM lessons.

Keywords: *hands-on learning, perceived learning, engagement, interaction, satisfaction.*

Introduction

Nowadays, promoting student interest in STEM, and particularly in science, has become a crucial educational goal among researchers due to a declining interest in STEM in secondary schools (Steidtmann et al., 2022). Malaysia greatly idealizes STEM education since it contributes to the nation's growth, produces the necessary number of STEM workers, and will eventually meet the demands and overcome all the hurdles of a STEM-driven economy (Aspin et al., 2022). According to Meng et al. (2014), the enrollment of science students at the Malaysian secondary school level has shown a decline, causing serious concern about how to create student interest in STEM. The perception that STEM fields are very difficult causes interest in these fields to decline. Teachers play a vital role in revitalizing interest in these subjects by presenting innovative and creative ways of teaching. Learning theories frequently cause students to get bored (Shasitiran, 2023).

Engaging students in STEM-based activities permits students' ideas and understanding to be tested, compared to the traditional way of hearing and reading about a topic (Ewers, 2001). STEM programs that exclude science experiences are hard to conceptualize (Ates & Eryilmaz, 2011). In Malaysia, as part of various STEM initiatives, the Malaysian Education Blueprint intends to raise student interest through new learning approaches, thus enhancing the curriculum and sharpening the skills and abilities of educators by considering how students can succeed in the 21st century and beyond (Ministry of Education, 2013).

In order to create individuals who can utilize and manage science and technology resources, it is crucial to foster interest in STEM (Vennix et al., 2018). One situational aspect that is frequently believed to spark students' interest and inspire them to learn science is practical work, also known as hands-on experience (Bergin, 1999). Educational authorities strongly advocate the use of hands-on activities in STEM classes (Shahali et al., 2017). Therefore, teachers play a crucial role in developing strategies for enhancing student engagement and curiosity in STEM subjects (Shasitiran, 2023). Given the increasing demand for education reform in STEM, the intention of this research was to explore the effects of hands-on learning instruction techniques on communicating STEM concepts during classes.

Literature Review

Hands-on Learning

Hands-on learning approaches have been promoted by researchers around the world in recent years. Various interpretations have also been proposed for hands-on learning. One of the most widely known and accepted definitions of hands-on learning is "learning by doing" (Sadi & Cakiroglu, 2011). According to some experts, hands-on learning improves a student's ability to think critically as part of a comprehensive learning experience (Haury & Rillero, 1994). Thus, hands-on activities imply experiential learning (Holstermann et al., 2010).

In a study conducted at secondary schools in Narayanganj, Bangladesh, it was found that the focus on multiple senses during hands-on learning inspired students and increased their standards of learning and participation. Furthermore, hands-on learning assisted the students with the problem-based approach by enabling them to engage in the experience and process of finding solutions (Musharrat, 2020). Hands-on learning also assisted students in acquiring the necessary skills, knowledge, and attitudes as a result of their active participation in the learning process. The goal of hands-on learning is to help students learn and understand a subject (Albadi, 2019). Musharrat (2020) discovered that hands-on learning helped students engage more consciously and actively in their learning. Moreover, Albadi (2019) stated that hands-on learning is an effective method for assisting students to gain a deeper grasp of the knowledge that is essential for their class.

Furthermore, hands-on learning plays an essential role in boosting motivation among higher secondary school students. In a study involving 30 students from a higher secondary humanities education combination group, a positive effect of hands-on learning was observed in terms of the students' motivation and academic achievement. Hands-on learning proved more successful in developing the students' higher-order thinking capabilities. Furthermore, the research findings revealed that hands-on learning produced a joyful and curious classroom atmosphere. It also improved the students' lesson engagement in comparison to traditional teaching. Besides that, it became the students' favourite learning strategy (Anwer, 2019).

The findings of another survey study at CQUniversity, Australia, provided valuable insights into the students' views on hands-on learning during an engineering skills course. The findings indicated that the students thoroughly appreciated the hands-on activities of the course. This was due to the students' positive attitudes towards the use of hands-on activities during learning, which enhanced their knowledge of engineering as a career (Patil et al., 2009). Similarly, Ravi and Xaviera (2007) discovered that hands-on learning assists students to prepare mentally, besides physically exploring a subject's content by creating a work environment that is identical to the world of work. In a study conducted in the north of Germany, a total of 141 students from biology education classes answered a survey on interest in and experience of hands-on learning. The findings suggested that different hands-on activities might stimulate a student's curiosity in different ways. Based on the study, hands-on experience had a positive effect on interest, which is pertinent to hands-on learning (Holstermann et al., 2010).

In addition, in a study conducted in a public school in Ankara, Turkey, the positive impact of hands-on learning on the achievement of ninth-grade physics students was observed. In this research, the respondents were divided into an experimental group with 70 students and a control group with 60 students. The monitored group was exposed to the traditional teaching method in the classroom. The hands-on learning instruction was deemed comparatively more effective, as the students gained significantly higher achievements in physics than those learning via the traditional method (Atez & Eryilmaz, 2011).

Previous research has also indicated the significance of hands-on learning in science education (Jirout & Klahr, 2012). In a study conducted in Tanzania involving 169 senior chemistry students, it was revealed that the students demonstrated scientific curiosity when hands-on learning was conducted, and this was found to be among the most effective approaches to fostering their curiosity. Furthermore, hands-on learning during the chemistry lessons was able to develop the students' desire for learning (Kibga et al., 2021). Similarly, Ajayi (2017) observed that hands-on learning during chemistry lessons resulted in considerably greater mean interest levels than when other methods were used, such as group discussions. Thus, the use of hands-on learning by chemistry teachers should be encouraged to enhance students' interest in chemistry.

By investigating subject matter through hands-on activities, students acquire both the content and the thinking process. Hands-on learning has been shown to support problem-based learning by emphasizing the experiences and skills associated with science processes, including exploring, suggesting, proposing, and finding solutions (Musharrat, 2020). Consequently, students should be physically and mentally connected to hands-on learning experiences that motivate them to think critically (Victor & Kellough, 1997).

