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The Level of Marzano Higher-Order Thinking Skills among Polytechnic Students

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Abstract:
This study aims to identify polytechnic students' level of Marzano Higher-Order Thinking Skills (HOTS) based on two dimensions, 'Extension and Refinement of Knowledge' and 'Meaningful Use of Knowledge,' and to analyze the difference in the students' level of Marzano HOTS based on these two dimensions depending on the students' demographic factors. This study design was a survey using quantitative methods. A total of 313 students were randomly selected as the survey sample. A questionnaire in the form of closed-ended questions was used as the research instrument. Data were analyzed using frequency percentage and MANOVA test. The findings showed no significant differences in the eight HOTS in the dimension of 'Extension and Refinement of Knowledge' with the gender and socio-economic status (SES) factors. However, there were significant differences in the eight HOTS with the academic achievement factor. Meanwhile, based on the dimension of 'Meaningful Use of Knowledge,' the findings showed no significant differences in the five HOTS in this dimension with the gender and academic achievement factors. The paper includes implications of the Higher-Order Thinking Skills (HOTS) for students to improve their academic performance. In future research, the authors can further identify university students' HOTS levels in the technical area.

Keywords: polytechnic students, Marzano higher-order thinking skills, academic performance.

理工学生马尔扎诺高阶思维能力水平

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摘要：
本研究旨在基于“知识的扩展和细化”和“知识的有意义的使用”两个维度来确定理工学院学生的马尔扎诺高阶思维技能(热点)水平，并分析学生的思维能力水平差异。马扎诺热点基于这两个维度取决于学生的人口统计因素。本研究设计是一项使用定量方法的调查。随机抽取313名学生作为调查样本。以封闭式问题形式的问卷作为研究工具。使用频率百分比和曼诺瓦检验分析数据。调查结果显示，八个热点在“知识的扩展和细化”维度与性别和社会经济地位(社会服务部)因素没有显着差异。然而，八项热点与学业成就因素存在显着差异。同时，基于“有意义的知识使用”维度，研究结果表明，该维度的五个热点与性别和学业成就因素没有显着差异。该论文包括高阶思维技能(热点)对学生提高学业成绩的影响。在未来的研究中，作者可以进一步确定大学生在技术领域的热点水平。

关键词：理工学生，马尔扎诺高阶思维能力，学习成绩。

1. Introduction

In the globalization and knowledge era, all students face the industrial era 4.0, different from before. As educators, teachers have a very important role in preparing students to face that era. One of the abilities that can support them in facing that era is high-level thinking skills, which we often recognize as Higher-Order Thinking Skills (HOTS). This ability is required for the students to learn in the classroom, live their lives, work, and solve everyday problems. HOTS in teaching and learning (T&L) can improve students' academic achievement and skills (Sulaiman et al., 2017).

Malaysian Ministry of Higher Education has shown a high commitment to the agenda of the Polytechnic Transformation Plan. One of the strategic objectives to transform the polytechnics, drafted into two phases in 2009 and 2010, is to improve and expand access to quality polytechnic education (Policy Development Division, 2013). To achieve the strategic objectives, each polytechnic needs to achieve one of the expected outcomes of the polytechnic transformation phase two, producing high-performing graduates. Individuals who have the competence, knowledge, and innovation are to develop to move to a knowledge-based economic activity (The Office of Prime Minister, 2013).

Institutions of Higher Learning play an important role in producing a younger generation with the skills to be competitive in the industry and be a source of economic growth. The preparation must be extremely good to support the ability of students competent. Polytechnic is a pre-employment education and training institution that equips students with academic, generic, and technical skills. Therefore, students also need to master HOTS and research ability to use technology. So, the country has talent that is capable of producing something innovative.

