Social and Management Research Journal, Vol 17, No 2 (2020) 101-132
https://doi.org/10.24191/smrj.v17i2.10516

The Relationships between Physical Learning Environment, Psychological Characteristics, and HOTS

Mohd Azry Abdul Malik[1], Mazlini Adnan[2], Mohd Rahimie Md Noor[3], Muhammad Firdaus Mustapha[4]

[1]Department of Statistics, Faculty of Computer Science and Mathematics, Universiti Teknologi MARA, Malaysia
[2]Department of Mathematics, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, Malaysia
[3]Department of Mathematics, Faculty of Computer Science and Mathematics, Universiti Teknologi MARA, Malaysia
[4]Department of Computer Science, Faculty of Computer Science and Mathematics, Universiti Teknologi MARA, Malaysia

*Corresponding author's e-mail: [1]azry056@uitm.edu.my

Received: 19 Sept 2020
Accepted: 19 June 2010
Online First: 1 September 2020

ABSTRACT

The study investigates the relationships between the physical learning environment (PLE), psychological characteristics (students' academic self-efficacy and satisfaction), and higher-order thinking skills (HOTS) in statistics education. The study also aimed to determine if psychological characteristics mediate the relationships between the PLE and HOTS. A total of 285 students were selected as samples using cluster sampling. The study instruments were adapted from Smart classroom inventory, science laboratory environment inventory, test of science-related attitudes, self-efficacy in learning and performance for college, and dimension of learning rubrics. The gathered data were analysed using Partial Least Square Structural Equation Modeling (PLS-SEM). The findings revealed that a significant direct relationship existed between PLE and HOTS. Moreover, the PLE also did influence the students' HOTS indirectly through psychological characteristics *(academic self-efficacy and satisfaction). The findings from this study give an important and valuable contribution to knowledge in the area of HOTS research in the context of Malaysian Institution of Higher Learning. The implication of this study suggests that the good quality of PLE in statistics education would influence students' HOTS directly and also indirectly through the positive development of psychological characteristics in teaching and learning (T&L) process.*

Keywords: *physical learning environment, psychological characteristics, academic self-efficacy, satisfaction, higher-order thinking skills*

INTRODUCTION

Preparing students with HOTS is very essential to solve employability problems where the best way to prepare future employees is to teach students how to think instead of what to think (Chinedu, Libunao, Kamen & Saud, 2014). Most companies demand workers with a decent level of HOTS such as problem-solving, creative thinking, and critical thinking. Being aware of those employment requirements, the university should produce students with the qualities and skills based on the requirements set by the potential employers or industries and give specific attention to students' HOTS development. Hence, the quality of the T&L process, learning environment, support systems, and programs offered by the university need to be excellent. Thinking can be viewed as a process of using intelligence to handle the problem. Knowing the knowledge alone is not enough to face a complex situation. Every educator understands this reality but only a few seem to care about it. Only a small portion of educators embedded HOTS in their T&L process (McMillan, 2001). Educators rarely asses application, reasoning skills, and other HOTS among their student in T&L process (McMillan, Myron & Workman, 2002). The majority of the T&L process in Mathematics education is still focusing on a lower level of cognitive activities (Mohd Ali & Shaharom Noordin, 2003).

Several factors that influence the development of HOTS of a student such as teaching strategies, teaching methods, support systems, technology usage, and others. Quality of learning environments (LE) is one of the factors that can facilitate improvement in the cognitive and psychological characteristics of learners (King, Goodson & Rohani, 2009). The good quality of LE gives a significant positive effect on students' cognitive and also towards students' psychological characteristics (Che Nidzam, Kamisah & Lilia, 2013; Fraser, Alridge & Adolphe, 2010; Wolf & Fraser 2008). Therefore, in line with the Malaysia Education Blueprint 2013-2025, this study attempts to fill the gaps by studying the factors that influence HOTS development in statistics education. This study numerically assesses the relationship between the physical learning environment (PLE), psychological characteristics, and students' HOTS. Even though PLE gives a great influence on the development of an individual, Chism (2006) reported that studies relating to PLE are still relatively scanty and suggest conducting a further study about the impact of the physical environment on learning. Research on the interrelationship of PLE design and education practice is still not sufficient (Veal & Jackson, 2006). More research are needed to assess the learning environment especially on the effects of the design or physical aspects on educators and learners (Higgins, Hall, Wall, Woolner & McCaughey, 2005). Moreover, Budsankom, Sawangboon, Damrongpanit, and Chuensirimongkol (2015) suggested that the psychological factors must also be considered and exerted to the learning environment study. The psychological characteristics refer to the behavioural characteristics of how an individual expresses their feelings that cause different thinking skills processes and the way they learn (Santrock, 2009). As suggested by Budsankom *et al*. (2015) this study includes academic self-efficacy and satisfaction construct as mediating construct linking the relationship between PLE and HOTS constructs.

This study is different from other studies in three aspects. First, the study focuses on the diploma level of education. In Malaysia's situation, although numerous studies of the educational field have been conducted among students in primary, secondary schools, undergraduate and even in the level of postgraduate, study focusing on the diploma level was inadequate (Azry, Mazlini, Norafefah, Amri & Jasrul, 2017). Secondly, this study also investigates the relationship between the quality of PLE and HOTS with the occurrence of psychological characteristics as mediating variables. Following that, this study attempts to assess the PLE set up in the T&L process in statistics education that can give a direct and/or indirect effect to HOTS. According to the Bureau of Labour Statistics (BLS) forecasts, the employment of statisticians will increase by 34% from 2014 to 2024, compared to 28% for mathematical science occupations. A statistician is projected to be one of the fastest-growing jobs (American Statistical Association, 2016). Even so, statistics courses or subjects, as compared to science and mathematics are still lacking attention (Azry *et al*., 2017). From the year 2000 to 2012, only 20 published research papers related to statistics education were found in an electronic search in Malaysia (Reston, Krishnan, & Noraini, 2015). Research and developments in statistics education which comprise facilitating the learning of statistical thinking and reasoning is important (MacGillivray & Pereira-Mendoza, 2011). Thus, thirdly, this study involves statistics education.