The Role of the Teacher in Hands-On Learning

Generally, secondary education is the foundation of future education as it prepares students for higher education. Thus, the use of the right approach at the secondary level to construct scientific knowledge is essential and of considerable concern to educators (Adak, 2017). Previous studies have identified a lack of satisfactory teaching methodologies as one of the main factors of students' failure in basic science. Many teachers are attempting to modify their teaching practices to encourage critical thinking among their students.

Qahtani (2016), for instance, encouraged the use of different teaching methods so that students with different learning abilities would acquire the necessary information, as well as gain knowledge and advancement in the education system. Moreover, it has been observed that teachers act as facilitators, delegators, and personal models to instill knowledge in students during the learning process (Qahtani, 2016). Teachers are no longer information transmitters (Albadi, 2019). According to Gill (2013), teachers are not entertainers but have a crucial role in engaging students in the learning process. A teacher's self-inventory of their students' strengths and weaknesses can identify the learning needs of the students and their most preferred learning methods.

A gradual transformation from a conventional instructor-centered method to student-driven learning in acquiring knowledge is highly recommended by Bhalli et al. (2016). A structured active teaching format is an exciting alternative teaching format for students (Bhalli et al., 2016). Based on hands-on research, gaining knowledge and independent skill development depend greatly on the multi-role of educators. One of their roles is to create an educational environment by giving pertinent support and guidance at each cognitive level to enable first-hand knowledge to be attained (Kudryashov et al., 2016).

In research conducted among the upper basic level students in Nigeria, it was recommended that teachers employ appropriate activity-based learning strategies and submerge them into daily lesson plan sessions to enhance students' learning outcomes (Mustapha et al., 2020). Lessons created by teachers during hands-on learning give students quality and positive experiences (Holstermann et al., 2010). Bahadir and Ozdemir (2013) highlighted that teachers should organize hands-on activities according to their priority to create 'learning by doing' and experiences of a learning environment.

Although the role of teachers is crucial in conducting hands-on learning, some teachers are opposed to interactive classrooms because the activities are time-consuming, which means the teachers are unable to cover the syllabus completely (Ekwueme & Meremikwu, 2010). In a study on the success and challenges of hands-on learning, it was found that teachers were less aware of conducting hands-on learning, especially in science classes. Apart from that, the development of teaching materials, exam-oriented systems, inadequate teaching, and overloaded classes were found to be the major challenges preventing the effective application of hands-on activities in science classrooms (Musharrat, 2020).

However, research has confirmed that teaching is highly linked with innovation and creativity. As teaching skill encompasses innovation and creativity, alongside adequate instructional resources, it can increase students' thinking and essential skills (Rif'at et al., 2020). Younis (2018) also supported the claim that teachers' creativity when introducing subject content to students can attract the students' interest and engage them in learning. Albadi (2019) emphasized that teachers are central members of the teaching and learning community; henceforth, they should act as good leaders in the classroom by advancing knowledge and asking deeper questions, besides avoiding the direct delivery of subject content. The literature related to this study shows the importance and the essential function of teachers in facilitating hands-on instruction. Very few studies have investigated the significance of hands-on-based learning on students' retention levels in STEM-based subjects.

STEM education is emphasized in Malaysia's Education Blueprint 2013–2025 as a key objective for preparing students for the challenges of the 21st century. Therefore, the government has enhanced the education system by implementing STEM education in schools (Ministry of Education, 2013). Unfortunately, despite the government's best attempts to improve STEM through a variety of policies and efforts, student enthusiasm for STEM has declined in recent years (Rasli et al., 2020). This decrease is a serious and alarming issue. On a practical level, it is obvious that in schools, where there were previously four or five STEM classes, there are now just one or two (Bernama, 2019). According to research by the Ministry of Education (2013), students believe that excelling in STEM disciplines is more challenging than excelling in the arts. Due to this impression, many students have chosen arts courses over the discipline of science.

Based on previous studies, learning experiences play an essential role in preparing students for future problems they will encounter in STEM fields of study (Ng, 2016). Studies show that hands-on learning experiences are crucial, regardless of the outcome, since they stimulate students' interest in selecting STEM-related fields for their future employment (Aeschlimann et al., 2016; Lent et al., 2018). During the learning process, engagement concentrates on students' attitudes and dispositions toward lifelong learning and classroom experiences. This should encourage instructors to efficiently design classes and activities that stimulate students to take an active role in their education by assessing the degree of student engagement (Mandernach et al., 2011). Zhuang et al. (2020) highlighted that students' views of the STEM education experience are reflected in their levels of satisfaction. In addition, student satisfaction has a significant impact on motivation, aptitude, and interest in engaging in classes (Scholtenhuis et al., 2021). In terms of student interaction, Garrion et al. (2000) discovered that student interaction was crucial for achieving more profound levels of discourse and idea development. Lin (2016) stated that perceived learning is a retrospective self-evaluation of how significantly students feel they have learned from an educational experience. Throughout the teaching and learning process, the factors engagement, satisfaction, interaction, and perceived learning are interconnected to each other. Therefore, this study aims to evaluate students' engagement, satisfaction, interaction, and perceived learning in STEM-based subjects after the implementation of hands-on learning. The primary objective of this research was to identify any significant difference in student performance before and after hands-on learning, besides evaluating the significance of the effect of each variable. Moreover, students' opinions on hands-on learning and suggestions were also obtained to encourage persistent learning among students.

Methodology

Sample

In this research, the respondents were 47 students from a gifted and talented center in Selangor, Malaysia. At this center, the students are exposed to STEM-based subjects from as early as 13 years old. The respondents were ninth-grade science students, with high intellectual potential and considerable talents. All the selected respondents were from the age group of 14 to 15 years old, and, for one semester, they experienced hands-on activities such as clay modeling, experiments, and projects in STEM lessons.

Instrument

Quantitative research studies are useful in establishing relationships between variables by truly focusing on describing and explaining data (Fraenkel et al., 2012). According to Walter (2010), questionnaire-based research is a popular form of research to use since it allows researchers to obtain information related to individuals' personalities, attitudes, values, beliefs, behaviors, and opinions. Therefore, posing related and relevant questions through a questionnaire related to a topic or issue is considered to be able to provide answers to the researcher. A questionnaire was distributed and administered systematically for the purposes of this study since it would provide insightful links and elicit accurate information from the respondents (Walter 2010).

