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Determining the Factors that Promote Higher Order Thinking Skills in Mathematics Technology Enhanced Learning Environment: Perspective from University Students

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Abstract

The purpose of this study was to investigate the factors that influence promotion of higher order thinking skills (HOTS) among mathematics higher learning institution students in technology enhanced learning environment (TEL) in Malaysia. The study used descriptive research design. Data of the study was collected by using quantitative research approach. A total of 250 students from three public universities participated in the study. The study explores the relationship between students' attitude towards technology use and organisation support towards promotion of HOTS in mathematics TEL environment. Results from structural equation modelling reported that students' attitude towards technology use had a positive direct relationship with HOTS. Meanwhile, organisation support had a positive direct relationship with students' attitude towards technology use which in turn indirectly influence promotion of HOTS. The hypothesized structural equation model accounted for 20.2% of the variance in HOTS. The results indicated a need for further studies in order to examine factors that predict promotion of HOTS in mathematics TEL at higher learning institutions in Malaysia.

Keywords: attitude; critical thinking; student; higher learning institution; organisation.

1 Introduction

In the last few years, there have been many changes in the Malaysian Universities learning and teaching system. According to the Malaysian Ministry of Education, the new model for universities in Malaysia focuses on achieving effective learning on the part of the student by encouraging self-learning and creation of creative thinking. The changes that the Malaysian Higher Education experiences have introduced integration of new resources such as Information and Communication Technologies (ICT). According to [25], integration of ICT in university environment demanding for a change of mentality in both educators and students. The role of ICT in education context is becoming increasingly important as it's promised many academic benefits directly and indirectly. ICT provides a platform for the students to gain access to digital information, provide creative learning environment to develop critical thinking skills, support student-centered and self-regulated learning, promote collaborative learning and improve teaching and learning qualities ([11]; [29]). Substantial benefits of ICT resources make the university management to plan for integrating ICT resources appropriately to achieve great improvement in their teaching and learning activities to provide benefits to their main stakeholders who mainly consist of students.

Past studies acknowledged the potential of ICT tools to promote higher order thinking skills (HOTS). For instant, [27] stated that ICT tools promote sharing, interactivity and collaboration among students that subsequently promote HOTS. ICT also believed to change the traditional educational approach (teacher-centred learning) into a more interactive and engaging environment to facilitate authentic knowledge transmission. This enables the students to become producer of knowledge under the educators' guidance ([19]; [28]). ICT such as simulation tools provide learners with opportunities to explore and experience realistic scenarios. In this context, learning tasks are linked to a greater, genuine and intricate problem in which players can examine alternative ideas and take ownership for the consequences. Besides, they can receive feedback and opportunities for reflection in order to develop HOTS ([23]; [31]). Thus, maximising learning of HOTS with ICT has been emphasised in multiple developed countries such as the United Kingdom, the United States of America and Singapore. Malaysian government through Malaysian Education Blueprint 2013 - 2025 also place great emphasis on developing HOTS among students. Generally, HOTS refer to critical thinking, problem solving, decision making and creative thinking ([22]). HOTS widely recognized as a way of thinking that moves beyond memorization, recall and understanding of facts to synthesis, analysis, evaluation and creation of knowledge ([17].

The concept of HOTS has been a major concern in the Malaysian mathematics syllabus. In Malaysian schools, almost 60% of the examination questions for mathematics are designed to test HOTS. Besides, public examinations in Malaysia for primary and secondary school levels consist of $40\% - 50\%$ questions that related to HOTS [1]. At the higher learning institution levels, educators provide $60\% - 70\%$ assignment and examination questions that focused on HOTS. Besides, most of the educators integrated ICT tools in the higher learning institution classrooms to conduct teaching and learning activities to promote HOTS among students. This is in accordance with the shift proposed in Malaysian Education Blueprint 2013 - 2025 where Malaysian higher learning institutions are encouraged to transform delivery model of teaching to technology-enabled innovations. However, the scenario in Malaysian higher learning institution shows that performance of students in mathematics questions related to HOTS still not at the encouraging level. The students are lacking in mathematical problem-solving skills, analysis, reasoning, evaluating and creating. Thus, there is a dire need to investigate the factors that influence promotion of HOTS in ICT integrated mathematics classroom. Besides, past studies related to understanding the factors that influence promotion of HOTS either in traditional or ICT integrated classrooms in Malaysia have

been focusing mainly on primary and secondary level schools ([12]). Thus, the current study aims to investigate the factors that influence promotion of HOTS in mathematics technology enhanced learning environment (TEL) at higher learning institutions in Malaysia.

