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A Literature Review: Cognitive Assessment of HOTS in Technical Vocational Learning

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***Abstract*—At present, design of learning orientation in vocational schools has led to HOTS (Higher Order Thinking Skills), because it can encourage students to think broadly and deeply about the subject matter, shape the character as an effective communicator, critical thinkers, and competent problems solver. But, most of vocational teacher still use Lower Order Thinking Skills (LOTS) assessment which only facilitates students in the field of short-term memory. This literature review will focus on the assessment of the HOTS aspects of cognitive assessment in vocational learning. The goal of this article is to review relevant journals deeply to get an overview of the extent to which the development of HOTS studies in various parts of the world relates to the methods, models and approaches used and get an overview of the HOTS management model that can be used. The conclusion is low percentage of HOTS questions becomes an indicator of the low cognitive level of students, it can impact on the inability of graduates to compete in Industrial World.**

Keywords—cognitive assessment; HOTS; vocational learning

I. INTRODUCTION

Education plays a role for develop thinking skills needed to produce productive and meaningful lives. However, education in the 21st century still emphasizes memorization of facts without understanding [1]. The task faced by the teacher is to prepare students with critical thinking skills in order to achieve success in the future [2]. Entering the global market era, companies recruit employees who can transfer their critical thinking skills to the workplace [3-5]. Critical thinking is the ability to analyze, interpret, evaluate, summarize, and synthesize information. These skills are able to be instilled and developed in learning through the concept of problem solving that requires higher-order thinking skills (HOTS).

At present, design of learning in vocational high schools has been directed to HOTS, so the development of the HOTS assessment is a priority [5]. Assessment is a process that is carried out as a step to evaluate the performance of the entire system, analyze the effectiveness of teaching, and obtain information in the framework of decision making towards students that aims to improve the quality of learning [6-7].

HOTS is a meta-cognitive skill that triggers acting and thinking in a high-level thinking mode and includes sub-skills of analysis, synthesis, and evaluation [8-9]. The basic principle in the development of HOTS assessment is student's task must demand knowledge and expertise in new situations, not just the ability to remember what is contained in the textbook. HOTS can encourage students to think broadly and deeply and form learners to be effective communicators, critical and dynamic thinkers, creative and competent problem solvers [3], [10-13]. These thinking skills are the demands of the company as demand driven towards new employees.

On the other hand, assessments used by the majority of teachers at the time of evaluation tend to be still in the domain of low order thinking skills (LOTS), which only facilitates students in the short-term memory [12]. Judging from the composition, the number of LOTS items is more than the HOTS problem. The low percentage of HOTS questions is an indicator of students' low cognitive levels in schools. Empirical studies in the past 10 years related to the application of strategies and learning models in improving HOTS can be found in several journals as follows: effectiveness of the Multidimensional Curriculum model at elementary and junior high school [2]; applying flipped classroom models at junior high school level [13-14]; development of critical thinking assessments at the high school level [15]; application of inquiry-based learning models, problem solving groups, HOT-Question and HOT-Lab at the college level [16-19]; and the development of WebQuests media for teachers [18]. So far, studies have not been found that focus on reviewing the development of HOTS especially at vocational level.

This literature review will focus on the assessment of the HOTS aspects of cognitive assessment in vocational learning. The goal of this article is to review relevant

journals in depth to get an overview of the extent to which the development of HOTS studies in various parts of the world relates to the methods, models and approaches used and get an overview of the HOTS management model that can be used in vocational learning. Based on the objectives to be achieved in this literature review, the presentation of the research questions is as follows: (1) How is the development of HOTS studies in various parts of the world related to the methods, models and approaches used? (2) What is the HOTS management model that can be used in vocational learning?

II. Theoretical Framework

A. Cognitive Assessment

Assessment is the last stage of learning which aims to determine the achievement of the objectives set in the curriculum [19]. The function of the assessment is as a provider of information and quality control of education, which includes all components of education from the implementation process to educational products [20].

In assessing the competencies of students covering the cognitive, affective, and psychomotor domains, there are a number of assessment techniques that can be used by educators to gather information. Cognitive domain assessment is done through oral and written tests, as well as assignments. The cognitive domain according to Bloom's taxonomy conceptualized in 1956 was changed by Anderson & Krathwohl [21]. The results of the revision are shown in the following picture:

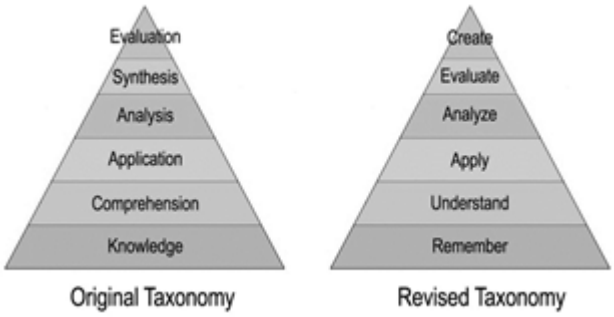

Fig. 1. Cognitive domain Bloom's taxonomy before and after revision.