The questionnaire used in this research was adopted and modified from the Student Learning and Satisfaction in Online Learning Environments Instrument (SLS-OLE) (Gray & DiLoreto, 2016). This questionnaire was designed to study the effects of student engagement, student satisfaction, and perceived learning in online learning environments. Since this study intended to evaluate students' engagement, satisfaction, interaction, and perceived learning in STEM-based subjects, the questionnaire was revised to more accurately reflect the research needs. Upon modification of the questionnaire, face validity and content validity were used to validate the appropriateness of the questions according to experts. The questionnaire consists of six sections: Section A: demographic information; Section B: perceived learning; Section C: student engagement; Section D: student satisfaction, Section E: student interaction; and Section F: open-ended questions to obtain students' views on hands-on learning. A Likert scale was used to gauge each respondent's level of agreement or disagreement for each questionnaire item. Students were requested to respond to each questionnaire item as follows: *strongly disagree* (= 1), *disagree* (= 2), *neutral* (= 3), *agree* (= 4), and *strongly agree* (= 5). After undertaking hands-on activities during the STEM class, the students were given the questionnaire. The students were given a maximum of 15 minutes to answer each questionnaire item, and about one week was spent collecting the data.

Analysis

SPSS software was used to analyze the quantitative data. Firstly, descriptive analysis of the demographic information was performed. Secondly, reliability analysis was performed for all the survey constructs to assess the extent of bias or errors. This ensured that the measurements would be fixed throughout time and for the items in the instruments (Sekaran & Bougie, 2016). The paired t-tests and linear regression analysis were conducted for the entire student sample since these analyses were useful and flexible tools for the statistical model. A paired t-test analysis was conducted to identify any significant difference in student performance between the pre-test and post-test scores. To meet the aim of this study, the relationship between the independent and dependent variables was evaluated using linear regression analysis.

The qualitative data were analyzed with Atlas.ti software using a thematic approach. The data were repeatedly read and coded with respect to the categories. The data were encoded into themes, and relationships between the themes were laid out in order to formulate a diagram to identify the effects of hands-on learning and suggestions by the students.

Results and Discussion

Respondents' Information

Table 1 summarizes the respondents' demographic information. Overall, 25 female and 22 male students in the age group of 14 to 15 years old participated in this research.

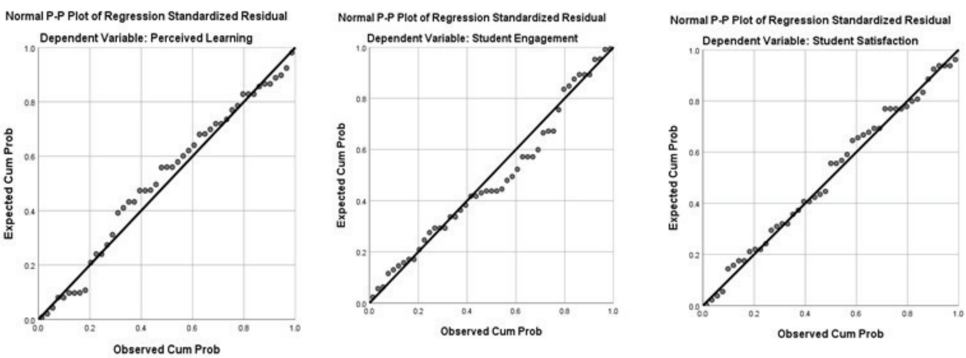
Table 1
Demographic Information of the Research Respondents (N= 47)

Characteristics	N	%
Age		
14	6	12.8
15	41	87.2
Gender		
Male	22	46.8
Female	25	53.2

Linearity Test

Linearity refers to the error term of distribution. Linearity test is important for regression analysis because correlation can capture only the linear association between variables. If there is a substantial nonlinear relationship, it will be ignored in the analysis because it will underestimate the actual strength of the relationship (Tabachnick & Fidell, 2013). In this research, linearity was determined by observations of scatterplots. The results of the linearity of different variables in this study indicated no clear relationships between the residuals. Thus, the predicted values fulfilled the assumptions of linearity. Therefore, the data were considered to be linear. The linear straight lines against the predicted values are presented in Figure 1.

Figure 1
Linearity Test



Reliability Analysis

Cronbach's alpha coefficients were used to find the questionnaire's reliability by identifying the correlation value between the scores for each item. Table 2 shows the Cronbach's alpha values, which were used to determine the reliability of the measuring items under each variable. As shown in the Table 2, the Cronbach's alpha values for the perceived learning, student engagement, student satisfaction, and student interaction were 0.732, 0.745, 0.893, and 0.877, respectively, exceeding the minimum value of 0.70. Meanwhile, the overall Cronbach's alpha value for this study was 0.918. Based on Hair et al., (2016), a Cronbach's alpha score of more than 0.900 indicates very good strength using the rule of thumb. This indicates that, overall, the variables provided a reliable measure of internal consistency.

Table 2
Reliability of Variables

Variable	Number of Items	Reliability
Perceived Learning	7	0.732
Student Engagement	6	0.745
Student Satisfaction	6	0.893
Student Interaction	7	0.877
Overall	26	0.918

Paired T-Test

A paired t-test analysis was employed to ascertain whether the pre-test and post-test results indicated a significant difference in the students' performance. Table 3 displays the results of the paired t-test analysis for the pre- and post-test scores.