HOTS is the ability to apply knowledge, skills, and values to make reasoning and reflection to solve problems, make decisions, innovate, and create something (Malaysian Examination Council, 2013). Thus, HOTS requires intellectual skills with extensive and deep thinking to make judgments and decisions or solve problems. HOTS also refer to the thinking skills activated when individuals encounter unfamiliar problems, uncertainties, questions, and dilemmas. In such situations, students cannot simply use a memorized solution but a combination of critical, logical, reflective, metacognitive, and creative thinking to develop a creative strategy to solve it (King et al., 2011). Furthermore, students must understand, integrate, correlate the information pieces, categorize, and manipulate the information to discover new meaning and understanding. This enables students to apply their knowledge toward new solutions to each problem or event. The HOTS continues creativity and critical thinking skills that focus on assessing, analyzing, exploring, and creating aspects (Ahmad et al., 2018).

The importance of implementing HOTS became very demanding in the industry because learning was not sitting and quietly listening to the teacher deliver the material anymore. HOTS in teaching and learning can improve students' academic performance and skills (Sulaiman et al., 2017). Therefore, the generation of project ideas for technical subjects to produce a new product involving problem-solving, critical, and creative thinking; and decision making; that students have to learn from Marzano HOTS in order to handle the problems encountered in learning the process of high-order thinking patterns (Lewis & Smith, 1993).

2. Problem Statement

Students need to equip themselves with critical thinking and problem-solving skills to meet the desire of employers to find new employees (Rodzalan & Saat, 2015). Technical and Vocational Education and Training (TVET) is an important path for vocational education and skills development. Meanwhile, Malaysia needs to increase 2.5 times the TVET enrolment by 2025 through the Economic Transformation Program (ETP) (The Office of Prime Minister, 2013). Unfortunately, the offer of TVET employees is insufficient in 10 of the 12 National Key Economic Areas (NKEAs). The employer reported that some graduates lacked in TS (Thinking Skills) critical knowledge (Kementerian Pendidikan Malaysia, 2015). Tahir et al. (2018) stated that the local graduates have been credulous in solving

problems and making wise conclusions and decisions pertinent to their job context.

Lecturers are encouraged to apply a problem-solving skills approach to students in institutions of higher learning, including polytechnics. The study by Yee et al. (2016) was carried out over 60 lecturers' polytechnics, and its findings showed that 61.7% of the lecturers consider students having difficulty solving problems in TL. The study also shows that 60% of the lecturers agree that the lack of using TS in their teaching and learning will cause difficulties in solving problems among students. Students still have low intellectual levels and are weak in thinking. Although TS in the curriculum has been practiced, its emphasis on thinking skills is poor, and fewer thinking skills are taught to students in the learning session.

The Kestrel Education Consultant from England and the 21st Century School of the United States in 2011 stated that high-level thinking among teachers and students in Malaysia was still low (Kementerian Pendidikan Malaysia, 2015). Students are not creative in problem-solving due to weaknesses in applying HOTS in learning (Yee, 2015). Research by Yee et al. (2015) on 375 students in technical university of Malaysia found that students mastered only 4 Marzano HOTS with modest domination, while 9 HOTS are still low.

Thus, the main purpose of this study is to investigate polytechnic students' level of Marzano HOTS based on two dimensions**:** the dimension of 'Extension and Refinement of Knowledge' and the dimension of 'Meaningful Use of Knowledge.' The study also aims to analyze the differences in the level of Marzano HOTS based on the two dimensions and the students' demographic factors: gender, academic achievement, and socio-economic status (SES). The study was conducted on students at Kota Baharu Polytechnic.

3. Research Methodology

This study utilized a survey and a quantitative approach involving the data collection process using a questionnaire adapted by the researchers (Johari, 2003).

3.1. Sample Study

A population is a group of individuals who interest researchers, have the set characteristics, and allow researchers to generalize their findings (Idris, 2013). In this study, the sample consisted of first-year and second-year diploma students in Civil Engineering, Quantity Surveying, Electrical and Electronic Engineering, Mechanical Engineering, and Marketing at Kota Bharu Polytechnic. A study sample refers to a small number of units taken from a large group or population. In this study, a total of 313 students were selected as a sample by random sampling based on the minimum number in the Krejcie and Morgan's sampling table (Krejcie & Morgan, 1970).

3.2. Study Instrument

According to Chua (2006), a study instrument is a measuring tool used to determine whether the required information and data can be obtained. A questionnaire is an instrument used to obtain the data in this study. The questionnaire was modified from Yee (2015), and the researchers used this questionnaire after obtaining permission. The questions in this study are close-ended with answer options of (a), (b), (c), and (d) (Table 1).