Each category of cognitive abilities must be based on a sequence of abilities and there will not be a leap of ability. For example: the ability to understand a concept must be preceded by the ability to remember and the ability to apply a concept must be preceded by the ability to understand.

B. HOTS

HOTS is called meta-cognitive thinking, the ability to describe the ability to connect several different concepts, in interpret, solve problems (problem solving), choose problem solving strategies, find (discovery) new methods, argue (reasoning), and make the right decisions [8-9]. HOTS assessment is a measurement instrument used to measure high-level thinking skills, namely the ability to think that is not just recall (recall), restate (restate), or refer without doing processing (recite). In general, HOTS questions measure ability in the analyzing-C4 domain, evaluate (evaluating-C5), and create (creating-C6). HOTS questions in the context of assessment to measure abilities: (1) transfer one concept to another; (2) processing and applying information; (3) looking for links from various different information; (4) use information to solve problems; and (5) critically examine ideas and information. Nonetheless, HOTS-based questions do not mean the problem is more difficult than the question of recall.

In the preparation of HOTS questions, the stimulus is generally used. Stimulus is the basis for making questions. In the context of HOTS, the stimulus presented should be contextual and interesting. The creativity of a teacher greatly influences the quality and variation of the stimulus used in writing HOTS questions.

III. Methodology

Literature review is conducted on journals published in the last 10 years with the aim of producing references that are more focused on the development of the latest problems and solutions. Journals were collected through several well-known publications such as Elsevier, Springer, Taylor & Francis, Wiley, Sage, IEEE and ResearchGate. Keywords used in journal search include: Assessment, Cognitive, HOTS, and Vocational. Each of these journals will be reviewed about what part is studied, the scope of the problem under study, the focus of the research, and the results of the research.

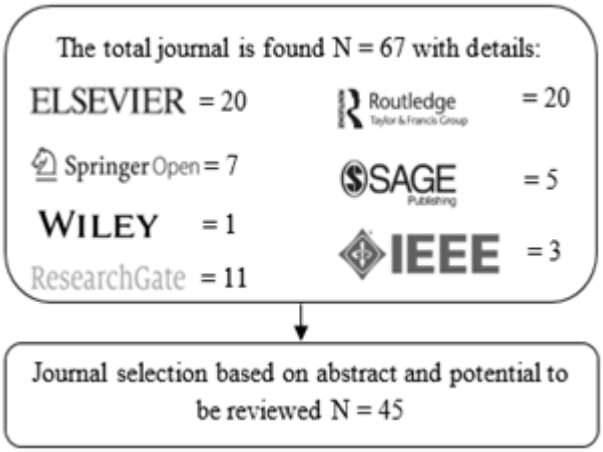

Fig. 2. Flow chart of the literature review process.

IV. Result and Discussion

A. Technical Vocational Learning

Generally, thinking skills of vocational students are still low. When do practice, students are able to do jobs well based on teacher demonstrations and job sheets. But when they found error, they have not been able to analyze the cause of the error (C4-analyze level), evaluate error steps (C5-evaluate level) and create a solution for manage error (C6-create level). The biggest problem faced by students is the difficulty in generate ideas [22]. This pattern is same with research that states the highest learning styles in vocational students are doers and the lowest are thinkers [1]. This fact can be found in the journal Learning Style Disparity and HOTS among 375 engineering students from 4 universities in Malaysia namely UTHM, UTEM, UMP, and UNIMAP as presented in table 1.

TABLE I. Pattern of Learning Styles

Learning Styles	%
Doer	28%
Watcher	26%
Feeler	24%
Thinker	22%

The majority of students are great at memorizing, but not for their thinking skills. A study that reviewed HOTS's learning needs analysis to generate ideas for 246 students at the Technical Education Faculty, Universiti Tun Hussein Onn Malaysia (UTHM) based on the opinions of 242 academic staff [22]. In this study it was reported that a number of 201 academic staff (83.1%) found engineering students having difficulties in completing individual tasks and a number of 194 academic staff (80.2%) argued that the difficulties of engineering students in completing individual tasks were difficulties in generating ideas, which is a reflection of weak thinking ability. Good and creative ideas can only be produced through HOTS, where a number of 227 academic staff (93.7%) feel very important for students of HOTS learning techniques to generate ideas in completing their assignments. Therefore, students are given a variety of academic and non-academic projects that are more challenging and complex, thus requiring them to solve problems creatively. It is also useful to meet the demands of companies that suggest the importance of students to be equipped with the skills to make decisions, think critically and creatively before entering the workforce.

At present, the design of learning in vocational schools has been directed to HOTS. One of the reason is construction of the National Examination questions is continuously improved so as to measure the ability of students in the higher cognitive domain ..." [5]. In other hand, many vocational teachers still use low order thinking skills (LOTS) assessment, which only facilitates students in the short term memory [12]. This phenomenon is not only a local problem, but also be global issue. There are international concerns about the dominant practice of LOTS assessment which only encourages students to focus on learning that emphasizes memorization [23]. The low percentage of HOTS questions is an indicator of students' low cognitive level [24]. As a result, graduates are less skilled and lack high-level thinking skills to solve problems in their life [1].