LITERATURE REVIEW

The Concept of Psychological Characteristics: Academic self-efficacy and Student Satisfaction

From an educational perspective, academic self-efficacy can be referred to as a person's belief that they can successfully reach the designated level on an academic task or achieve a specific academic goal (Bandura, 1997). A similar definition was given by Woolfolk (2004) where academic self-efficacy is defined as students' readiness, keenness, intention, and endeavour to achieve learning objectives with eminent accomplishment. This type of psychological characteristic also refers to students' self-awareness proficiency in working and completing the goals (Stajkovic & Luthans, 2003). When students fail to complete their tasks, high self-efficacy students will be able to maintain their focus and put an extra effort to achieve the goal successfully. In a simpler implication analogy, a person with a stronger self-efficacy means that a person is likely to have more positive behaviour and attitude to achieve their goal. Students with higher self-efficacy also show a higher level of participation, positive behaviour, and attitude in mastering the learning outcome of the course.

Generally, poor self-efficacy students are more probable to believe that they cannot be successful (Azry *et al*., 2017). Consequently, they lack the determination to succeed, low in terms of comprehensive effort and always avoid challenging tasks (Azry *et al*., 2017). Students with poor self-efficacy have low desire and aspiration which in turn results in poor academic performances (Bandura & Locke, 2003), while students with a strong efficacy are more motivated and like to challenge themselves with the tough task (Margolis & McCabe, 2006). Therefore, this study attempts to assess the extent of the LE influence students' academic self-efficacy. This study also attempts to view the influence of academic self-efficacy toward HOTS in statistics education.

Student satisfaction can be defined as the subjective students' perceptions of how well is the quality of LE, the support system, and services provided by universities contribute to their academic success. According to Moore (2009), a student is considered satisfied when they are successful and contented with their learning experience. Sweeney and Ingram (2001) came out with a similar definition where they defined student satisfaction as the perception of their accomplishment and enjoyment in the learning process. Both definitions focus on success and accomplishment in the learning process, and enjoyment with the learning experience. Thurmond, Wambach, Connors, and Frey (2002) described student satisfaction as an outcome reflection that occurs between students and instructors, while Wu *et al*. (2010) referred satisfaction as a student attitude, feeling, and hopes to receive a good quality system of the LE. In this study, the satisfaction construct is measuring the students' satisfaction in the T&L process of a statistics course.

The Concept of Higher Order Thinking Skills

Thinking is divided into two levels which are lower-order thinking (LOTS) and higher-order thinking skills (HOTS). By referring to Bloom's taxonomy of the cognitive process, LOTS refer to the level of knowledge and understanding, while HOTS start from the level of application to the evaluation's stage (Brookhart, 2010). In statistics education, most of the students can get the correct answer by following the procedure but only a few of them can really make reasoning with the process or procedure involved, and rarely can apply and expand the knowledge into different situations. HOTS can be characterised as a complex cognitive process that utilises and expands the dispensation and construction of information. Amongst prominent foundations of HOTS are integrating skills such as analysis, synthesis, and evaluation (Tal & Hochberg, 2003). Tan, Aris, and Abu (2006) developed a framework of Generative Learning Object Organizer and Thinking Task (GLOOTT), a pedagogically-enriched web-based learning environment designed to improve HOTS. In the study, the authors described HOTS using an element of analysis, synthesis, and evaluation skills. Budsankom *et al*. (2015), referred to HOTS as finding the solution to a problem through different levels of the thinking process.

Zohar and Dori (2003) also explained HOTS as a thinking process constituted of complicated procedures and based on employment skills such as assessment, synthesis, comparison, interpretation, analysis, inference, inductive, and deductive reasoning to solve unfamiliar problems. HOTS focuse on developing students' abilities to be able to analyse effectively, evaluate by drawing inference from existing information, and creating something new (Chinedu *et al*., 2015). HOTS involve analysing information to determine the problem, evaluating the problem, and creating new workable solutions (Rajendran & Idris, 2008). It has been noted from the above literature that some of the researchers define HOTS in different ways. The present study found that the scope of HOTS definition given by Brookhart (2010) is more holistic as compared to the others. According to Brookhart, the illustration of HOTS falls into three categories; 1) HOTS are defined in terms of the transfer, 2) HOTS as critical thinking and, 3) HOTS as problem-solving.

Relationship between Learning Environment and HOTS

In 2015, Budsankom *et al.* conducted a study to identify a factor influencing HOTS of students. They applied the Meta-analytic structural equation modeling (MASEM) based on a database of 166 empirical studies. MASEM confirmed that LE has a significant direct effect on students' HOTS development (Budsankom *et. al*., 2015). Previous studies conducted also have found that LE construct can affect students' psychological characteristics significantly and simultaneously giving significant influence on learning (Chism, 2006; Monahan, 2002; Strange & Banning, 2001). LE did significantly affect learning, ideas, values, and attitudes (Sanoff, 2000). Tanner (2000), Fraser, and Kahle (2007) also identified that a good LE also give influences student achievement positively. Altogether, there is strong evidence to the hypothesis that LE constructs give a direct effect on students' HOTS.

Relationship between Learning Environment and Psychological Characteristics

Budsankom *et al.* (2015) discovered that LE has a significant direct effect on students' psychological characteristics. In the same year of 2015, Rozario and Suhaimi performed a study that aimed to observe the influence of two constructs: classroom learning environment and academic self-efficacy towards students' achievement. For this purpose, samples of 200 students were randomly selected from two campuses of Masterskill Global College. The analysis results of their study reported that LE constructs significantly influences students' achievement. In the same manner, academic self-efficacy also found to positively influence students' achievement. Baeten, Dochy, and Struyven (2013) also investigated the effect of different learning environments on students' psychological characteristics and academic achievement. The authors stressed out that psychological construct is important because it has been related to autonomous motivation and achievement. The study involved 1098 respondents answering a questionnaire and a quasi-experimental pre-test/post-test design was set up consisting of four different LEs. As a result, the study by Baetan *et al.* (2013) found that a different learning environment set up gave a different impact on students' psychological characteristics and achievement.

In short, Dorman (2009) showed consistent findings whereas associations between the classroom learning environment and affective outcomes were found to be statistically significant. By using 661 students as respondents, Ogbuehi and Fraser (2007) found positive associations between perceptions of the classroom learning environment and students' attitudes. Dorman and Adams (2004) in their studies indicated that the classroom environment is positively related to student academic self-efficacy. The psychological characteristics can be developed continually by improving the learning environment and learning process (Baetan *et al*, 2013; Dorman, 2009). Fraser and Kahle (2007) in their research also revealed that environments were to be consistently accounted for students' attitude scores. Moreover, the learning environment has a significant relationship with student achievement motivation (Ari & Eliassy, 2003). On the whole, there is strong evidence to hypothesise that learning environment constructs give a direct effect on students' psychological characteristics.