Table 1. Allocation and distribution number of instrument item

Part	Aspect of study	Item number
Part A	Respondent background	Nine items
Part B	'Extending and Refining Knowledge' dimension	25 items
Part C	'Meaningful Use of Knowledge' dimension	19 items

4. Findings and Discussion

The polytechnic students' Marzano HOTS for Research Questions 1 and 2 were analyzed using descriptive statistics to get the frequency and percentage using SPSS version 21. While analyzing the difference in the level of Marzano HOTS depending on the students' demographic factors, a multivariate analysis of variance (MANOVA) test has been done to answer Research Questions 3 and 4.

Table 2. Data analysis of the study

No.	Research Questions	Research Form	Statistics
1.	What are the polytechnic students' levels of mastering Marzano HOTS based on the 'Extension and Refinement of Knowledge' dimension?	Descriptive	Percentage (%)
2.	What are the polytechnic students' levels of mastering Marzano HOTS based on the 'Meaningful Use of Knowledge' dimension?	Descriptive	Percentage (%)
3.	What is the difference in the level of Marzano HOTS based on the 'Extension and Refinement of Knowledge' dimension and students' demographic factors?	Inference	MANOVA
4.	What is the difference in the level of Marzano HOTS based on the 'Meaningful Use of Knowledge' dimension and students' demographic factors?	Descriptive	Mean

4.1. The Level of Mastering Marzano HOTS Based on the 'Extension and Refinement of Knowledge' Dimension

Table 3 shows the majority of students had a high level of comparing HOTS (57.5%), induction HOTS (49.5%), and constructing support HOTS (48.6%). The majority of students have a moderate level of analyzing perspectives HOTS (58.5%), followed by classifying HOTS (46.6%) and error analysis HOTS (41.9%). Meanwhile, the majority of students had a low level of

abstracting HOTS (35.1%), followed by deduction HOTS (30.4%) and error analysis HOTS (24.3%).

Table 3. HOTS levels based on the 'Extension and Refinement of Knowledge' dimension

HOTS	Level					
	High		Moderate		Low	
	Frequency	Percent %	Frequency	Percent%	Frequency	Percent %
Comparing	180	57.5	111	35.5	22	7.0
Classifying	139	44.4	146	46.6	28	8.9
Induction	155	49.5	122	39.0	36	11.5
Deduction	108	34.5	110	35.1	95	30.4
Errors Analysis	106	33.9	131	41.9	76	24.3
Constructing Support	152	48.6	112	35.8	49	15.7
Abstracting	86	27.5	117	37.4	110	35.1
Analyzing Perspectives	80	25.6	183	58.5	50	16.0

The majority of the students have the highest level of comparing HOTS. This matter is caused by the assumption that this skill is easy for most students to master because mostly polytechnic lecturers give students the patterned assignment comparison possibility.

Students' high-level inductive HOTS were probably due to the encouragement from lecturers to students to apply HOTS in teaching and learning, test, assignment, quiz, etc. Abdul Hamid (2001) stated that we think by looking and analyzing the data using induction reasoning. Subsequently, we made a hypothesis to explain the relationship between the available data.

Nevertheless, students also have a high level of constructing support HOTS. This matter is caused by the lecturers' efforts to apply this HOTS among students. This helps students understand the content and support the information needed to build a strong argument in any matter. Abdul Hamid (2001) agreed that the purpose of constructing support skills is to make an individual more clearly understand something before taking appropriate action.

4.2. The Level of Mastering Marzano HOTS based on the 'Meaningful Use of Knowledge' Dimension

Table 4 shows that the majority of students had a high level of investigative HOTS (49.5%), followed by creating HOTS (36.4%) and decision-making HOTS (33.2%). Students' majority (66.8%) have a moderate level of problem-solving and experiment inquiry HOTS, followed by decision-making HOTS (59.4%) and creating HOTS (56.9%). The majority of students had a low level of problem-solving HOTS (10.2%), followed by decision-making HOTS (7.3%) and creating HOTS (6.7%).