2 Literature Review

2.1 Factors that influence promotion of HOTS in ICT integrated classrooms

[20] asserted that students' attitude towards technology use indirectly affect the promotion of HOTS in TEL environment. In TEL environment it is vital to understand the attitude towards technology use of students to enable the students maximise the learning benefits from the TEL environment. [5] and [13] highlighted that confidence in learning through technology shape the attitude of the students in TEL environment. Those students who have more self-confident and believe learning though technology could be useful for them show positive attitudes towards technology use. Engage in workshops or training programmes that teach the students how to use the technology also influence their attitudes. This is because it makes the process of learning easier, faster, and more exciting ([3]). Furthermore, access to greater quantities of resources rapidly also believe to shape their attitude. Students believe that sufficient learning resources enable them to look for the necessary information that they need to accomplish their task on time ([3]).

Many studies have been conducted indicating the students' attitudes towards technology use and the influences on academic achievement. Past studies reported mixed results regarding the relationship between students' attitudes towards technology use and their academic achievement. Some studies reported that students' attitudes towards technology use influence their academic achievement significantly ([26]). For instance, [16] highlighted that positive attitude of students towards technology use could alleviate their learning performance and increase their learning interest. Meanwhile, there are other studies emphasized that attitudes towards technology use alone does not influence students' academic performance. These studies reported that other factors such as teaching strategies and learning resources contributes more towards students' academic achievement in TEL environment ([14]; [21]). It is important to highlight that most of the studies discussing the students' academic achievement generally, very limited studies have explored the relationship between attitudes towards technology and promotion of HOTS in mathematics classroom specifically. Thus, the current study investigates the relationship between students' attitude towards technology use and promotion of HOTS in mathematics TEL environment. The second hypothesis of the study is:
H_1: Students' attitude towards technology use has a direct impact towards promotion of HOTS in mathematics TEL environment.

Organisation support is considered one of the important factors that influence integration of technology to promote HOTS. Organisational support such as providing sufficient equipment or connectivity, adequate training programmes, adequate technical support and administrative/peer support are considered important factors that influence instructors and students to use technology to achieve academic benefits ([18]). According to [25], integration of technology in education would be unsuccessful if the organisation does not have an explicit policy on when and how the technology can be integrated and if the organisation does not provide adequate training programme that guide the educators on the use of technology tools. According to [4], failure to deliver effective training means a lack of preparation, insufficient or ineffective teaching and inad-

equate training and practice. Not a well-trained educator might end up discontinuing the effort of integrating technology tools in their teaching and learning activities that affect the learning process of students. Organisational support is considered as important factor that influence use of technology tools by educators and students to foster academic benefits. Thus, the current study investigates the relationship between organisational support and attitude towards technology use of instructors and students in mathematics TEL environment. The third and fourth hypothesis of the study are:
H_2: Organisational support has a direct impact towards students' attitude towards technology use. Figure 1. shows the research model of the study.

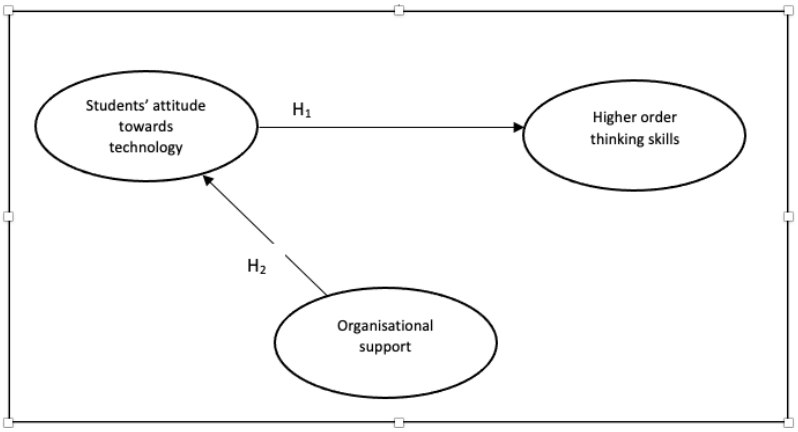

Figure 1: Research model with hypothesis.

3 Methods

3.0.1 Research Design

The research used descriptive research design. Descriptive research design was used because the research aimed to determine the factors that influence the promotion of HOTS in ICT integrated classes among students. According to [6] descriptive research design is the appropriate research design if the research is aimed at answering the "what" type of research questions. This study used quantitative approach to collect data from the target respondents. Quantitative approach was used in order to determine the frequency of the factors that influence the promotion of HOTS in ICT integrated classes.