Table 3
Paired T-Test Analysis of Student Performance, Based on the Pre-Test and Post-Test Scores

Variable	Pair	N	Mean	Standard Deviation	t	Df	Sig
Pre-Test Performance – Post-Test Performance Scores	Pre	47	5545.11	1846.910	-15.279	46	0.000
	Post	47	7556.60	1096.687			

The findings from the paired t-test analysis demonstrated that the p-value was 0.000, indicating a lower degree of significance at $\alpha = 0.05$. Thus, the results indicate a statistically significant difference in the students' performance, based on the pre-test and post-test scores ($t (46) = -15.279$, $p < 0.05$). Furthermore, the descriptive analysis revealed a significant difference between the means of the pre-test and post-test performance scores, in which $M = 5545.11$ and $M = 7556.60$, respectively. According to the analysis, there was a significant distinction between the pre-test and post-test scores of the students' performance following their engagement with hands-on activities. The increased mean value indicates that the students had started paying attention to their lessons and the crucial topics that would be addressed following the pre-test. The assessment of key information, which was unknown during the pre-test, showed a significant improvement in the post-test. As a whole, this study demonstrated a rise in the post-test scores, indicating that the students' comprehension and mastery of STEM content successfully increased as a result of hands-on activities undertaken during STEM lessons. In addition, this demonstrates that one of the goals of hands-on learning was met: stimulating students' interest in STEM. The pre-tests also served as a mechanism for enhancing the students' inquisitiveness, concentration, and desire to acquire knowledge during the hands-on activities. Khashi'ie et al. (2017) obtained a similar finding, whereby the students' achievement in the post-test was better than their performance in the pre-test. This suggests that the students were focused throughout the hands-on classes and able to comprehend the key learning goals. The significant difference also indicates substantial increases in the students' knowledge and active involvement in hands-on learning, which shaped their understanding of STEM-based subjects.

Correlation Analysis

The Pearson correlation coefficient was employed in this research to analyze and test the strength of the relationships between the variables. Table 4 shows the findings of the correlation analyses, which examined the relationships between perceived learning, student engagement, student satisfaction, and student interaction. Based on the findings, student engagement ($r (45) = 0.510$, $p = 0.000 < 0.05$), student satisfaction ($r (45) = 0.794$, $p = 0.000 < 0.05$), and student interaction ($r (45) = 0.560$, $p = 0.000 < 0.05$) had significant associations with perceived learning. The findings also showed that student satisfaction ($r (45) = 0.547$, $p = 0.000 < 0.05$) and student interaction ($r (45) = 0.632$, $p = 0.000 < 0.05$) had noticeable relationships with student engagement. Furthermore, a significant relationship was found between student interaction and student satisfaction ($r (45) = 0.587$, $p = 0.000 < 0.05$). Overall, all the variables had moderately positive relationships with each other.

Table 4

Correlations between Variables

Variables	Perceived Learning	Student Engagement	Student Satisfaction	Student Interaction
Perceived Learning	1	0.510*	0.794*	0.560*
Student Engagement	0.510*	1	0.547**	0.632*
Student Satisfaction	0.794*	0.547*	1	0.587*
Student Interaction	0.560*	0.632*	0.587*	1

Note: * Correlation is significant at the 0.05 level (2-tailed).

The moderately positive relationships indicate that when students actively engage during hands-on activities, there is a high tendency for them to participate in and spend additional time on the learning process, which eventually leads to increased perceived learning. In short, student engagement, student satisfaction, and student interaction are significantly associated with students' perceived learning. Student engagement might have resulted in conflict during hands-on learning, which could contribute to a lack of satisfaction and interaction among students. This explains why all four factors correlate with each other to achieve the valuable learning experiences obtained through hands-on activities. The obtained results are also congruent with the findings of Glapaththi et al. (2019) and Kim and Kim (2021), who revealed that student engagement had statistically significant and strong positive effects on educational achievement and satisfaction. Although STEM topics were found to be more abstract, student engagement can make abstract concepts more relatable through hands-on learning. Grey and Diloreto (2016), on the other hand, observed that student involvement had no significant effect on student satisfaction. This is because student engagement was barely facilitated by the instructor's presence, which led to student satisfaction.

Linear Regression Analysis: Student Interaction and Student Engagement

Linear regression analysis was carried out to identify any significant effects between student interaction and student engagement (Table 5). The results indicated that 40.0 percent of the variance in student engagement was explained by student interaction ($R2 = 0.400$, $F = 29.939$, $p < 0.05$). The remaining 60.0 percent of the variance was explained by the exclusion of the variables.

Table 5

Regression Analysis of the Significant Effects of the Association Between Student Interaction and Student Engagement

	Unstandardized B	Std. Error	Standardized Beta	T	P-Value
Constant	1.751				
Student Interaction	0.493	0.090	0.632	5.472	0.000*
R^2	0.400				
F	29.939				
Significant	0.000				

Note: *Significance level: 0.05 (2-tailed)

The results of the investigation demonstrated that student interaction significantly affected student engagement. The study's p-value of 0.000 was less than α = 0.05, indicating the significant impact of student interaction on student engagement (t (45) = 5.472, $p < 0.05$). This demonstrated how student interaction influences student engagement. In other words, a one-unit increase in student interaction results in a 0.493 increase in student engagement.

Meanwhile, student interaction during hands-on learning is imperative for student engagement. A great degree of interaction during hands-on learning prompts substantial engagement in learning with peers. Kim and Kim (2021) highlighted that one reason for this significant effect is that student interaction often explicates student engagement in academic activities before positively affecting their satisfaction. Rahmatpour et al. (2021), on the other hand, emphasized that a lack of interaction frequently leads to low student engagement and a decline in student satisfaction (Martin et al., 2018).

Linear Regression Analysis: Student Interaction and Perceived Learning

Linear regression analysis was conducted to identify any significant effect between student interaction and perceived learning (Table 6). The findings showed that student interaction accounted for 56.0 percent of the variance in perceived learning (R2 = 0.560, F = 20.553, $p < 0.05$). The remaining 44.0 percent of variance was explained by the exclusion of the variables.

Based on the analysis, it was found that the p-value = 0.000, which was less than α = 0.05. Thus, student interaction had a significant effect on perceived learning (t (45) = 4.534, $p < 0.05$). It can be concluded that student interaction affects perceived learning, as a one-unit increase in student interaction would increase perceived learning by 0.430. According to Kuo (2010), student-student interaction significantly impacts students' participation in activities, resulting in a high level of satisfaction. When students interact during hands-on activities, their perceived learning increases, whether intently or unintentionally. The results of this research are consistent with those obtained by Moore (2014) and Baber (2020), who concluded that perceived learning outcomes had a significant effect on student satisfaction.