B. Developing HOTS in Learning

Teacher who teaches and conducts assessments with HOTS on a regular basis, will get positive developments on his students, namely thinking skills and performance will improve overall [10]. Some research which develop HOTS in learning can be found in journals as table 2.

TABLE II. SUMMARY OF RESEARCH ON DEVELOPING HOTS IN LEARNING

Study	Participants	Methods	Basic Findings
Effectiveness of the multidimensional curriculum model in developing HOTS in elementary and secondary students [2].	394 elementary and secondary school students in Israel.	Quantitative quasiexperimental pre-post design, using a study module based on MdCM.	Findings indicate improvement in measured thinking skills in the intervention group (N = 199) by 40% compared to 4% in control group (N = 195). Most improved skills were future thinking and creative thinking.
Facilitating higher-order thinking with the flipped classroom model: a student teacher's experience in a Hong Kong secondary school [13].	28 students in a public secondary school in Hong Kong.	Exploratory study with a mixed methods approach.	The result is that most students accept the application of this new teaching model because it provides a lot of time in the classroom to discuss, create a supportive learning environment, and make it possible to improve students' higher order thinking skills.
Promoting higher order thinking skills using inquiry-based Learning [17].	66 Chemistry students of 2nd semester of Chemistry.	Quantitative analysis	There has been an understanding of scientific concepts and developing abilities of inquiry. In most of the experiments, that most of the students are in the category of A+ and B grades.
Effect of Higher Order Thinking Laboratory on the Improvement of Critical and Creative Thinking Skills [25]	60 Physics students of 4th semester of UIN Sunan Gunung Djati.	Quasy experiment method with pre-test post-test control group design	Normalized gains (N-gain) for critical thinking skills in HOT Lab class is 60.2% (medium category) and verification class is 29.30% (low category). While N-gain for creative thinking skills higher (0.7-high category) than control class (0.29-low category). It means that HOT Lab is better for improving critical and creative thinking skills.
Using higher order thinking questions to foster critical thinking: a classroom study [26]	A total of 147 students of Educational Psychology.	Quizzes contained factual multiple-choice questions, factual essay questions or essay items requiring HOT.	There are significant improvement across the semester. Scores rise from a mean of 24.62 on the pre-test (SD = 5.63) to 25.46 (SD = 5.13) on the post-test.

Teacher never knows about student's future, especially their profession. But teacher can ensure the skills that are always needed in the workplace. It means today's education needs to prepare individuals for tomorrow's life. Skills students need in the 21st century called as '7 C', among others: (a) critical thinking and problem-solving; (b) communication; (c) collaboration; (d) computing and ICT; (e) career; (f) cross-cultural; and (g) creativity and innovation. The Multidimensional Curriculum Model (MdCM) was used in this research to investigate the development HOTS among students [2]. The MdCM includes all three types/processes of thinking: scientific thinking-inquiry; creative thinking-problem finding and problem-solving; and future thinking-personal and time perspectives.

Flipped classroom is another teaching model for promotes HOTS which adopts a student-centered approach. Teachers often calls this model as e-learning approach, because in the process it supported by technological facilities. HOTS can be promoted through this model because students can directly pause the video, then think about learning content [13]. This model allows teachers to use time primarily in the top layers of Bloom's taxonomy such as application, synthesis, evaluation and analysis.

Same with MdCM and Flipped Classroom Model, inquiry can foster HOTS too. The advantages of inquiry-based learning are students can be used to identify relevant concept that need to be understood, allowing students to integrate patterns of knowledge creation so they can design a new experiment. Research by Madhuri et al. (2012) shows inquiry-based pedagogy has better proved outcomes compared to a conventional recipe lab approach.

Critical and creative thinking skills of 21st century students can be developed through HOT-Lab model [25] and HOT questions [26]. Character of HOT-Lab model is there are problem solving and high-level thinking activities through laboratory. The results of this model are proven to be successful in improving both of 21st century skills.

HOT questions contained factual multiple-choice questions, factual essay questions or essay items requiring higher order thinking. This kind of questions encourage students to think deeply about content, facilitate semantic coding, require students to review and rethink factual content with more complex forms of thinking.

V. CONCLUSION

The main problem of students in vocational field is the difficulty in generating ideas to complete individual tasks. This is evident in the study of the Disparity in Learning Style in the field of engineering students who stated that the thinker is the lowest learning style pattern, while the doer is the most dominant. The HOTS assessment in learning can overcome problems related to thinking skills. LOTS assessment only facilitates students in the field of short term memory has an impact on graduates becoming less skilled and lacking in high-level thinking skills to solve problems that arise in life. There are various models, methods and approaches have been applied to develop HOTS in 21st century learning.

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