The learning environment as a predictor of higher order thinking skills

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ABSTRACT

The learning environment is one of the elements that will influence higher-order thinking skills (HOTS). The purpose of this study was to test the influence of the learning environment on HOTS. The researcher selected 82 forms two students from two secondary schools in Kuala Nerus, Terengganu, Malaysia, as the study sample. The researcher has adopted a set of questionnaires that have been developed by previous researchers and a questionnaire developed by the researcher himself. Multiple regression analysis has found that material environment and cooperation between students' constructs are predictors of HOTS. Therefore, the Ministry of Education Malaysia as a stakeholder in the education sector in the country is expected to: i) Allocate ample expenditure to purchase and maintain all laboratory equipment and materials and ii) Organize workshops on the maintenance of laboratory equipment and materials for laboratory assistants in high school to ensure they are always in the best possible condition. The researcher suggested that future studies focus on producing maintenance modules for the materials and science equipment for laboratory assistants' use. It is hoped that with this module, the focus on improving Malaysian students' HOTS will be easily achieved by 2025.

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1. INTRODUCTION

Malaysia's achievement in Trends in International Mathematics and Science Study (TIMSS) 2019 has seen a slight decrease of 11 points in the average score value compared to TIMSS 2015 (average score 2019=460 and average score 2015=471) [1]. This is quite far behind our neighboring country, Singapore, which has always ranked first among TIMSS member countries. The importance of mastering higher-order thinking skills (HOTS) in the 21st-century learning environment has been emphasized by Ichsan *et al*. [2] in their study. However, the TIMSS 2019 report has upset many parties as Malaysia has recorded a significant increase in the average score of 45 points during TIMSS 2015 compared to TIMSS 2011 (average score 2011=426). Phang *et al*. [3] argued that the cause of this decline was the small allocation of time for investigative activities compared to theory classes.

Science laboratories are the most suitable place to conduct experiments [4]. The teaching and learning of science must take place in a science laboratory because it requires an environment that can stimulate the active learning of students [5], [6]. Materials and apparatus have been provided for students' usage in the science lab. In addition, safety equipment has been made available for use in the event of an accident [7]. Previous studies have acknowledged that active learning can help improve students' HOTS [8]–[10]. Therefore, it is important for teachers to create a learning environment that supports active learning in which teachers only act as facilitators [11]. The results of this study have strengthened the theory that a conducive learning environment will successfully improve students' critical and creative thinking skills [12].

However, the study's findings regarding the science laboratory learning environment are very worrying. The majority of the findings stated that the inadequacy of laboratory equipment and materials has made it difficult for students to develop their HOTS. What is even more upsetting is that most studies have revealed that the main problem that teachers and students face is the unavailability of science equipment and materials [13], [14]. As a result, the Ministry of Education (MOE) Malaysia has proved its determination to improve the HOTS of students, where they have allocated a large amount of expenditure of RM240 million in the 2017 Budget [15]. This colossal budget is expected to resolve the complaints of science teachers and students regarding the lack of science equipment and materials in school science laboratories.

International researchers have proven that the science laboratory learning environment can influence students' HOTS [16]–[18]. Subramaniam [19] has found that experimental activities will successfully improve students' science process skills (SPS). In addition, a study by Mutmainnah *et al*. [20] found that SPS is closely related to HOTS. As a result of these studies, MOE has taken the initiative by making the practical science test compulsory for *Sijil Pelajaran Malaysia* (SPM) candidates starting in 2021 for Pure Science and Additional Science subjects. The basis of its implementation is based on Wave 1 of PPPM (2013-2025), which is to strengthen the foundation of learning [21]. Therefore, this proves that this study should be conducted to study the influence of science laboratory learning environment on HOTS. This is because no research has been found conducted in Malaysia. The objectives of this study are: i) Identify the construct level of the learning environment in secondary schools and ii) Identify the constructs of the learning environment as a predictor of the level of HOTS.