Table 6

Regression Analysis of the Significant Effects of the Association Between Student Interaction and Perceived Learning

	Unstandardized B	Std. Error	Standardized Beta	T	P-Value
Constant	1.751				
Student Interaction	0.430	0.095	0.560	4.534	0.000*
R^2	0.560				
F	20.553				
Significant	0.000				

Note: *Significance level: 0.05 (2-tailed)

Linear Regression Analysis: Student Engagement and Student Satisfaction

The significant effect between student engagement and student satisfaction was examined using linear regression analysis (Table 7). The results showed that 29.9% of the variance in student satisfaction was explained by student engagement (R2 = 0.299, F = 19.172, $p < 0.05$). The exclusion of the variables accounted for the remaining 70.1 percent of the variation.

Table 7

Regression Analysis of the Significant Effects of the Association Between Student Engagement and Student Satisfaction

	Unstandardized B	Std. Error	Standardized Beta	T	P-Value
Constant	1.682				
Student Engagement	0.696	0.159	0.547	4.379	0.000*
R^2	0.299				
F	19.172				
Significant	0.000				

Note: *Significance level: 0.05 (2-tailed)

The regression analysis results indicated that the p-value = 0.000 was less than $\alpha = 0.05$. Thus, there was a significant association between student engagement and student satisfaction ($t(45) = 4.379$, $p < 0.05$). The findings suggest that student engagement influences student satisfaction. This is because a one-unit increase in student engagement would increase student satisfaction by 0.696.

Satisfaction is viewed as a spontaneous experience (Deci et al., 1996), whereby learners' feelings and attitudes toward the learning process or their perceived level of fulfillment are linked to their motivation to study, which plays a crucial role (Topala & Tomozii, 2014). Thus, it can be concluded that learning satisfaction is mainly induced by learning experience gained through engagement in hands-on activities. Most importantly, hands-on learning assists students in achieving the required educational objectives through participation in the hands-on activities, which fosters greater student satisfaction.

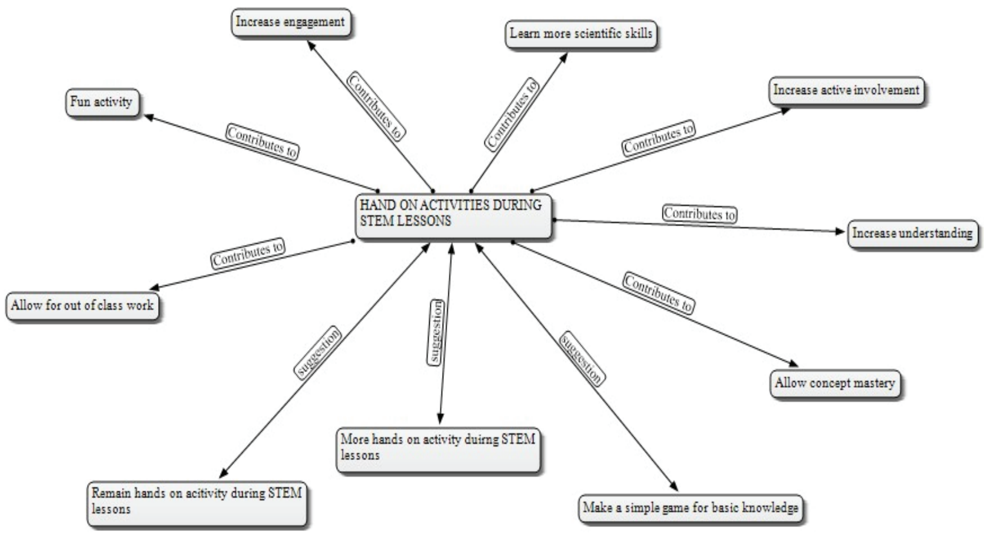
Students' Opinions on Hands-On Learning and Their Suggestions

Figure 2 shows students' opinions on the hands-on learning activities undertaken during STEM lessons, as well as their suggestions. The students stated that hands-on learning allows out-of-class work. Sitting and listening are the main modes of instruction that students have been using. Hands-on activity during STEM lessons allows students to engage with one another and get some fresh air, helping them avoid a stuffy and stressful learning atmosphere. Studies also show that out-of-class settings increase motivation and support self-determination, which leads to higher achievement (Wunschmann et al., 2017). Students feel that activities during hands-on learning are fun. This increases the students' engagement in activities. This engagement can promote curiosity about scientific phenomena, the testing of hypotheses, experiments, and the application of scientific principles. Therefore, hands-on activities during STEM lessons develop a deeper comprehension of scientific ideas while improving problem-solving abilities in real-world contexts.

Moreover, the use of hands-on learning during STEM lessons enhances students' scientific skills. Having enhanced scientific skills can promote a greater understanding of STEM concepts and an improved capacity to recall difficult scientific concepts. This facilitates a more profound understanding of scientific concepts among the students. The findings also show that hands-on activities during STEM lessons encourage the active involvement of students. This aligned with the study conducted by Ekwueme et al. (2015) on the impact of the hands-on-approach. The findings of their study showed that students' involvement and performance in basic scientific and mathematics activities improved when the hands-on approach was used in teaching. The active involvement of students provides a total learning experience during hands-on learning, which allows the students to observe, touch, and manipulate objects while learning. Besides that, students expressed the view that hands-on activities increased their understanding of the lesson. This is because the students were exposed to real-world scenarios in which they needed to use analytical thinking and creative problem-solving skills. Hands-on learning also assists students in acquiring a deeper understanding of STEM subjects. This enables the retention of STEM-related knowledge among students. In addition, Holstermann et al. (2010) observed a significant relationship between the quality of hands-on experiences and interest in the respective hands-on activities. The use of hands-on activities enables teachers to foster students' interest in real-world applications and promote enthusiasm for STEM topics.

Apart from that, the students suggested that hands-on activities should remain, and more activities should be conducted during STEM lessons. Hands-on activity during STEM lessons facilitates the acquisition of new skills. When students tend to engage in hands-on activities, they enjoy learning and discovering. Thus, hands-on activity nurtures and promotes students' passion for the sciences. According to Fluther et al. (2022), children learn well when they are actively engaged in hands-on activities. Students also suggested conducting simple games in the form of hands-on activities that would ensure they had basic knowledge before the class. This would enable deep engagement by the students in a certain topic and create opportunities for them to explore beyond their textbooks. This is similar to the findings of Fluther et al. (2022), who stated that the pedagogical approach gives teachers a wide array of opportunities to enhance science education. Hands-on activities bridge efforts to improve the delivery of science lessons.