Relationship between Psychological Characteristics and Students' HOTS

Budsankom *et al.* (2015) have suggested that learning management must be concerned about the current situation and focus on HOTS improvement in the education system. Students with HOTS are capable to invent new knowledge, think critically, and logically when solving problems. MASEM revealed that students' psychological characteristic has a significant direct effect on HOTS. The study also indicated two indirect effects toward HOTS through students' psychological characteristics; 1) psychological characteristics mediate the relationship between classroom environment and HOTS 2) psychological characteristics mediates the relationship between family characteristic and HOTS. Hence, the psychological characteristics have been identified as important mediator constructs for HOTS.

Lather, Jain, and Shukla (2014) have performed a study on the HOTS concerning psychological characteristics. HOTS is represented by components of creativity while internal and external locus of control is representing psychological characteristics. The results showed that the respondents with an external and internal locus of control significantly differ on components of creativity. The study results also revealed that compared to students with an external locus of control, the students with an internal locus of control were found to be higher and better on fluency, elaboration, flexibility, figural response, norm-referenced creativity, criterion-referenced creativity, and total creativity. Browne and Freeman (2000) have found that a good learning environment positively influenced students' critical thinking. At the same time, the results of their study also revealed that the psychological characteristics of a student have a significant influence on HOTS. The psychological components that encourage passivity in a learner will obstruct higher-order thinking development. Besides, Velayutham, Aldridge, and Fraser (2011) examined the influence of psychological constructs (learning goal orientation, task value, and self-efficacy) on students' self-regulation. The study involved 1360 science students and their results revealed that motivational beliefs of learning goal orientation, task value, and self-efficacy significantly influenced students' self-regulation in learning.

In another study related to psychological characteristics and HOTS, student's self-efficacy positively affects engagement and effort and is important to the learning process (Aldridge & Fraser, 2008). Student self-efficacy regarding competence has important implications for student outcomes (Aldridge & Fraser, 2008; Velayutham & Aldridge, 2012). Psychological characteristics are a predictor of academic achievement (Edman & Brazil, 2007). Next, student satisfaction is claimed to be related to several outcome variables such as persistence (Allen & Seaman, 2007). Booker and Rebman (2005) agreed with the claim by bringing the evidence in his study that student satisfaction has significantly influence student's retention and decision. Sinclaire (2011) reported that student satisfaction as the most important key to continuous learning. Winberg and Hedman (2008) in their study also mentioned that student satisfaction helps ensure students' academic success. Besides that, high satisfaction leads the students to become more consistent in learning and highly motivated (Allen & Seaman, 2007). The attitudes and expectations of students regarding the T&L process are considered to be significant factors underlying their achievement (Reed, Drijvers, & Kirschner, 2010). According to Kind, Jones, and Barmby (2007), developing a positive attitude is important for students' achievement.

Summary on the Relationships among Constructs

The constructs involved in this study are the physical learning environment, students' academic self-efficacy, satisfaction, and HOTS. Table 2.1 compiles the recent supporting literature of the relationship between learning environment, psychological characteristics, and HOTS.

Table 1: The Recent Supporting Literature on the Direct Relationships between Construct

Relationship	Supporting literature
The learning environment positively influences higher-order thinking skills.	Budsankom *et al*., 2015; Loes *et al*., 2015; Pascarella *et al*., 2013; Galton *et al*., 2009; Fraser & Kahle, 2007; Chism, 2006; Monahan, 2002; Strange & Banning, 2001;
The learning environment positively influences students' psychological characteristics.	Budsankom *et al*., 2015; Rozario & Suhaimi, 2015; Dorman & Adams, 2014; Ernest, 2013; Baetan *et al*., 2013; Velayutham & Algridge, 2012; Dorman & Fraser, 2009;
Psychological characteristic positively influences higher-order thinking skills.	Budsankom *et al*., 2015; Lather *et al*., 2014; Velayutham & Aldridge, 2012; Velayutham *et al*., 2011; Reed *et al*., 2010; Winberg & Hedman, 2008; Aldridge & Fraser, 2008;

METHODOLOGY

Research Design

The study mainly focuses on the quantitative approach to achieve the study objectives and employed a cross-sectional design. By using the survey method in collecting the data, this study employed a structured questionnaire consisted of closed-ended questions in the data collection.

Target Population

The target population for this study was the diploma students from the Faculty of Computer Science and Mathematics (FSKM) at Universiti Teknologi MARA (UiTM), Malaysia. The study involved specific faculty to stay focus on students who had experienced the teaching and learning lesson in statistics subject only. The detailed information about the population available for this study is as Table 2.

Table 2: Target Population

Campus	Total Student	Population (N)
Campus A	94	380
Campus B	191	
Campus C	95	

Sampling and Data Collection

This study employed a probability sampling technique and focused on cluster sampling. Since the target population was clustered together in different campuses geographically, cluster sampling was considered as the most appropriate sampling design for this study which resulted in two campuses were selected. Campus A and Campus B were chosen for data collection whereas Campus C was then automatically used for the pilot study. Therefore, 94 students from Campus A and 191 students from Campus B with a total equal to 285 students became the respondent for a quantitative study. By the 95% confidence level, the target sample gives only a 5% margin of sampling error.

Instrumentation

The questionnaire consisted of five sections. Section A covered information on demographic profiles while Section B, C, D, and E covered the physical learning environment, student self-efficacy, student satisfaction, and lastly higher-order thinking skills variables respectively.

Table 3: The Summary of Instruments Used in the Questionnaire After Pre-Test

Construct	Items	Source
Physical learning environment	22	Smart classroom inventory, SCI (Bao, Siu, & Guang, 2015) and Science Laboratory Environment Inventory, PSLEI (Che Nidzam *et al.*, 2014)
Academic self-efficacy	8	Self-Efficacy in Learning and Performance for College
Student's satisfaction	8	Test of Science Related Attitudes, TOSRA
Higher-order thinking skills	8	The dimension of learning Rubrics

Techniques of Data Analysis

Data screening was performed to identify data entry errors and to examine the statistical assumptions of analysis which involve checking for missing data, outlier, and normality. After screening, data cleaning was performed. The data was then analysed using Partial Least Square-Structural Equation Modeling (PLS-SEM).