2. WALBERG'S PRODUCTIVITY MODEL

Walberg's productivity model has proven the existence of the learning environment's influence on students' cognitive levels. This model is developed from the production productivity model used in the industrial sector and plantations to save production costs. For example, the inadequacy of science equipment and materials that often occurs in science laboratories can affect the production outcomes of learning in science education [22]. Cognitive involves the knowledge and way of thinking of students [23]. Walberg identified three factors influencing learning outcomes: aptitude, instruction, and the environment. However, Walberg found that the psycho-social learning environment of the classroom was more influential on science learning outcomes [24].

Based on Figure 1, the environmental factor consists of four elements, namely the home environment, the environment of the classroom/science laboratory, peers, and television. A learning environment is where the learning process takes place, such as a classroom, science laboratory, open space, or office [25]. Meanwhile, aptitude consists of three elements: abilities, progress, and motivation. Teaching consists of two elements, namely quantity, and quality. In all, nine elements are interconnected with each other to optimize learning. Learning consists of three elements, namely affective, behavioral, and cognitive. Affective involves students' emotions, such as liking the way teachers teach and the fun of learning science. behavior, on the other hand, involves adherence to laboratory rules and also adherence to time. In contrast, cognitive involves the way students reason and provide solutions to a problem [26].

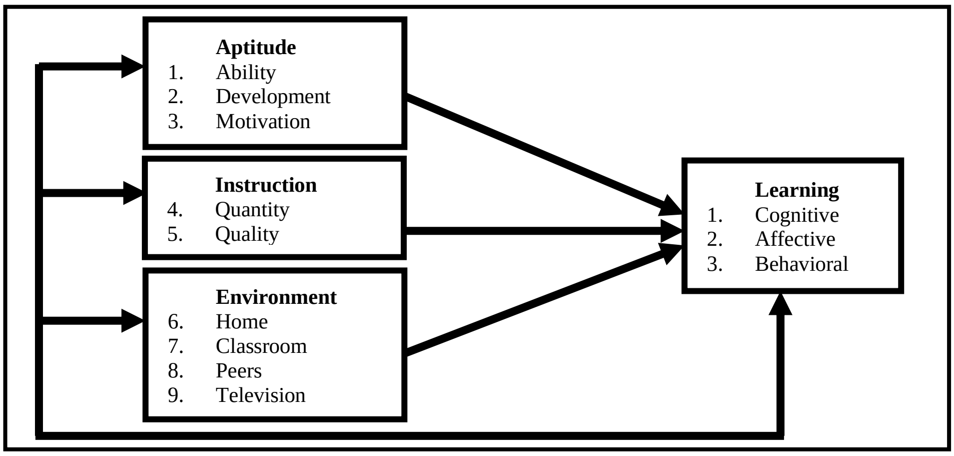

Figure 1. Walberg productivity model

3. RESEARCH METHOD

This study has employed quantitative methods in the form of a cross-sectional survey. Meanwhile, the presentation and report of the study must utilize a form of questionnaire instrument [27]. Therefore, the researcher has used a set of questionnaire instruments divided into four parts consisting of a questionnaire used by previous researchers and a questionnaire developed by the researcher himself.

3.1. Respondent profile

A total of 82 forms two students were involved in this study. The selection of form two students is in accordance with the criteria of respondents set in the assessment of TIMSS and the program for international student assessment (PISA) [1]. These students were drawn from two schools–one school with good achievement and another school with low achievement in the Form 3 Assessment in 2017. Table 1 presents the profile of the respondents in this study.

Table 1. Respondents' profile

No.	Gender	Frequency (*f*)	Percentage (%)
1	Male	31	37.8
2	Female	51	62.2
	Total	82	100.0

3.2. Research instruments

Researchers have used a set of questionnaires containing four sections, which are: i) Respondents' demography; ii) Learning environment; iii) Multiple-choice HOTS questions; and iv) Open-ended HOTS questions. Part A contains only one item. The students are required to indicate their respective gender. The responses consisted of 'male' and 'female', which is 1 for 'male' and 2 for 'female'. In Malaysia, there are only two genders that are recognized, namely 'male' and 'female'.

