Assessment of Learning Domains in Material Technology Courses Using Product Oriented Module in Vocational Education

Kinanti Wijaya*, Sutrisno, Siti Zulfa Yuzni
Civil Engineering Department
Universitas Negeri Medan
Medan, Indonesia
*kinanti.w@gmail.com

Syafiatun Siregar, Harun Sitompul
Building Engineering Education
Universitas Negeri Medan
Medan, Indonesia

Abstract—**Materials technology practice is learning in the laboratory which is contained in the civil engineering study program. Learning in the laboratory is not only sharpens competencies in the psychomotor domain but also in the cognitive and affective domains. This study has identified measurable and authentic assessments to sharpen competencies in the three learning domains using product-oriented modules during the learning process to produce effective and meaningful learning. The study used the ADDIE method with data analysis using expert judgment involving 4 experts in the field of vocational education and 3 experts in the construction industry. The result showed that the three learning domains using product-oriented modules are very relevant to the competency needs in the world of work in the field of civil engineering.**

Keywords—material technology, meaningful learning, laboratory works

I. INTRODUCTION

International economic networks create new patterns and challenges at work. In a knowledge-based economy and innovative creative ideas, a well-educated workforce is a key element and human capital in gaining competitiveness and gaining prosperity [1]. Vocational Technology Education has a very big role in the economic development of a country so that it can develop the labor market [2]. So the Indonesian government makes efforts to maintain and improve the quality of education in Indonesia.

Seeing the current development of the labor market, where the skills of the workforce needed are basic skills and work skills to keep up with the development of science and technology and be able to produce independent businesses. Therefore, the government has begun to concentrate on developing quality vocational education because it is believed to be able to equip the nation's generation with certain applied skills so that they have a competitive spirit to be able to compete in the era of the industrial revolution 4.0. To achieve this goal, the world of education must have a valid assessment tool. So that it can evaluate learning appropriately.

Designing an assessment for teachers is very challenging because it must have specific criteria in three learning domains so that learning can be evaluated [3]. Assessment is born based on the curriculum, learning activities, and learning outcomes to be achieved. So the purpose of this study is to identify measurable and authentic assessments to sharpen competencies in the cognitive, psychomotor, and affective domains using product-oriented modules. Product-oriented modules are the learning media used in the material technology course in this study. The characteristics of a product-oriented module are that it has procedural content; there are specific theoretical studies in analyzing, describing conclusions, and recommendations for improvement [4]. The product-oriented module used is also equipped with a product achievement measurement tool so that in the end the reader can produce a product.

II. RESEARCH METHODS

This study follows five systematic development stage of ADDIE model involving seven experts in validating competency indicators in three learning domains. The research is conducting in Medan particularly in UNIMED. The ADDIE procedure with five-stage taken in this study are described as follows:

A. Analysis Stage

At this stage, the needs analysis of the main skills related to the science of building materials in the world of work was carried out. This information was obtained through literature reviews and surveys in the industrial world of civil engineering field. The survey results show that industry requires expertise in conducting testing stages based on applicable standards, reporting critical test results, making innovative work and having high integrity.

B. Design Stage

At this stage, an authentic assessment design activity is carried out based on the results of the needs analysis that has been carried out in the analysis stage. This assessment is also designed to align the curriculum and the expected outcomes and be in line with the learning activities carried out during the learning process. UNIMED's civil engineering study program has a special mission that graduates have an entrepreneurial spirit. Therefore, the product-oriented module supports the achievement of the mission of the study program.

C. Development Stage

At this development stage, the activities were carried out after the authentic assessment designed correctly. This assessment is developed by compiling an assessment rubric so that the learning evaluation will be truly authentic. The assessment which completes with a rubric are discussed in a small forum involving 5 vocational education experts to obtain a valid authentic assessment instrument. The results of the discussions in the small forum obtained several suggestions for improvement from experts. Furthermore, the assessment instrument was revised according to the results of a small forum discussion.

TABLE I. EXPERTS ADVICE IN THE SMALL FORUM DISCUSSION

Field of Expert	Advice
Language	The assessment instrument needs a little improvement in composing sentences to make it more communicative and follow EYD
Civil Engineering	The sentences in the rubric should be corrected using specific and operational verbs.
	Psychomotor assessment indicators on the instrument to be simplified to facilitate the assessment process.
	The sentence on the instrument needs to be improved so that it is easier to understand the meaning of the assessment
	It is necessary to add an assessment of commitment to work completion in the affective assessment instrument

D. Implementation Stage

At this stage, the application of the assessment sheet that has been designed and developed is carried out by distributing it to 4 experts in Vocational Education and 3 practitioners in the construction industry through FGD. The assessment that have been completed with validity testing instruments are discussed in the FGD. The data analysis by expert's judgment technique uses a Likert scale questionnaire to measure the validity of the authentic assessment sheet. The Likert scale used is a scale of 1-5. Where a scale of 1 state that it is not valid, up to a scale of 5 states it is very valid.