RESULTS AND DISCUSSION

The Descriptive Analysis of Respondent Demographic Profile

Most of the respondents were mainly female which constituted 76.5 percent compared to 23.5 percent of male respondents. 7.6 percent of respondents age was below 20 years old and 92.4 percent were age 20 to 22 years old. The allocation of the respondents is 65.9 percent from Campus B and 34.1 percent from Campus A and the majority of the respondent 90.2 percent were from semester 5 students.

Assessment of Measurement Model for the Study

To evaluate the measurement model, reliability and validity tests were used. According to Sekaran and Bougie (2010), reliability is to test how consistently a measuring instrument measures whatever concept it is measuring, while validity is a test of how well an instrument that is developed measures the particular concept it is intended to measure. In assessing the reflective measurement items, Hair *et al*. (2011), recommend achieving satisfaction in reliability (indicator reliability, and internal consistency reliability), convergent, and discriminant validity.

Indicator and Internal Consistency Reliability

To achieve indicator reliability, indicator loadings (factor loadings) should be higher than 0.7 (Hair *et al*., 2011; Valerie 2012). During the deletion stage, all of the outer loadings are above the minimum requirement of 0.7, except for PD2 and PD6 were removed to improve the reliability of the construct. Therefore, these two items were deleted. The values of all the acceptable outer loading after the deletion process are shown in Table 4.1. Another assessment that needs to put a consideration is the assessment of internal consistency reliability. It can be asses through measuring the composite reliability (CR). Composite reliability values reflect the level to which construct indicators reveal the latent variables and they should be greater than 0.70. Based on Hair *et al*. (2011) and Valerie (2012), CR should be higher than 0.7. The result of the CR is also shown in Table 4. All the CR exceeded the recommended value of 0.70, indicating that the measurement scale used in this study had high internal consistency (Sekaran & Bougie, 2010).

Table 4: Factor Loading, Composite Reliability, and Cronbach Alpha Value

Construct	Factor loading FL	Composite reliability CR
Physical Design (PD)		**.881**
PD1	.791	
PD3	.868	
PD4	.896	
PD5	.879	
Learning Space (LS)		**0.874**
LS1	.788	
LS2	.799	
LS3	.892	
LS4	.799	
LS5	.797	
Technology (T)		**.0903**
T1	.819	
T2	.857	
T3	.811	
T4	.875	
T5	.757	
T6	.805	
Indoor air, temperature and lighting quality (I)		**.849**
I1	.776	
I2	.802	
I3	.813	
I4	.807	
I5	.737	

Satisfaction (SA)		**.969**
SA1	.880	
SA2	.924	
SA3	.919	
SA4	.925	
SA5	.894	
SA6	.913	
SA7	.877	
SA8	.912	
Academic self-efficacy (SE)		**.969**
SE1	.888	
SE2	.906	
SE3	.901	
SE4	.899	
SE5	.914	
SE6	.901	
SE7	.915	
SE8	.922	
Higher-order thinking skills (HOTS)		**.950**
H1	.880	
H2	.867	
H3	.865	
H4	.900	

H5	.860
H6	.858
H7	.821
H8	.826

Convergent Validity

Convergent validity is described as the level to which many items measuring the same concept (Ramayah, Wai, & Boey, 2011). Convergent validity was assessed using the average variance extracted (AVE). AVE measures the variance captured by the indicators relative to measurement error should be higher than 0.50 to justify the use of the construct (Valerie, 2012). In this study, the AVEs ranged from 0.656 to 0.736, which were all within the suggested range.

Table 5: Summary of Average Variance Extracted Values

Construct	Average variance extracted (AVE)
Higher-order thinking skills (HOTS)	0.74
Satisfaction (SA)	0.82
Academic self-efficacy (SE)	0.82
Indoor air, temperature and lighting quality (I)	0.62
Learning space (LS)	0.666
Physical design (PD)	0.739
Technology (T)	0.675

Discriminant Validity

Discriminant validity is the extent to which a construct is different from other constructs. The more updated way to assess discriminant validity is by using the Heterotrait-Monotrait ratio of correlations (HTMT) where HTMT below 0.85 referring to the discriminant validity is established (Kline 2011). The value of HTMT for each construct shows the value below 0.85 as in Table 6 which indicates discriminant validity achieved.

Table 6: Discriminant Validity using HTMT

	HOTS	I	LS	PD	SA	SE	T
HOTS							
I	0.317						
LS	0.526	0.55					
PD	0.533	0.439	0.841				
SA	0.734	0.276	0.510	0.397			
SE	0.747	0.389	0.583	0.476	0.798		
T	0.587	0.464	0.793	0.786	0.509	0.583	

PD=physical design, LS=learning space, T=technology, I=indoor air, temperature and lighting quality, SE= academic self-efficacy, SA=satisfaction, HOTS= higher-order thinking skills

To sum it all, all the constructs have achieved reliability and validity. The study involved a higher-order construct of PLE. Therefore, before proceeding with structural modeling, the study assesses the second-order constructs in the next section.

Assessments of formative Higher-Order Construct

There are three approaches to estimate the construct score; 1) The repeated indicator approach; 2) The two-stage approach; 3) The hybrid approach. This study used a reflective-formative type II model and employed repeated indicator approach mode B as suggested by Becker *et al*. (2012). Therefore weight and loading are now represented by the path coefficients between higher-order and lower-order constructs and not by the manifest indicators that repeated at construct level. The results of these analyses may be biased if collinearity is present (Hair, Hult, Ringle & Sarstedt, 2014). In this study, multicollinearity does not exist for PLE and psychosocial learning environment higher-order construct whereas the results for VIF were all less than 5. After obtaining that the constructs did not have multicollinearity problems, the next step is the assessment of the path coefficient for the lower-order construct to higher-order. This step required a bootstrapping procedure. The results of the significance of the path coefficients are shown in Table 7.

Table 7: Significance of Path Coefficient

Path	Path coefficient	T Statistics (|O/ STDEV|)	P Values
I → PLE	*0.095*	*21.929*	*0.225*
LS → PLE	*0.413*	*14.234*	*0.000*
PD → PLE	0.014	*26.400*	0.456
T → PLE	0.578	4.9720	0.000

PD=physical design, LS=learning space, T=technology, I=indoor air, temperature and lighting quality, SE= academic self-efficacy, SA=satisfaction, PLE= physical learning environment

Looking at the relative importance of the lower-order construct in contributing to PLE as the higher-order construct, technology (LS=0.578) is the most important, followed by learning space (LS=0.413). Furthermore, physical design (PD=0.014) and indoor air, temperature, and lighting quality (I=0.095) give a weak contribution to PLE.