Part B employed a questionnaire adapted and modified from Ahmad [28] of the science laboratory environment inventory (SLEI), which was originally developed by Fraser. This instrument is used to test the psychosocial environment in science laboratories and has been tested in six countries, namely Canada, Australia, United States, England, Israel and also Nigeria both at the secondary school and university levels [29]. The learning environment questionnaire consisted of 35 items. The questionnaire was broken down into five constructs: collaboration between students, freedom to generate ideas, integration, clarity of rules, and material environment. Each construct contains seven items.

Part C consisted of 10 multiple-choice questions. These multiple-choice questions were adapted from the 'higher-order thinking level test' (HOTLT) constructed by Artosh [30]. There are three levels of HOTS tested in this question, namely the levels of applying, analyzing, and evaluating that have been developed using Bloom's taxonomy model. However, the Ministry of Education Malaysia has stated that HOTS must consist of the level of thinking to applying, analyzing, evaluating, and creating [31].

Bloom's taxonomy model consists of three higher thinking levels. There were three questions representing the level of applying, five questions representing the level of analyzing, and two multiple-choice questions representing the level of evaluating. A total of 10 multiple questions were used to test HOTS.

Next, Section D consisted of eight open-ended response questions. Guided by a study by Stanger-Hall [32], he found that structured questions were better at promoting higher-order thinking skills among students. Researchers have constructed this question based on Bloom's Taxonomy Model, where the level of HOTS consisted of applying, analyzing, evaluating, and creating. This open-response type question was adapted from the Form 3 Assessment in 2016 and 2017. Next, the researcher requested assistance from five science teachers from the Terengganu state questioning committee (AKRAM) for the question validation process. Bloom's taxonomy model has undergone a significant change, where the highest level of thinking is 'creating'. In contrast to bloom's taxonomic model, which is 'evaluating'. Each construct is represented by two open-ended response-type questions.

4. RESULTS

4.1. Research question 1: What is the construct level of the secondary school learning environment?

Table 2 shows that the highest mean is the clarity of rules (Mean=4.088), while the lowest mean is the material environment (mean=1.351). Afterward, they are followed by other constructs, namely cooperation between students (mean=3.638), freedom to generate ideas (mean=2.110), and also integration (mean=1.945). Overall, the science laboratory-learning environment level among secondary schools in Kuala Nerus, Terengganu is moderate.

Table 2. Mean for learning environment construct

Construct	Mean	Standard Deviation
Cooperation between students	3.638	.467
Freedom to generate ideas	2.110	.770
Integration	1.945	.725
Clarity of rules	4.088	.612
Material environment	1.351	.478
Overall	2.626	.610

4.2. Research question 2: Is the construct of the learning environment a predictor of the level of HOTS?

4.2.1. Applying

Table 3 shows the multiple regression analysis of learning environment constructs on the level of thinking skills (applying). Multiple regression analysis was used to test whether the five constructs of the learning environment independent variables, which are cooperation between students, freedom to generate ideas, integration, clarity of rules, and material environment, could significantly predict the dependent variable, which is thinking skills (applying). The results of the regression analysis showed that the material environment constructs for the learning environment independent variable could explain significantly by 8.6% in the dependent variable (R^2=0.086, F (1.80)=7.514, p<.01). The material environment showed a significant influence (β=.293, p=.008) on thinking skills (applying).

Table 3. Multiple regression analysis of learning environment constructs on the level of applying

Independent variable					Dependent variable: Application			
Model	R	R^2	Adjusted R^2	Std. Error of estimate	β Unstandardized	Non-standard error	β Standard	P
Constant					8.376	.721		.000
1	.293[a]	.086	.074	2.166	1.379	.503	.293	.008
F value						7.514		.008

a. Predictors: Material environment

4.2.2. Analyzing

Table 4 shows the multiple regression analysis of learning environment constructs on the level of thinking skills (analyzing). Multiple regression analysis was used to test whether the five constructs of the learning environment independent variables, namely cooperation between students, freedom to generate ideas, integration, clarity of rules, and material environment, could significantly predict the dependent variable, which is thinking skills (analyzing). The results of regression analysis showed that the construct of material environment and cooperation between students for the independent variable of learning environment could explain significantly by 14.8% in the dependent variable (R^2=.148, F (2,79)=6.840, p<.01). The material environment and collaboration between students showed a significant influence (β=.229, p=.031) on thinking skills (analyzing).