3.1 Respondents

The respondents consisted of 250 undergraduate and postgraduate students from three local public universities in Malaysia. The three public universities were selected because they actively integrate ICT tools in teaching and learning of mathematics. The information on the academicians actively integrate ICT tools in teaching and learning of mathematics was obtained from the head of department from the respective universities. The respondents were from department of mathematics. The mean age of the respondents was 23.5 with standard deviation of 6.30. 82% of participants were females, 18% were males. They were mostly Bumiputra (82.4%), followed by

Table 1: Demographic details of the participants.

Demographic details	Category	Frequency	Percentage (%)
Gender	Male	45	18
	Female	205	82
Ethnic	Malay	206	82.4
	Female	205	82
	Chinese	20	8
	Indian	9	3.6
	Others	15	6
Programme	Bachelor	171	68.4
	Master	79	31.6

Chinese (8%), Indians (3.6%) and others (6%). Table 1 shows the demographic distribution of the respondents.

3.2 Procedure

Data for the study were collected using the convenient sampling technique by means of an online survey. The researchers emailed the questionnaire to all the students with a cover letter indicating the purpose and significance of the study together with a link to the questionnaire on Google Form. The students were informed that their participation was voluntary and returning the completed questionnaire was equivalent to an informed consent. A total of 258 students answered the online questionnaire. After 8 invalid responses were eliminated, 250 valid samples were collected.

3.3 Instrument

The survey instruments consisted of two parts. The first part collected the participants' demographic information, such as gender, age, ethnic group, level of education and the technologies they use in their learning process. The second part consisted of a set of items (measured by 5-point Likert Scale, 1 = strongly disagree, 5 = strongly agree) representing the constructs of interest, namely, instructors' attitude towards technology use (6 items) (adapted from [9]), students' attitude towards technology use (4 items) (adapted from [9]), organisational support (4 items) (adapted from [30]), and higher order thinking skills (4 items) (adapted from [20]). Two experts in the field of ICT in education evaluated the validity of the instrument.

4 Results

4.1 Descriptive statistics

SPSS 28.0 was used to compute the descriptive statistics. Table 2 shows the mean scores and standard deviations of students' responses to the questionnaire. The instructors' attitude towards technology use and students' attitude towards technology use were moderate (M = 3.71, M =

Table 2: Descriptive results.

Construct	SATT	ORG	HOTS
Mean	3.90	3.82	3.36
Standard deviations	0.66	0.71	0.90

Table 3: Results of measurement model.

Construct and item	Standardised factor loading	Cronbach's alpha $(> 0.70)^a$	Composite reliability $(> 0.70)^a$	Average variance extracted $(> 0.50)^a$
Students' Attitude towards Technology use (SATT)		0.86	0.84	0.58
SATT1	0.78			
SATT2	0.73			
SATT3	0.80			
SATT4	0.72			
Organisational factor (ORG)		0.86	0.84	0.58
ORG1	0.71			
ORG2	0.74			
ORG3	0.80			
ORG4	0.80			
Higher order thinking skills (HOTS)		0.86		
HOTS1	0.54		0.87	0.63
HOTS2	0.86			
HOTS3	0.87			
HOTS4	0.86			

*a indicates an acceptable level of reliability or validity

3.90, respectively). In addition, the students also rated organisational support and higher order thinking skills as moderate (M = 3.82, M = 3.36, respectively).

4.2 Test of the measurement model

The CFA results are shown in Table 3. The standardised factor loadings for all items were greater than 0.50, between 0.54 to 0.87 within the acceptable range of 0.4 suggested by [10]. All Cronbach's alphas were more than 0.70 indicating good reliability of item within a construct ([8]). Composite reliability (CR) and average variance extracted (AVE) were used to measure the convergent validity of the measurement model. All the CR values of the constructs were greater than 0.70 indicating good internal consistency ([24]). AVE of the all the constructs were greater than 0.5 within the acceptable range suggested by [24].

The comparative fit index (CFI) and Tucker-Lewis index (TLI) were used to analyse the fit of the measurement model, with values greater than 0.90 indicating an acceptable fit. The root mean square error of approximation (RMSEA) and standardised root mean square residual (SRMR)

were also calculated where values less than 0.08 indicating acceptable results ([15]). The model fit indices for the measurement models indicated they had acceptable fit to the data. The model fit indices were CFI = 0.95, TLI = 0.94, RMSEA = 0.069, SRMR = 0.059, GFI = 0.90. The indices for the measurement model showed that they have acceptable fit to the data.