Table 4. HOTS levels based on the 'Meaningful Use of Knowledge' dimension

HOTS	Level					
	High		Moderate		Low	
	Frequency	Percent%	Frequency	Percent%	Frequency	Percent %
Decisions making	104	33.2	186	59.4	23	7.3
Problem Solving	72	23.0	209	66.8	32	10.2
Experimental Inquiry	85	27.2	209	66.8	19	6.1
Creating	114	36.4	178	56.9	21	6.7
Investigative	155	49.5	146	46.6	12	3.8

The majority of students had a high level of investigative HOTS. This is caused by the fact that students mostly use their knowledge in investigative skills with full benefits to complete the tasks assigned by the lecturers. The students can master the investigative HOTS well because of their practical work in this polytechnic. Live experience during practical work enables students to understand and master these skills better. Furthermore, practical percentage points (70%) higher than the theoretical percentage points (30%) could also motivate them to continue to collect experiences from investigative activities in each practical work. This is similar to findings by Yee et al. (2015), who stated that the background of students taking vocational courses is more inclined to something practical such as the need for investigation in their practical work.

The majority of students had a high level of creating HOTS and decision-making HOTS. On another note, this shows that implementing learning that focuses on practical work encourages students to use creating HOTS and decision-making HOTS in each project. Apart from that, Osman (2010) stated that creating HOTS can open students' minds to more innovations and educate them to become more thinking and confident to make decisions.

4.3. The Level of Marzano HOTS Based On 'Extension and Refinement of Knowledge' Dimension with Students' Demographic Factors

Based on the MANOVA test (Table 5), the study showed no significant differences between eight HOTS in this dimension with the three factors of gender, academic achievements, and socio-economic status. However, this study shows a significant difference between eight HOTS with academic achievement factors.

In general, student academic achievement factors influence students' HOTS. Students with high-achieving certainly have a high level of HOTS. They were smart in applying HOTS during the examination. Unsurprisingly, students with low results rarely apply this HOTS because they prefer to answer the exams by memorizing notes only.

Table 5. The overall difference in Marzano HOTS based on the 'Extending and Refining Knowledge' dimension with students' demographic factors

Number	HOTS	Mean value	Standard deviation	Significant value, *p*
1	Gender	1.49	0.501	0.564
2	Academic achievement	2.70	1.163	0.024
3	Socio-economic status	2.88	1.295	0.227

Note: Significant differences in p < .05

Nevertheless, the findings showed a significant difference in the students' levels of deductive and constructing support HOTS with academic achievement factor. Students' level of inductive HOTS also showed a significant difference with socio-economic status factors. However, there was no significant difference in the students' levels of HOTS with gender factor (Table 6).

Table 6. The difference of 8 Marzano HOTS based on the 'Extension and Refinement of Knowledge' dimension with students' demographic factors

Number	HOTS	Mean value	Standard deviation	Significant value, *p*		
				Gender	Academic achievement	Socio-economic status
1	Comparing	3.1768	0.65262	0.234	0.050	0.094
2	Classifying	3.0000	0.36330	0.728	0.764	0.230
3	Inductive	2.8669	0.78380	0.600	0.356	0.028
4	Deductive	2.6944	0.72791	0.072	0.010	0.998
5	Errors Analysing	2.6944	0.71707	0.519	0.842	0.196
6	Constructing Support	2.9521	0.62033	0.538	0.017	0.591
7	Abstracting	2.6624	0.68457	0.520	0.632	0.895
8	Analyzing Perspectives	2.8871	0.71763	0.758	0.284	0.911

Note: Significant differences in p < .05

4.4. The Level of Marzano HOTS Based On 'Meaningful Use of Knowledge' Dimension with Students' Demographic Factors

Overall, the findings show (Table 7) no significant difference between five HOTS in this dimension with the gender and academic achievement factors. However, for the socio-economic status factor, it was found that there were significant differences between these five HOTS.

Generally, socio-economic status factors influenced students' HOTS. The 'Meaningful Use of Knowledge' dimension means students know how to use their prior knowledge. The researcher argues that rich students are perhaps smarter in life because they get much knowledge through travel activities, which can affect their HOTS knowledge.