Table 4. Multiple regression analysis of learning environment constructs on the level of analyzing

Independent variable					Dependent variable: Analyze			
Model	R	R^2	Adjusted R^2	Std. Error of estimate	β Unstandardized	Non-standard error	β Standard	P
Constant					5.863	3.021		.056
1	.309[a]	.095	.084	3.386	2.367	.769	.320	.003
2	.384[b]	.148	.126	3.308	1.735	.788	.229	.031
F value						6.840		.002

a. Predictors: Material environment; b. Predictors: Material environment, cooperation between students

4.2.3. Evaluating

Table 5 shows the multiple regression analysis of learning environment constructs on the level of thinking skills (evaluating). Multiple regression analysis was used to test whether the five constructs of the learning environment independent variables, namely cooperation between students, freedom to generate ideas, integration, clarity of rules, and material environment, could significantly predict the dependent variable, which is thinking skills (evaluating). The results of regression analysis showed that the material environment constructs for the learning environment independent variable could explain significantly by 11.1% in the dependent variable (R^2=.111, F (1.80)=9.969, p<.01). The material environment showed a significant influence (β=.333, p=.002) on thinking (evaluating) skills.

Table 5. Multiple regression analysis of learning environment constructs on the level of evaluating

	Independent variable				Dependent variable: Evaluate			
Model	R	R^2	Adjusted R^2	Std. Error of estimate	β Unstandardized	Non-standard error	β Standard	P
Constant					8.763	.821		.000
1	.333[a]	.111	.100	2.467	1.810	.573	.333	.002
F value						9.969		.002

a. Predictors: Material environment

4.2.4. Creating

Table 6 shows the multiple regression analysis of learning environment constructs on the level of thinking skills (creating). Multiple regression analysis was used to test whether the five constructs of the learning environment independent variables, namely cooperation between students, freedom to generate ideas, integration, clarity of rules, and material environment, could significantly predict the dependent variable, which is thinking skills (creating). The results of regression analysis showed that the material environment constructs for the learning environment independent variable could explain significantly by 7.9% in the dependent variable (R^2=.079, F (1.80)=6.826, p<.01). The material environment showed a significant influence (β=.280, p=.011) on thinking skills (creating).

Table 6. Multiple regression analysis of learning environment constructs on the level of creating

	Independent variable				Dependent variable: Creating			
Model	R	R^2	Adjusted R^2	Std. Error of estimate	β Unstandardized	Non-standard error	β Standard	P
Constant					7.837	.830		.000
1	.280[a]	.079	.067	2.493	1.513	.579	.280	.011
F value						6.826		.011

a. Predictors: Material environment

5. DISCUSSION

5.1. The constructed level of the secondary school learning environment

The results of the descriptive test conducted are very disappointing, where the mean value for the material environment construct is the lowest, which is 1.351 compared to the other five learning environment constructs. This has worried the Malaysian Ministry of Education. At the same time, the findings by Allanas [33] also agreed that the construct of the material environment has a low mean along with the construct of freedom to generate ideas. The findings of this study are also supported by Bogusevschi, Muntean, and Muntean [34] when it was found that among the problems faced by the school is the lack of laboratory equipment and poor laboratory conditions. These issues can hamper efforts in developing students' science process skills [35].