The Structural Model Assessment

Hair *et al.* (2011), also suggests that before examining the significance of the structural model, collinearity of the model constructs must be checked by calculating the variance inflation factor (VIF) values and it should be less than 5. The results of these analyses may be biased if collinearity is present. In this study, the results for VIF were all less than 5 as suggested by Hair *et al.* (2011). Thus, this study can proceed to the next analysis assessment of the structural model. After checking for collinearity, assessment continues with the level or the coefficient of determination R^2 values, the f^2 effect size, the predictive relevance, the significance of the path coefficient, and model fit.

Assessment of effect size (f^2) and coefficient of determination (R^2)

The coefficient of determination revealed the percentage of variation in the endogenous construct is explained by all exogenous constructs while the f2 effect size measures the individual specified exogenous constructs to the model. According to Hair *et al*. (2011), R^2 values of 0.75, 0.50, or 0.25 for endogenous latent variables in the structural model can be described as substantial, moderate, or weak, respectively. Based on Table 8, the R2 values of the satisfaction construct (0.301) and self-efficacy (0.389) are considered moderate and higher-order thinking skills (0.598) are in a substantial range. Based on Cohen (1988), the f^2 values of 0.02, 0.15, and 0.35, were used to interpret small, medium, and large effects sizes of the predictive variables, respectively. The result of effect size shows that PLE has a large effect size on SE (0.636), and a large effect on SA (0.43) and a small effect on HOTS (0.063). On the other hand, SA and SE give a moderate and small effect to HOTS by 0.115 and 0.090 respectively.

Table 8: R^2 and f^2 Effect Size of Latent Constructs Result

Construct	R2		f2 effect size	HOTS
		SA	SE	
Higher-order thinking skills (HOTS)	0.598			
Satisfaction (SA)	0.301			0.115
Self-efficacy (SE)	0.389			0.09
Physical learning environment (PLE)		0.43	0.636	0.636

Assessment of Predictive Relevance

Another criterion for the evaluation of the structural model is the predictive relevance Q^2, which is a measure that reflects how well-observed values are reconstructed by the model and its parameter estimates (Hair *et al*., 2011; Chin, 2010). The results in Table 4.6 show that the obtained cross-validated redundancy values for higher-order thinking skills construct, satisfaction, and self-efficacy were found to be 0.408, 0.229, and 0.295, respectively. According to Hair *et al*. (2011), a relative measure of predictive relevance Q^2 values of 0.02, 0.15, and 0.35 indicate that an exogenous construct has a small, medium, or large predictive relevance. These results show a range of Q^2 between 0.229 and 0.408 support the suggestion that the model has an adequate prediction quality. Therefore, the final structural equation modeling is as in Figure 1.

Table 9: Prediction Relevance of the Model

Total	SSO	SSE	Q² (=1-SSE/SSO)
Higher-order thinking skills (HOTS)	0.408	0.408	0.408
Satisfaction (SA)	0.295	0.295	0.229
Academic self-efficacy (SE)	0.295	0.295	0.295

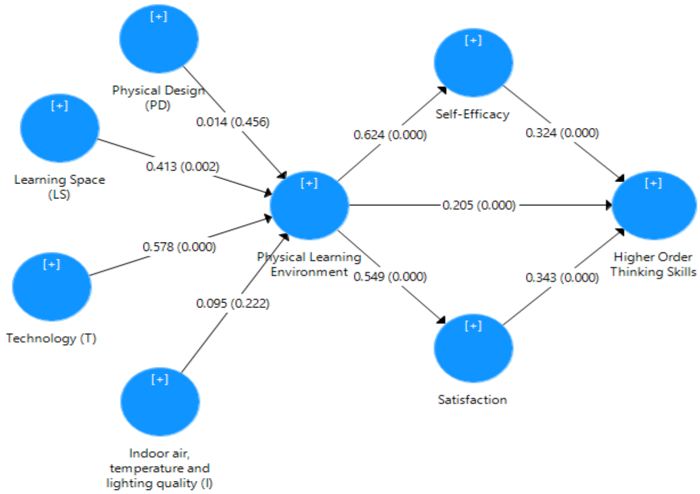

Figure 1: Final Structural Model

The Physical Learning Environment has a Significant and Direct Influence on Students' HOTS

The physical learning environment (IV) was hypothesized to have a significant direct relationship with higher-order thinking skills ability constructs (DV). To determine these relationships, the PLS algorithm and bootstrapping algorithm were conducted. The results in Table 10 that the physical learning environment construct has a significant positive relationship with higher HOTS constructs (ß = .205, *p*-value = .000). These results indicate there is a significant positive relationship between physical learning environment and higher-order thinking skills ability.

Table 10: Direct Relationship Result

Hypothesis	Path	Path coefficient	*p*-values	Result
H1	PLE → HOTS	0.205	.000*	significant

*Significant at $p < .05$. PLE=physical learning environment, HOTS= higher-order thinking skills

Psychological Characteristics Mediated Relationship between Exogenous and Endogenous

The mediator in this study is the psychological characteristics. Testing the effects of mediation involves variables that exist in the relationship between the variables exogenous to endogenous by using the bootstrapping method based on Preacher and Hayes (2004). Table 11 shows the direct relationship between PLE and SE is significant (ß=.624, *p*=.000). The direct relationship between SE and HOTS also significant (ß=.324, *p*=.000). This implies that self-efficacy does mediate the relationship between the physical learning environment and HOTS. For the satisfaction construct, PLE has a significant direct relationship with SA (ß=.549, *p*=.000), and SA has a significant direct relationship with HOTS (ß=.343, *p*=.000). This, again, implies that the satisfaction construct also significantly mediates the relationship between the physical learning environment and HOTS. So, H2 and H3 are supported. Altogether, based on Table 12, there existed a significant indirect effect of the physical learning environment toward HOTS with the occurrences of SE and SA as the mediator (ß=0.391, *p*=0.000). Again, the strength of the mediation effect is assessed using variance accounted for (VAF). Table 13 shows VAF for SA and SE for this case is equal to 65.6% (0.391/0.596). Thus, the VAF indicates that 65.6% of the effect of the physical learning environment on HOTS is explained by SE and SA as mediators. There is also a small difference in specific indirect effect since the difference between the indirect effect of SE (0.624*0.324=0.202) and SA (0.343*0.549=0.188) is 0.013.