Table 7. The difference in HOTS based on the 'Meaningful Use of Knowledge' dimension with students' demographic factors

Number	HOTS	Mean value	Standard deviation	Significant value, *p*
1	Gender	1.49	0.501	0.366
2	Academic achievement	2.70	1.163	0.226
3	Socio-economic status	3.14	1.343	0.000

Note: Significant differences in p < .05

Table 8 shows no significant difference in the students' level of HOTS with gender factor. Students' levels of decision-making and problem-solving HOTS also showed a significant difference with academic achievement factors. Socio-economic status factors also showed significant differences in the students' levels of decision-making and creating HOTS.

Table 8. The difference HOTS dimension of 'Meaningful Use of Knowledge' with demography factor

Number	HOTS	Mean value	Standard deviation	Significant value, *p*		
				Gender	Academic achievement	Socio-economic status
1	Decision-making	2.8810	0.47071	0.882	0.048	0.000
2	Problem-Solving	2.7796	0.50217	0.806	0.038	0.152
3	Experimental Inquiry	2.8251	0.47277	0.084	0.145	0.059
4	Creating	2.8871	0.30587	0.081	0.309	0.012
5	Investigative	3.0950	0.51844	0.513	0.878	0.762

Note: Significant differences in p < .05

Overall, based on the dimension of 'Extension and Refinement of Knowledge,' most of the three high-level HOTS are comparing HOTS, inductive HOTS, and constructing support HOTS. The majority of the three moderate-level HOTS is analyzing perspectives HOTS, classifying HOTS, and analyzing errors HOTS. The majority of the three low-level HOTS are abstracting HOTS, deductive HOTS, and analyzing errors HOTS. However, the HOTS level among polytechnic students is, on average, at a moderate level with a mean value of 2.60-3.20 for eight HOTS in this dimension.

Moreover, based on the dimension of 'Meaningful Use of Knowledge,' most of the three high-level HOTS are investigative HOTS, creating HOTS, and decision-making HOTS. Nevertheless, most of the three moderate-level HOTS are problem-solving HOTS, experimental inquiry HOTS, and decision-making HOTS. Most of the three low-level HOTS are problem-solving HOTS, decision-making HOTS, and creating HOTS. However, the average level of HOTS among polytechnic students is moderate, with a mean value of 2.70-3.10 for the five HOTS in this dimension.

The study's findings show no significant differences between the eight HOTS in the ‘Extension and Refinement of Knowledge’ dimension with gender factors and socio-economic status. However, there is a significant difference between eight HOTS with the academic achievement factors.

Meanwhile, based on the dimension of 'Meaningful Use of Knowledge,' the finding showed no significant differences between the five HOTS with gender and academic achievement factors. However, the socio-economic status factors show significant differences between the five HOTS.

5. Conclusion

The learning process needs to involve all students' learning abilities to maximize the results obtained. Students need to be trained to improve these levels by applying the appropriate approach or learning activities.

The study's findings are important because they provide empirical evidence of polytechnic students' levels of mastery of Marzano HOTS. This study has great implications for teaching and learning. It shows that lecturers should diversify and increase teaching and learning activities based on HOTS regardless of university entry qualifications and years of study. Therefore, lecturers play an important role in inculcating HOTS and helping students master the HOTS. Nevertheless, students' achievement depends on effective lecturers who can manage and plan their teaching and learning process to become meaningful and helpful for the students.

6. Limitations and Further Study

The findings are limited to first-year and second-year diploma students in Civil Engineering, Quantity Surveying, Electrical and Electronic Engineering, Mechanical Engineering, and Marketing at Kota Bharu Polytechnic, Kelantan, Malaysia.

HOTS are important in helping students improve their academic performance. Higher education is transforming, as HOTS is growing more competitive and challenging. The challenges for higher education have increased may fold, service quality will be a deciding factor in the future. In the future scope, the authors can further identify the university students' HOTS levels in the technical area. Only those higher education institutes will be able to survive that can cater to the diverse needs of students.

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Co-Authors’ Contributions

The authors were involved in conducting research, collecting and analyzing data, creating and reviewing articles under the obligations of research group members.

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