E. Evaluation Stage

At this stage, evaluation activities are carried out from the results of assessments carried out by experts. The advice given by the experts is used to improve this research product. Furthermore, the assessment sheet is analyzed using the TCR formula as in equation (1), where the average score obtained from the experts is compared with the ideal score times 100%. Then the TCR value is converted into the achievement level category [5].

$$TCR = \text{average score/ideal score x } 100\% \qquad (1)$$

TABLE II. CATEGORY OF ACHIEVEMENT LEVEL

Achievement Level (%)	Category
80 <TCR≤ 100	Very Relevant
60 <TCR≤ 80	Relevant
40 <TCR≤ 60	Quite Relevant
20 <TCR≤ 40	Less Relevant
TCR < 20	Not Relevant

If the TCR value reaches the category "relevant" to the "very relevant" category so the product research concluded to be valid and authentic.

III. IDENTIFICATION OF MAIN SKILLS IN THE FIELD OF MATERIAL TECHNOLOGY IN THE WORLD WORK

A civil engineer must design and construct public works and various types of buildings, ensuring their functioning, integrity, and durability of buildings while keeping in mind all technical, economic, aesthetic, and environmental factors. At the same time considering all building materials and their construction because there is no single building construction without using building materials. It can be imagined without proper knowledge of the properties of these materials how their behavior and durability can be handled at the construction project site [6].

In addition, graduates of vocational education technology in the field of civil engineering are the ability to choose various types of building materials according to the needs of building elements. If in a Quality Engineer profession based on the 2013 SKKNI, the competencies that must be mastered are applying laws and regulations on construction services, occupational safety, and health management systems as well as work environment and quality control, reviewing the scope of work, specifications, and implementation methods; make plans for making construction quality; Controlling material quality and equipment capacity; quality control in the construction implementation process; and make a control result report.

Therefore the building materials expertise expected of a civil engineer according to Industry Skill Councils Australia is: analyzing ability, analyzing and interpreting complex and technical documents regarding reference materials; b) reporting records and information, c) developing and implementing operational plans collaboratively and effectively; d) ensure a process that identifies errors and the necessary corrective action; e) procurement of material procurement systems; f) understand building construction materials and technology and understand how to use work equipment.

IV. LEARNING OUTCOMES OF MATERIAL TECHNOLOGY IN HIGHER EDUCATION

The material technology course is in the first two-year semester of the civil engineering study program at the State University of Medan. The activities carried out in this course are the introduction of material technology, explaining the quality standards of building materials, the manufacturing process, and the analysis of material quality standards. Building materials include concrete, stone, brick, glass, steel, wood, plastic, and composite materials. Each of these materials is studied for their physical properties, the way they are made, and current developments to improve or change their physical properties [7]. So the expected product from this course is a service product complete with a report. As the understanding of the product that products are not only in the form of objects but services are also a product [8]. So in this case, the service product in question is the skill in determining the material quality and making material quality analysis reports so that students can innovate building materials to sustain the production of an industry and the integrity of raw materials on earth as current competency demands [9].

V. RESULTS AND DISCUSSION

Based on the identification of the main skills in the field of materials technology in the world of work and the target learning outcomes in higher education, and assessment indicator is obtained. Assessment indicators are divided into three domains to achieve educational goals as Bloom's taxonomy theory presents a consistent way to develop the most powerful student learning program outcome assessment tool [10].

A. Cognitive Domain

The cognitive realm deals with the mind. In this domain, it measures the achievement of a meaningful learning process so that students can take advantage of the science of building materials.

TABLE III.   ASSESSMENT OF THE COGNITIVE DOMAIN OF MATERIALS TECHNOLOGY SUBJECT

Indicators	Rubrics	Score
Perform work preparation in the laboratory	The accuracy of describing the condition of the materials and laboratory test equipment independently at the preparation stage	4
	The accuracy of describing the condition of the materials and laboratory test equipment under the guidance of the preparation stage	3
	Requires special guidance to describe the condition of laboratory materials and test equipment at the preparation stage	2
	Errors in describing the condition of materials and laboratory test equipment at the preparation stage	1

Table 3. Cont.