Table 11: Direct Path Coefficient Result for Mediation

Path	Path coefficient	*P* Values	Significant
PLE → HOTS	0.205	.000*	Significant
PLE → SA	0.549	.000*	Significant
SA → HOTS	0.343	.001*	Significant
PLE → SE	0.624	.000*	Significant
SE → HOTS	0.324	.000*	Significant

*Significant at $p < 0.05$. PLE=physical learning environment, SE=self-efficacy, SA=satisfaction, HOTS= higher-order thinking skills

Table 12: Indirect Effect of Mediation

Exogenous construct	Mediation	Endogenous construct	Indirect effect	*P* values	Result
Physical learning environment	SE SA	Higher-order thinking skills	0.391	0.000*	Significant

*Significant at $p < 0.05$. SE=academic self-efficacy, SA= satisfaction

Table 13: Total Effect of Mediation

Exogenous construct	Mediation	Endogenous construct	Total effect	*P* values	Result
Physical learning environment	SE SA	Higher-order thinking skills	0.596	0.000*	Significant

*Significant at $p < 0.05$. SE=academic self-efficacy, SA= satisfaction

Summary of the Results

Initially, data screening and cleaning were conducted for missing data and outliers to ensure the study processes good data. Normality has been assessed to view the distribution and to avoid data contain extreme kurtosis. Descriptive statistics were provided on the profile of respondents. Using

PLS-SEM, the analysis revealed the significant direct relationships between the physical learning environment and HOTS. The mediation effects of self-efficacy and satisfaction was found on the relationships between the physical learning environment and HOTS. The summary of the findings is in Table 14.

Table 14: Summary of Hypotheses Testing Result

Hypothesis Result

	Hypothesis	Result
H1	The physical learning environment has a significant and direct influence on students' higher-order thinking skills.	Supported
H2	Self-efficacy mediates the relationship between the physical learning environment and higher-order thinking skills.	Supported
H3	Satisfaction mediates the relationship between the physical learning environment and higher-order thinking skills.	Supported

CONCLUSION

The present study found that the physical learning environment (β = .205, *p*-value = .000) has a significant and direct influence on students' HOTS. The results assert that the PLE is an important factor in students' HOTS development. These findings are consistent with the results obtained by Budsankom *et al.* (2015). In their study, based on the results of Meta-analytic structural equation modeling, the authors conclude that the quality of the PLE is one of the factors contribute to the development of HOTS. Thus, the study concludes that the results in a statistics educational setting is consistent with other subject settings on the influence of the physical learning environment quality toward student HOTS.

This study also found that self-efficacy and satisfaction mediate the relationship between physical learning environments and HOTS. The psychological characteristics in this study refer to the academic self-efficacy of the student and their satisfaction. The findings are similar to Budsankom *et al.* (2015) that the psychological characteristics of students are an important mediator variable for HOTS. Specifically, the study found that the learning environment gives a significant influence on student self-efficacy and satisfaction. The study results are also consistent with Baetan *et al.* (2013) who explore the interrelationship between learning environments, psychological characteristics, and academic achievement. These results also support the similar findings of Dorman (2009), Nelson and Debacker (2008), and Patrick *et al.* (2007), all of them found that the learning environment positively affects the psychological characteristics of the student. Moreover, this study also found psychological characteristics (self-efficacy and satisfaction) having a significant and direct influence on students' HOTS in statistic subject. The results of this study are again consistent with a study that involved 244 undergraduates as respondents by Lather *et al*. (2014). The authors found that psychological characteristics can influence student HOTS. Thus, the study concludes that the results in a statistics educational setting are consistent with other subject settings on the significant mediator of psychological characteristics intervening in the relationship between the PLE and HOTS construct. The physical learning environment gives a significant indirect effect on students' HOTS through psychological characteristics (students' self-efficacy and satisfaction).

In conclusion, the physical learning environment gives a direct significant effect on students' HOTS in statistics education. More importantly, the findings also proved that the physical learning environment did give a large indirect significant effect on the development of students' HOTS.

REFERENCES

Allen, I.E. & Seaman, J. (2007). Online Nation: Five Years of Growth in Online Learning. The Sloan Consortium, Needham, Mass.

American Statistical Association (2016). Employment Projections program, Bureau of Labour Statistics, U.S. DOI:10.1787/117cfb83-en

Ari, R. B. & Eliassy, L. (2003). The differential effects of the learning environment on student achievement motivation: A comparison between frontal and complex instruction strategies. *Journal of Social Behaviour and Personality, 31*(2), 143-166. DOI: 10.2224/ sbp.2003.31.2.143

Azry, M. A. M, Mazlini A., Norafefah, M. S., Amri A. R., & Jasrul, N. G., (2017). The relationship between the learning environment and psychological characteristics in higher education. *Journal of Advanced Research in Social and Behavioural Sciences, 7*(1), 96-117.

Baeten M., Dochy F., & Struyven K. (2013). The effects of different learning environments on students' motivation for learning and their achievement. *Journal of Education Psychology, 83*(3), 484-501. DOI:10.1111/j.2044-8279.2012.02076.x

Bandura, A. (1997). *Self-Efficacy*: The Exercise of Control. New York: W.H. Freeman and Company.

Bandura, A., & Locke, E. A. (2003). Negative self-efficacy and goal effects revisited. *Journal of Applied Psychology, 88*(1), 87–99. DOI:10.1037/0021-9010.88.

Bao, P. L., Siu, C.K., & Guang, C. (2015). Development and validation of the smart classroom inventory. *Smart Learning Environments, 2*(1), 1-18. DOI: 10.1186/s40561-015-0012-0

Becker, J. M., Klein, K., & Wetzels, M. (2012). Hierarchical latent variable models in PLS-SEM: Guidelines for using reflective-formative type models. *Long Range Planning, 45*(5), 359-394. DOI: 10.1016/j. lrp.2012.10.001

Booker, Q. E., & Rebman, C. E. (2005). E-student retention: Factors affecting customer loyalty for online program success. *Issues in Information Systems, 1*(1), 183-189.

Brookhart, S. M., (2010). How to assess higher-order thinking skills in your classroom. Alexandria, Virginia USA. Association for Supervision and Curriculum Development ASCD.