4.3 Test of the structural models

The structural equation model as a whole accounted for 20.2% of the variance in HOTS. Students' attitude towards technology use was a predictor of HOTS ($\beta = 0.12, p < .001$). Thus, H_1 is supported. While organisational support was also significantly and directly linked to students' attitude towards technology use ($\beta = 0.66, p < .05$) which indicates that H_2 was supported.

5 Discussion

This study investigated the factors that influence promotion of HOTS in mathematics technology enhanced learning environment (TEL) at three higher learning institutions in Malaysia. A conceptual model was developed based on previous research and theory in the area and tested using structural equation modelling. The results supported the hypothesized paths from students' attitude towards technology use to higher order thinking skills (H_2). This study also found statistically significant and positive relationships between organisational support to students' attitude towards technology use (H_2).

With the acceptance of H_1, it has been found that students' attitude towards technology use has a positive effect on promotion of their higher order thinking skills. The findings showed that positive attitude of students towards ICT tools encourage them to use the ICT tools effectively in their learning activities to obtain better academic achievements. Besides, students could also find the ICT tools benefit them both affectively and cognitively where they find that use of ICT tools is enjoyable and enable them to interact easily with their peers and instructors. This can lead to the promotion of HOTS in mathematics TEL. This finding is consistent with the findings of [20] who asserted that students' attitudes towards technology influence promotion of HOTS in TEL environment that was mediated by deep learning motives and strategies.

As per the second hypothesis, organisational support strongly influence students' attitudes towards technology use. The finding implies that organisational support is important predictor that shape the attitude students towards integration of ICT tools in their teaching and learning activities. Organisational support such as technical support, training programmes and clear policies in terms of integration of ICT tools motivates the students to use the ICT tools without any technical hurdles. This let them focus on the teaching and learning activities that enables the students to engage in their learning activities effectively. This can directly and significantly lead to the promotion of HOTS in mathematics TEL environment. This finding is consistent with that of [7] and [18], who suggested that organisational support is one of the important predictors that influence and shape the attitude of learners towards ICT tools.

In sum, the findings of this study shows that students' attitude towards technology use directly influence higher order thinking skills of students. This relationship shows that positive attitudes

of students toward technology use is important to alleviate students' higher order thinking skills in mathematics TEL environment. Positive attitudes of students towards ICT tools enable them to enjoy its use and find more options to get learning benefits through its integration. Meanwhile, organisational support strongly influences students' attitude towards technology use which in turn assist in promotion of higher order thinking skills of the students in mathematics TEL environment. Organisational support is considered the backbone the students effective use of ICT tools. Proper support from the organisation motivates and shapes the attitude of students towards ICT tools. This can lead to the promotion of higher order thinking skills in mathematics TEL environment. The findings of the study suggest that TEL is optimal learning platform for who had positive attitudes towards technology use and received sufficient organisational support.

Practical suggestions can be drawn from the findings indicating that students' attitude towards technology use had the significance direct influence on higher-order thinking. First, to create positive attitude towards technology use among students, the top management of higher learning institution should provide conducive environment to integrate ICT tools effectively in teaching and learning activities. The top management should encourage and motivate the students to integrate the ICT tools successfully in their learning activities. The top management is also suggested to provide proper directions and prepare appropriate plans to enable the students to use the ICT tools. This could lead to formation of positive attitude toward technology use among the students ([2]).

This study has several limitations. First, the study used convenient sampling technique to collect data. Thus, this may affect the generalisability of the result. Second, the study only examines the effect of organisational factor and attitudes towards technology use to enhance higher order thinking skills in mathematics TEL environment. Thus, future studies are encouraged to include more related variables such as learning material and task factor in TEL environment to further explore factors that influence promotion of higher order thinking skills in TEL environment.

6 Conclusions

In this study, the researchers investigated the effect of organisational factor and students' attitude towards technology use to promote higher order thinking skills of university students in mathematics TEL environment. Research results suggested organisational support indirectly affect promotion of higher order thinking skills through students' attitude towards technology use. Meanwhile students' attitude towards technology use directly affect promotion of higher order thinking skills. The current study contributed to people's understanding of to what extend organisational factor and students' attitude towards technology use influence promotion of higher order thinking skills in mathematics TEL environment by providing empirical evidence from three local public universities in Malaysia.

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Conflicts of Interest The authors declare no conflict of interest.

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