Students responded well when they stated that laboratory equipment was always available when they wanted to use it and had fun doing experiments in the laboratory. Even so, they found that most of the lab equipment was not working properly. For example, several microscopes could not be used to conduct experiments. This finding is supported by Monita and Ikhsan [36], who agreed that science equipment is indeed available, but most of it is already damaged and can no longer be used. This may be due to the laboratory assistants lacking the knowledge and skills to carry out maintenance work on the science equipment and materials on a regular basis. Therefore, the Ministry of Education Malaysia needs to organize workshops frequently related to maintaining and repairing science equipment for science laboratory assistants in schools. The school can monitor the process of care and repair of the science equipment.

Meanwhile, the clarity of the rules has the highest mean of 4.088. The science lab rules were displayed in front of the class to be read and followed. Usually, the teacher will explain the rules that need to be followed before starting the experimental activity. Laboratory rules consist of rules using chemicals, physics, and biology. Similar findings obtained by Lee *et al*. [37] have further reinforced that laboratory rules have been well-practiced while conducting laboratory activities. Laboratory rules are very important in ensuring the safety of students by providing specific rules when handling science equipment and materials [7]. In the event of an accident, there is a specific standard operating procedure (SOP) to do. The teacher is the first person to be notified in the event of an accident.

The next highest mean was the construct of cooperation between students (3.638). In 21st-century learning, cooperative learning has been practiced in experimental activities to save materials and equipment that need to be provided by laboratory assistants [38]. This is because student-centered learning will be able to elicit students' critical and creative thinking [39]. In student-centered learning, the teacher will provide a problem for students to solve in their respective groups. As the process of finding answers occurs, they will collaborate with each other. According to Peshkovskaya, Babkina, and Myagkov, groups of different genders were more effective than groups of the same gender [40].

Next is the freedom to generate ideas (mean=2.110). While students were conducting experiments, they were not given the freedom to choose their own investigative measures. They follow all the steps that have been set out in the textbook [33]. Finally, the integration construct (mean=1.945) requires students to relate the theoretical knowledge learned in class to experimental activities in the science laboratory [41].

5.2. The construct of the learning environment is a predictor of the level of HOTS

The four levels of thinking, namely applying, analyzing, evaluating, and creating, have produced the same result: the material environment is a predictor of the four levels of thinking. Many previous studies have successfully proven the importance of science equipment and materials in science learning. For example, Kamarudin and Halim [42] have found that the use of science equipment and materials can affect students' level of thinking. Science equipment and materials are needed while performing science experiments, which will improve students' SPS. Af'idayani, Setiadi, and Fahmi explained when students' SPS improves, it impacts students' HOTS [43].

Among the four levels of high-order thinking, the stage of evaluating gave the highest R^2 value of 11.1%. In comparison, the level of analysis is 14.8%, and the predictor consists of two constructs, namely the material environment and cooperation between students. Meanwhile, the R^2 values for the level of applying and creating were 8.6% and 7.9%, respectively. Cooperation between students can create excitement in the learning process and stimulate students' academic success [44]. Students will discuss finding a solution to the problem given by the teacher.

6. CONCLUSION

The findings of the main study have shown that laboratory science environment learning is a predictor of HOTS. Science equipment and materials that are always adequate and in good condition are important in motivating students to conduct self-investigation. This is because learning science involves the five senses to make students more active, creative, and thinking critically to solve problems in daily life. However, it is the great responsibility of the Ministry of Education Malaysia to provide science equipment and materials that are always sufficient and in good condition, as the results of this study have found that the mean value for the material environment construct is the lowest among the five learning environment constructs.

The researchers hope that the results of this study will make the Ministry of Education Malaysia allocate a sufficient amount of funds to supplying and maintaining laboratory equipment and materials. Researchers also suggested that maintenance courses on equipment and science materials for laboratory assistants be held regularly to ensure that their knowledge and skills are always at the optimum level. The researchers also hope that these issues can be solved before TIMSS 2023 so that the aspirations of PPPM 2013-2025 can be achieved by the year 2025. TIMSS 2023 will be the benchmark for the success of PPPM 2013-2025 and further help the Ministry of Education Malaysia formulate strategies to increase the average science score in TIMSS 2027.

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