Figure 2
Effects of Hands-on Learning and Suggestions by the Students



Conclusion

In conclusion, hands-on learning was found to be useful in learning STEM subjects. The findings showed a positive impact on student learning. The gifted and talented students' active involvement in hands-on learning also indicated a moderately positive relationship between student engagement, student satisfaction, student interaction, and perceived learning. The significant effect among all the variables tested using the regression analysis indicated that hands-on learning has extensive implications for teaching and learning. Students also gave positive feedback about the hands-on learning and encouraged its use during STEM lessons. Hands-on experience can increase engagement, and enable both an effective grasp of abstract ideas and greater understanding. The use of hands-on activities was found to potentially develop the students' interest in STEM subjects. This might be a first step to counteracting the decline in students' interest in STEM fields and motivating students to pursue STEM-related fields in higher education.

Incorporating hands-on learning was found to be essential for improving the efficacy and significance of the teaching and learning process, as well as retaining knowledge and growth. By considering the positive impact of hands-on learning, more samples from various levels and schools should be chosen for examination in future research. This study has several implications. Teachers can enhance and create programs that meet a lesson's objective by having a better understanding of the impact of hands-on learning. Thus, the study offers solutions that enable teachers to concentrate on hands-on activities so that students can gain a greater understanding of STEM subjects.

In addition, the study provides novel insights into the use of a hands-on method to ignite students' interest in STEM fields.

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References

Adak, S. (2017). Effectiveness of constructivist approach on academic achievement in science at secondary level. *Educational Research and Reviews*, *12*(22), 1074–1079. https://doi.org/10.5897/ERR2017.3298

Aeschlimann, B., Herzog, W., & Makarova, E. (2016). How to foster students' motivation in mathematics and science classes and promote students' STEM career choice. A study in Swiss high schools. *International Journal of Educational Research*, *79*, 31–41. https://doi.org/10.1016/j.ijer.2016.06.004

Albadi, A. (2019). *The impact of activity-based learning on students' achievement. A study among 12 grade science and environment student in a public school in Oman.* [Dissertation master, The British University, Dubai]. BiUD Campus Repository. https://bspace.buid.ac.ae/handle/1234/1511

Anwer, F. (2019). Activity-based teaching, student motivation and academic achievement. *Journal of Education and Educational Development*, *6*(1), 154–170. http://dx.doi.org/10.22555/joeed.v6i1.1782.g502

Aspin, S. H., Ali, M., & Bunyamin, M. A. H. (2022). STEM education in Malaysia: A Review. *Learning Science and Mathematics Journal*, *17*(1), 125–139.

Atez, O., & Eryilmaz, A. (2011). Effectiveness of hands-on and minds-on activities on students' achievement and attitudes towards physics. *Asia-Pacific Forum on Science Learning and Teaching*, *12*(1), 1-22.

Ajayi, O. V. (2017). Effect of hands-on activity-based method on interest of senior secondary students in organic chemistry. *Journal of Education*, *6*(1), 1–5. https://doi.org/10.31235/osf.io/tx2yr

Baber, H. (2020). Determinants of students' perceived learning outcome and satisfaction in online learning during the pandemic of COVID-19. *Journal of Education and e- Learning Research*, *7*(3), 285–292. https://doi.org/10.20448/journal.509.2020.73.285.292

Bahadir, E., & Ozdemir, A. S. (2013). The effects of dramatization as a teaching strategy of integer numbers on the achievement and retention levels of students. *International Journal Social Science Research*, *2*(2), 114–136. https://doi.org/10.20448/journal.509.2020.73.285.292

Bernama (2019, March 12). *Jumlah pelajar mengambil STEM kian merosot* [The number of students taking STEM is declining]. Berita Harian. https://www.bharian.com.my/berita/pendidikan/2019/03/540193/jumlah-pelajar-mengambil-stem-kian-merosot

Bhalli, M., Sattar, A., & Asif, M. (2016). Teaching strategies; perception of medical students used in basic science year. *The Professional Medical Journal*, *23*(5), 614–619. https://doi.org/10.29309/TPMJ/2016.23.05.1593

Delahaye, L. B., & Sekaran, U. (2001). *Applied business research: qualitative and quantitative methods*. John Wiley & Sons.

Deci, E. L., Ryan, R. M., & Williams, G. C. (1996). Need satisfaction and the self-regulation of learning. *Learning and Individual Differences*, *8*(3), 165–183. https://doi.org/10.1016/S1041-6080(96)90013-8

Ekwueme, C. O., Ekon, E. E., & Ezenwa-Nebife, D. (2015). The impact of hand-on approach on student academic performance in basic science and mathematics. *Higher Education Studies*, *5*(6), 47–51. https://doi.org/ 10.5539/hes.v5n6p47

Ekwueme, C. O., & Meremikwu, A. (2010). Evaluation of the millennium development goals project (NDG) for primary school teachers in Nigeria: Teacher's perspective. *International Journal of Research in Education*, *2*(6), 84–88.

Ekwueme, C. O., Ekon, E. E., & Ezenwa-nebife, D. C. (2015). The impact of hands-on-approach on student academic performance in basic science and mathematics. *Higher Education Studies*, *5*, 47–51. https://doi.org/10.5539/hes.v5n6p47

ElSayary, A. (2021). Using a reflective practice model to teach STEM education in a blended learning environment. *Eurasia Journal of Mathematics, Science and Technology in Education*, *17*(2), em1942. https://doi.org/ 10.29333/ejmste/9699

Ewers, T. G. (2001). *Teacher-directed versus learning cycles methods: effects on science process skills mastery and teacher efficacy among elementary education students.* [Doctor of Philosophy, University of Idaho]. ProQuest Dissertations & Theses.

Fluther, N. G. L., Nelson, D. G., & Romiro G. B. (2022). Pedagogical beliefs, techniques, and practices towards hands-on science. *American Journal of Educational Research*, *10*(10), 584–591. https://doi.org/10.12691/education-10-10-1.