Browne, M. N., & Freeman, K. (2000). Distinguishing features of critical thinking classrooms. *Teach. Higher Education, 5*(3), 301-309. DOI: 10.1080/713699143

Budsankom, P., Sawangboon T., Damrongpanit S., & Chuensirimongkol J. (2015). Factors affecting higher-order thinking skills of students: A meta-analytic structural equation modeling study. *Educational Research and Reviews, 10*(19), 2639-2652. DOI:10.5897/err2015.2371

Che Nidzam, C.A., Kamisah O., & Lilia, H. (2013). Physical and psychosocial aspects of the learning environment in the science laboratory and their relationship to teacher satisfaction. *Learning Environments Research*, *16*(3), 367-385. DOI: 10.1007/s10984-013-9136-8

Chin, W. W. (2009). How to Write Up and Report PLS Analyses. In Esposito Vinzi V., Chin W., Henseler J., Wang H. (Eds). *Handbook of Partial Least Squares*. Berlin: Springer. DOI: 10.1007/978-3-540-32827-8_29

Chinedu, C. C., Libunao, W.H., Kamen, Y.B., & Saud, M.S.B. (2014). Implementing Higher Order Thinking Skills in Teaching and Learning of Design and Technology Education. Paper presented at International Seminar on Technical and Vocational Education, Johor-Malaysia.

Chism, N. V. N. (2006). Challenging traditional assumptions and rethinking learning spaces. Learning Spaces, 2-1. Retrieved from http://www.educause.edu/learningspaces

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. New York: Routledge. DOI: 10.4324/9780203771587

Dorman, J. P. (2009). Associations between psychosocial environment and outcomes in technology-rich classrooms in Australian secondary schools. *Research in Education, 82*(1), 69-84. DOI: 10.7227/rie.82.6

Dorman, J. P. & Adams, J. (2004). Associations between students' perceptions of classroom environment and academic efficacy in Australian and British secondary schools. *Westminster Studies in Education, 27*(1), 69-85. DOI:10.1080/0140672040270106

Dorman, J. P., & Fraser, B. J. (2009). Psychosocial environment and affective outcomes in technology-rich classrooms: Testing a causal model. *Social Psychology of Education*: *An International Journal, 12*(1), 77-99. DOI: 10.1007/s11218-008-9069-8

Edman, J. L., & Brazil, B. (2007). Perceptions of campus climate, academic efficacy and academic success among community college students: An ethnic comparison. *Social Psychology of Education, 12*(3), 371-383. DOI: 10.1007/s11218-008-9082-y

Ernest, A. (2013). The effects of psychosocial learning environment on students' attitudes towards Mathematics. *Application of Structural Equation Modeling in Educational Research and Practice, 2*, 91-114. DOI: 10.1007/978-94-6209-332-4_5

Fraser, B. J. & Kahle, J. B. (2007). Classroom, home, and peer environment influence on student's outcomes in Science and Mathematics: An Analysis of systematic reform data. *International Journal of Science Education, 29*(15), 1891–1909. DOI: 10.1080/09500690601167178

Fraser, B. J., Aldridge, J. M., & Adolphe, F. S. G. (2010). A cross-national study of secondary science classroom environments in Australia and Indonesia. *Research in Science Education, 40*(4), 551-571. DOI: 10.1007/s11165-009-9133-1

Galton, M., Hargreaves, L., & Pell, T. (2009). Group work and whole-class teaching with 11 to 14-year olds compared. *Cambridge Journal of Education, 39*(1), 119-140. DOI: 10.1080/03057640802701994

Hair, J., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). *A Primer on Partial Least Squares Structural Equation Modeling*. Thousand Oaks: Sage.

Hair, J., Ringle, C., & Sarstedt, M. (2011). PLS-SEM: Indeed, a silver bullet. *The Journal of Marketing Theory and Practice, 19*(2), 139-152. DOI: 10.2753/mtp1069-6679190202

Higgins, S., Hall, E., Wall, K., Woolner, P. & McCaughey, C. (2005). *The Impact of School Environments: A Literature Review*. London: Design Council.

Kline, R. (2011). *Principles and Practice of Structural Equation Modeling, 3rd Edition*. New York: Guilford Press.

Kind, P., Jones, K., & Barmby. P. (2007). Development attitudes towards science measures. *International Journal of Science Education, 29*(7), 871-893. DOI: 10.1080/09500690600909091

King, F., Goodson, L., & Rohani, F. (2011). *Higher-Order Thinking Skills: Definitions, Strategies, Assessment. Tallahassee.* FL: Florida State University.

Lather A. S., Jain S., & Shukla A. D. (2014). Student's creativity in relation to locus of control: A study of Mysore University, India. *International Journal Indian Psycho, 2*(1), 146-165.

Loes, C. N., Salisbury, M. H. & Pascarella, E. T. (2015). Student perceptions of effective instruction and the development of critical thinking: A replication and extension. *Higher Education, 69*(5), 823-838. DOI: 10.1007/s10734-014-9807-0

MacGillivray, H., & Pereira-Mendoza, L. (2011). Teaching statistical thinking through investigative projects. In Batanero, C, Burril, G & Reading, C. (Eds). *Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education: A Joint ICMI/IASE Study*: *The 18th ICMI Study New ICMI Study Series*. Switzerland: Springer Science+Business. DOI: 10.1007/978-94-007-1131-0_14

Margolis, H. & McCabe, P. P. (2006). Improving self-efficacy and motivation: What to do, what to say. *Intervention in School & Clinic, 41*(4) 218-227. DOI: 10.1177/10534512060410040401

McMillan, J. H. (2001). Secondary teachers' classroom assessment and grading practices. *Educational Measurement*: *Issues and Practice, 20*(1), 20-32. https://doi.org/10.1111/j.1745-3992.2001.tb 00055.x

McMillan, J. H., Myron, S., & Workman, D. (2002). Elementary teachers'classroom assessment and grading practices. *Journal of Educational Research, 95*(4), 203-213. https://doi.org/10.1080/00220670209596593

Mohd. Ali I., & Shaharom N., (2003) Perbandingan Pencapaian Para Pelajar Dalam Pentaksiran Kerja Amali Dengan Peperiksaan Bertulis. Buletin Persatuan Pendidikan Sains dan Matematik Johor. Johor: Universiti Teknologi Malaysia.

Monahan, T. (2002). Flexible space & built pedagogy: Emerging IT embodiments. *Invention, 4*(1), 1-19.

Moore, J. C. (2009). A synthesis of Sloan-C effective practices. *Journal of Synchronous Learning Networks, 13*(4), 84-94. DOI:10.24059/olj.v13i4.1649

Nelson R. M., & Debacker T. K. (2008). Achievement motivation in adolescents: The role of peer climate and best friends. *The Journal of Experimental Education, 76*(2), 170-189. DOI:10.3200/jexe.76.2.170-190

Ogbuehi, P. I., & Fraser, B. J. (2007). The Learning environment, attitudes, and conceptual development associated with innovative strategies in middle-school mathematics. *Learning Environments Research, 10*(2), 101-114. DOI: 10.1007/s10984-007-9026-z

Pascarella E. T., Wang J. S., Trolian T. L., & Blaich C. (2013). How the instructional and learning environments of liberal arts colleges enhance cognitive development. *Higher Education, 66*(5), 569-583. DOI: 10.1007/s10734-013-9622-z

Patrick H., Ryan A., & Kaplan A. (2007). Early adolescents' perceptions of the classroom social environment, motivational beliefs, and engagement. *Journal of Educational Psychology, 99*(1), 83. https://doi.org/10.1037/0022-0663.99.1.83

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behaviour Research Methods, Instruments, & Computers, 36*(4), 717-731. DOI: 10.3758/bf03206553

Rajendran, N., & Idris, P. U. P. S. (2008). *Teaching & Acquiring Higher-Order Thinking Skills*: *Theory & Practice*. Penerbit Universiti Pendidikan Sultan Idris.

Ramayah, T., Lee, W.C., & Boey, C.I. (2011). Network Collaboration and Performance in the Tourism Sector. *Service Business, 5*(4), 411-428. DOI: 10.1007/s11628-011-0120-z

Reed, H.C., Drijvers, P., & Kirschner, P.A. (2010). Effects of attitudes and behaviours on learning mathematics with computer tools. *Computers & Education, 55*(1), 1-15. DOI: 10.1016/j.compedu.2009.11.012

Reston, E., Krishnan, S., & Noraini, I., (2014). Statistics education research in Malaysia and the Philippines: A comparative analysis. *Statistics Education Research Journal, 13*(2), 218-231.

Rozario G. D. & Suhaimi M. T (2015). The influence of the learning environment and academic self-efficacy towards mathematics achievement in Masterskill global college, Malaysia. *International Journal of Arts and Commerce, 4*(2), 43-52.

Sanoff, H. (2000). *Community Participation Methods in Design and Planning*. Wiley: New York.

Santrock J. W. (2009). *Educational Psychology*. New York, NY: McGraw Hill.

Sekaran, U., & Bougie, R. (2016). *Research Methods for Business*: *A Skill-Building Approach*. UK: John Wiley & Sons.

Sinclaire, J. (2011). Student satisfaction with online learning: Lessons from organizational behaviour. *Research in Higher Education Journal*, 11, 1-18. DOI: 10.12691/education-5-1-3

Stajkovic, A. D., & Luthans, F. (2003). Social cognitive theory and self-efficacy: Implications for motivation theory and practice. *Motivation and Work Behavior, 126*, 140.

Strange, C. C. & Banning, J. H. (2001). *Educating by Design*: *Creating Campus Learning Environments That Work*. San Francisco: Jossey-Bass.

Sweeney, J. C., & Ingram, D. (2001). A comparison of traditional and web-based tutorials in marketing education: An exploratory study. *Journal of Marketing Education, 23*(1), 55-62. DOI: 10.1177/0273475301231007

Tal, R., & Hochberg, N. (2003). Assessing high order thinking of learners participating in the "WISE" project in Israel. *Studies in Educational Evaluation, 29*(2), 69-89. DOI: 10.1016/s0191-491x(03)00016-6

Tan, W. C., Aris, B., & Abu, M. S. (2006). GLOOTT Model: A pedagogically enriched design framework of a learning environment to improve higher-order thinking skills. *AACE Journal, 14*(2), 139-153. DOI: 10.7459/ites/12.2.05

Tanner, C. K. (2000). The influence of school architecture on academic achievement. *Journal of Educational Administration, 38*(4), 309-330. DOI: 10.1108/09578230010373598

Thurmond, V. A., Wambach, K., Connors, H. R., & Frey, B. B. (2002). Evaluation of student satisfaction: Determining the impact of a web-based environment by controlling for student characteristics. *The American Journal of Distance Education, 16*(3), 169-189. DOI: 10.1207/s15389286ajde1603_4

Valerie, F. (2012). Re-discovering the PLS approach in management science. *Management, 15*(1), 101-123.

Veal, W. R & Jackson, Z. (2006). Developing a primary science methods classroom. I*nternational Journal of Science and Mathematics Education, 4*(2), 195-213. DOI:10.1007/s10763-005-9000-0

Velayutham, S., & Aldridge, J. M. (2012). Influence of psychosocial classroom environment on students' motivation and self-regulation in science learning: A structural equation modeling approach. *Research in Science Education, 43*(2), 507-527. DOI: 10.1007/s11165-011-9273-y

Velayutham, S., Aldridge, J. M., & Fraser, B.J. (2011). Development and validation of an instrument to measure students' motivation and self-regulation in science learning. *International Journal of Science Education, 33*(15), 2159-2179. DOI: 10.1080/09500693.2010.541529

Winberg, T.M., & Hedman, L. (2008). Student attitudes toward learning, level of pre-knowledge and instruction type in a computer-simulation: effects on flow experiences, and perceived learning outcomes. *Instructional Science, 36*(4), 269-287. DOI: 10.1007/s11251-007-9030-9

Wolf, S.J. & Fraser, B.J. (2008). The learning environment, attitudes and achievement among middle-school science students using inquiry-based laboratory activities. *Research in Science Education, 38*(3), 321-341. DOI: 10.1007/s11165-007-9052-y

Woolfolk A.E. (2004). *Educational Psychology*. Boston: Pearson Education, Inc.

Wu, H., Tennyson, R.D., & Hsia, T. (2010). A study of student satisfaction in a blended e-learning system environment. *Computers & Education, 55*(1), 155-164. DOI:10.1016/j.compedu.2009.12.012

Zohar, A., & Dori, Y.J. (2003). Higher-order thinking skills and low-achieving students: Are they mutually exclusive? *The Journal of the Learning Sciences, 12*(2), 145-181. DOI: 10.1207/s15327809jls1202_1