Hair, J. F., Celsi, M. M., Arthur, S., P., & Page, M. (2016). *The Essentials of Business Research Method* (3rd ed.). Routledge. https://doi.org/10.4324/9780429203374

Holstermann, N., Grube, D., & Bogeholz, S. (2010). Hands-on activities and their influence on students' interest. *Research in Science Education*, *40*(5), 743–757. https://doi.org/ 10.1007/s11165-009-9142-0

Jirout, J., & Klahr, D. (2012). Children's scientific curiosity: In search of an operational definition of an elusive concept. *Developmental Review*, *32*(2), 125–160. https://doi.org/10.1016/j.dr.2012.04.002

Idrisa, F., Hassana, Z., Ya'acoba, A., Gillb, S. K., & Awalc, N. A. M. (2012). The role of education in shaping youth's national identity. *Procedia – Social and Behavioral Sciences, 59*, 443–450. https://doi.org/10.1016/j.sbspro.2012.09.299

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, *2*(2-3), 87–105. https://doi.org/10.1016/S1096-7516(00)00016-6

Gill, E. (2013). What is your teaching style? 5 Effective teaching methods for your classroom. https://gimmenotes.co.za/wp-content/uploads/2018/12/What-is-Your-Teaching-Styl1.pdf

Glapaththi, I., Dissanayake, R., Welgama, T., Somachandara, U., Weerarathna, R. S., & Pathirana, G. Y. (2019). A study on the relationship between student engagement and their academic achievements. *Asian Social Science*, *15*(11), 1–16. https://doi.org/ 10.5539/ass.v15n11p1

Gray, J. A., & DiLoreto, M. (2016). The effects of student engagement, student satisfaction, and perceived learning in online learning environments. *International Journal of Educational Leadership Preparation*, *11*(1), 1–20. https://eric.ed.gov/?id=EJ1103654

Khashi'ie, N. S., Said, R. M., Zainal, N. A., & Miswan, N. H. (2017). A comparison study of students' performance in pre and post result of a mathematics competency test. *MATEC Web of Conferences*, *87*(10), 1–4. https://doi.org/10.1051/matecconf/20178704001

Kibga, E. S., Sentongo, J., & Gakuba, E. (2021). Effectiveness of hands-on activities to develop chemistry learners' curiosity in community secondary schools in Tanzania. *Journal of Turkish Science Education*, *18*(4), 605–621. https://doi.org/10.36681/tused.2021.93

Kim, S., & Kim, D. J. (2021). Structural relationship of key factors for student satisfaction and achievement in asynchronous online learning. *Sustainability*, *13*(12), 6734. https://doi.org/10.3390/su13126734

Kudryashova, A., Gorbatova, T., Rybushkina, S., & Ivanova, E. (2016). Teacher's roles to facilitate active learning. *Mediterranean Journal of Social Sciences*, *7*(1), 460–466. https://doi.org/10.3390/su13126734

Kuo, Y. (2010*). Interaction, Internet self-efficacy, and self-regulated learning as predictors of student satisfaction in distance education courses* [Unpublished Doctor of Philosophy Thesis]. Utah State University.

Lent, R. W., Sheu, H. B., Miller, M. J., Cusick, M. E., Penn, L. T., & Truong, N. N. (2018). Predictors of science, technology, engineering, and mathematics choice options: A meta-analytic path analysis of the social–cognitive choice model by gender and race/ethnicity. *Journal of Counseling Psychology*, *65*(1), 17–35. https://doi.org/10.1037/cou0000243

Lin, G. Y. (2016). Effects that Facebook-based online peer assessment with micro-teaching videos can have on attitudes toward peer assessment and perceived learning from peer assessment. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(9), 2295–2307. https://doi.org/10.12973/eurasia.2016.1280a

Meng, C. C., Idris, N., & Eu, L. K. (2014). Secondary students' perceptions of assessments in Science, Technology, Engineering, and Mathematics (STEM). *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(3), 219–227. https://doi.org/10.12973/eurasia.2014.1070a

Ministry of Education. (2013). *Malaysia education blueprint 2013–2025 (preschool to post-secondary education)* (1st ed.). Ministry of Education, Malaysia.

Moore, J. (2014). Effects of online interaction and instructor presence on students' satisfaction and success with online undergraduate public relations courses. *Journalism and Mass Communication Educator*, *69*(3), 271–288. https://doi.org/10.1177/1077695814536398

Musharrat, T. (2020). Teachers' perceptions about use and challenges of hands-on activities in secondary science classroom. *European Journal of Education Studies*, *7*(12), 20–27. http://dx.doi.org/10.46827/ejes.v7i12.3384

Mustapha, M. A., Gana, D. I. A., Waziri, M., Bukar, M. G., & Euba, M. A. (2020). Use of activity-based learning to improve students` outcomes in basic education subjects. *British Journal of Education*, *9*(1), 97–104. https://doi.org/ 10.2139/ssrn.3774169

Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). McGraw-Hill, New York.

Ng, S. B. (2016). Sharing Malaysian experience in participation of girls in STEM education Retrieved July 15, 2024, https://unesdoc.unesco.org/ark:/48223/pf0000244714

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). McGraw-Hill, New York.

Patil, A., Mann, L., Howard, P., & Martin, F. (2009, December 6-9). *Assessment of hands-on activities to enhance students' learning in the first-year engineering skills course* [Conference presentation]. 20th Australasian Association for Engineering Education Conference, University of Adelaide, Australia.

Rahmatpour, P., Peyrovi, H., & Sharif Nia, H. (2021). Development and psychometric evaluation of postgraduate nursing student academic satisfaction scale. *Nursing Open, 8*, 1145–1156. https://doi.org/10.1002/nop2.727

Rasli, M. A. M., Ghani, F. A., Razali, N. H. A., Rajadurai, J., Mukhtar, M. A. F. M., & Ahmad, H. (2020). Students' awareness of Science, Technology, Engineering and Mathematics (STEM) in Pahang. In N. S. Othman, A. H. B. Jaaffar, N. H. B. Harun, S. B. Buniamin, N. E. A. B. Mohamad, I. B. M. Ali, N. H. B. A. Razali, & S. L. B. M. Hashim (Eds.), *Driving Sustainability through business-technology synergy* (100th ed., pp. 862–869). European Publisher. https://doi.org/10.15405/epsbs.2020.12.05.94

Ravı, R., & Xaviera, P. (2007). Activity based learning as self-accessing strategy to promote learners' autonomy. *Journal on Educational Psychology*, *1*(2), 7–9. https://doi.org/10.26634/jpsy.1.2.457

Rif'at, P., Wati, M., & Suyidno, S. (2020). Developing students' responsibility and scientific creativity through creative responsibility-based learning in learning physics. *Berkala Ilmiah Pendidikan Fisika*, *8*(1),12–22. https://doi.org/10.20527/bipf.v8i1.7879

Sadi, O., & Cakiroglu, J. (2011). Effects of hands-on activity enriched instruction on students' achievement and attitudes towards science. *Journal of Baltic Science Education*, *10*(2), 87–97.

Sekaran, U., & Bougie, R. (2016). *Research methods for business: a skill-building approach* (7th ed.). Wiley & Sons, West Sussex.

Sekaran, U. (2003). *Research methods for business: a skill building approach* (4th ed.). John Wiley & Sons Publications, New York.

Scholtenhuis, L. O., Vahdatikhaki, F., & Rouwenhorst, C. (2021). Flipped microlecture classes: Satisfied learners and higher performance? *European Journal of Engineering Education*, *46*(3), 457–478. https://doi.org/10.1080/03043797.2020.1819961

Shah, I., & Rahat, T. (2014). Effect of activity-based teaching method in science. *International Journal of Humanities and Management Sciences, 2*(1), 39–41.

Shahali, E. H. M., Halim, L., Rasul, M. S., Osman, K., & Zulkifeli, M. A. (2017). STEM learning through engineering design: Impact on middle secondary students' interest towards STEM. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(5), 1189–1211. https://doi.org/10.12973/eurasia.2017.00667a

Shasitiran, J. (2023, May 26). Students feel STEM subjects are too tough, say educationists. *Free Malaysia Today*. https://www.freemalaysiatoday.com/category/nation/2023/05/26/students-feel-stem-subjects-too-tough-say-educationists/

Shivaraju, P. T., Manu, G., Vinaya, M. & Savkar, M. K. (2017). Evaluating the effectiveness of pre- and post-test model of learning in a medical school. *National Journal of Physiology, Pharmacy and Pharmacology, 7*(9), 947–951. https://doi.org/10.5455/njppp.2017.7.0412802052017

Steidtmann, L., Kleickmann, T., & Steffensky, M. (2022). Declining interest in science in lower secondary school classes: Quasi-experimental and longitudinal evidence on the role of teaching and teaching quality. *Journal of Research in Science Teaching*, *60*(1), 164–95. https://doi.org/10.1002/tea.21794

Tabachnick, B. G., & Fidell, L. S. (2012). *Using multivariate statistics* (6th ed.). Needham Hights, USA: Allyn and Bacon.

Topala, I., & Tomozii, S. (2014). Learning satisfaction: validity and reliability testing for students' learning satisfaction questionnaire (SLSQ). *Procedia – Social and Behavioral Sciences*, *128*, 380–386. https://doi.org/10.1016/j.sbspro.2014.03.175

Vennix, J., den Brok, P., & Taconis, R. (2018). Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM? *International Journal of Science Education*, *40*(11), 1263–1283. https://doi.org/10.1080/09500693.2018.1473659

Victor, E., & Kellough, R.D. (1997). *Science for the elementary and middle school* (8th ed.). Upper Saddle River, New Jersey: Prentice Hall.

Wunschmann, S., Wüst-Ackermann, P., Randler, C., Vollmer, C., & Itzek-Greulich, H. (2017). Learning achievement and motivation in an out-of-school setting—Visiting amphibians and reptiles in a zoo is more effective than a lesson at school. *Research in Science Education*, *47*(3), 497–518. https://doi.org/10.1007/s11165-016-9513-2

Younis, T. (2018). *A study of the effectiveness of inquiry-based learning and project-based learning of science and language subjects at high school level in the U.A.E.* [Master of Dissertation, The British University]. ProQuest Dissertations & Theses. https://www.proquest.com/docview/2878259249/51C180E980D84F51PQ/1?accountid=27931&sourcetype=Dissertations%20&%20Theses

„Hands-On“ mokymosi iš patirties poveikis STEM mokymuisi

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Santrauka

„Hands-on“ mokymasis – tai technika, kuri padeda mokiniams įgyti žinių patyriminio mokymosi metu. Nustatyta, kad tokio tipo mokymasis yra pagrindinis būdas didinti mokinių susidomėjimą mokymusi STEM pamokų metu. Šio tyrimo tikslas – įvertinti „hands-on“ poveikį STEM sąvokų įsisąmoninimui. Buvo atlikta apklausa, kurioje dalyvavo 47 14–15 metų amžiaus mokiniai. Tyrimas buvo atliktas Malaizijoje, Selangoro centre, kur mokosi gabūs ir talentingi mokiniai. Surinkti duomenys buvo analizuojami naudojant SPSS, kad būtų ištirti visi statistiškai reikšmingi mokinių rezultatų skirtumai pagal balus prieš testą ir po jo, taip pat nustatytas reikšmingas kiekvieno kintamojo poveikis. Šio tyrimo metu buvo pastebėta, kad, įsitraukus į „hands-on“ mokymąsi, reikšmingai skiriasi mokinių rezultatai, remiantis įvertinimu prieš testą ir po jo. Vidutiniškai teigiamas ryšys tarp dviejų kintamųjų parodė, kad „hands-on“ mokymais galima paskatinti susidomėjimą STEM mokymusi. Be to, analizuoti kintamieji teigiamai veikia mokinių mokymąsi. STEM pamokų metu išryškėjo teigiamas mokinių požiūris į „hands-on“ mokymąsi. Visa tai leidžia pedagogams įsitikinti „hands-on“ veiklos veiksmingumu gerinant STEM pagrindu grindžiamą mokinių mokymąsi.

Esminiai žodžiai: *„hands-on“ mokymasis, suvokiamas mokymasis, įsitraukimas, sąveika, pasitenkinimas.*

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