Perform experimental work in the laboratory	Clearly and precisely order the stages of material testing systematically and according to applicable standards	4
	Clearly order the stages of testing materials according to applicable standards	3
	Not quite precise in sequencing the stages of material testing	2
	Inaccurate in sequencing the stages of material testing	1
Obtain a preliminary data	Able to record the initial data needed clearly and accurately	4
	Able to record the preliminary data needed clearly and accurately under guidance	3
	There are deficiencies in recording the initial data required	2
	Not able to record the required data	1
Ability to analysis data	Initial data were analyzed appropriately by reference to independently applicable standards	4
	Initial data were analyzed incorrectly and referred to the applicable standards independently	3
	Initial data were analyzed in a guided manner and referred to applicable standards	2
	Initial data were not analyzed according to applicable standards	1
Ability to present data in graphical form	Work independently in displaying the results of data analysis in graphical form clearly and precisely	4
	Work independently in displaying the results of data analysis in graphical form with less clarity and accuracy	3
	Work in a guided manner in displaying the results of data analysis in graphical form clearly and precisely	2
	Requires special guidance in displaying the results of data analysis in graphical form clearly and precisely	1
Ability to interpret data critically	Interpret the results of data analysis carefully and appropriately by linking them to material quality standards	4
	Interpreting the results of the data analysis was sufficiently accurate by relating them to material quality standards	3
	Interpreting the results of data analysis is less accurate without linking them to material quality standards	2
	Interpreting the results of data analysis is not accurate and precise	1
Ability to determine material quality	The accuracy of inferring the quality of materials based on laboratory test results	4
	Sufficient accuracy in concluding material quality based on laboratory test results	3
	It is not accurate to conclude the quality of the materials based on the available data	2
	Inaccurate in concluding the quality of materials	1
Capable to make improvement recommendation	Make logical recommendations for corrective action against the material being tested	4
	Inaccurate in making logical recommendations for improvements to the material being tested	3
	Makes illogical recommendations for improvements to the material being tested	2
	Not able to make recommendations for improvements to the material being tested	1

The indicators and rubrics for assessing the cognitive domain of learning materials technology according to experts are very relevant. This is obtained from the TCR value which shows the number 95.36% which is included in the very relevant category. The judgment of the expert says that the indicator and rubric for cognitive assessment are very relevant to assess the interpersonal skill of higher education students.

B. Psychomotor Domain

The psychomotor domain deals with motor activities that are based on cognitive understanding.

TABLE IV. ASSESSMENT OF THE PSYCOMOTOR DOMAIN OF MATERIALS TECHNOLOGY SUBJECT

Indicators	Rubrics	Score
Implement experimental work safely	Carry out the test in compliance with the equipment for personal protective equipment	4
	Carry out tests with an adequate level of compliance with the completeness of personal protective equipment	3
	Carry out tests with a low level of compliance with the completeness of personal protective equipment	2
	Carry out tests without complying with the completeness of personal protective equipment	1
Ability to perform experiment successfully	Performs test steps precisely without guidance	4
	Performing the correct test steps in a guided manner	3
	Perform the test steps with guided hesitation	2
	Not able to use laboratory equipment	1
Ability to adapt experimental tools to solve problem situation	Able to innovate the use of equipment and materials appropriately to solve problems that occur	4
	Being able to innovate the use of equipment and materials precisely enough to solve problems that occur	3
	Less able to innovate the use of equipment and materials to solve problems that occur	2
	Not able to solve the problem	1
Ability to produce laboratory test reports	Producing clear, precise and systematic test reports	4
	Producing clear but less systematic test reports	3
	Producing vague and unsystematic test reports	2
	Not able to produce test reports properly	1

The results of the experts' assessment of the indicators and assessment rubrics of the psychomotor domain of learning materials technology are very relevant, with a TCR value of 94.28%. The judgment of the expert says that the indicator and rubric for psychomotor assessment are very relevant to the work world in the civil engineering field, especially for the quality control profession.

C. Affective Domain

The affective domain focuses on the attitude and willingness to participate and appreciate what is being learned

so that in the end applies these values in real life. The preparation of this affective aspect assessment was carried out by a team of lecturers in the concrete technology practice course based on the competence of the affective aspects that are demanded in the world of work. The assessment indicator and rubric were adapted from the results of research on the development of self-assessment instruments [11], assessment in laboratory work [12] and adapted for concrete technology practice courses. The purpose of developing an affective assessment instrument is to make it easier for lecturers to assess student attitudes during the learning process.

TABLE V. ASSESSMENT OF THE AFFECTIVE DOMAIN OF MATERIALS TECHNOLOGY SUBJECT

Indicators	Rubrics	Score
Discipline	Participate actively in learning and adopt a disciplined attitude	4
	Participate actively in learning and lack discipline	3
	Participate less actively in learning and do not apply discipline	2
	Participate less actively in learning and are not disciplined	1
Committed to getting the job done	Complete tasks thoroughly and precisely	4
	Complete the task completely but not quite right	3
	Completing tasks is not complete and not quite right	2
	Completing incomplete and improper tasks	1
To be responsible	Take full responsibility for their work	4
	Sufficiently responsible for his job	3
	Less responsible for their work	2
	Not responsible for his job	1
Good team work	Trying to cooperate with fellow friends	4
	Less trying to cooperate with fellow friends	3
	Not trying to cooperate with fellow friends	2
	Does not like to cooperate	1

The results of the experts' assessment of the indicators and rubric of the affective domain of learning materials technology are very relevant, with a TCR value of 93.57%. The judgment of the expert agrees with the affective assessment in order to show up the character student since they are in the higher education so that later they can adjust to the world of work.

Based on the TCR value in the three domains of assessment of materials technology learning, it is obtained an average level of achievement of 94.40%, so this value is included in the very relevant category. Judging from the TCR value obtained, it can be concluded that the material technology learning assessment sheet is valid and authentic.

TABLE VI. RESULT OF ASSESSMENT SHEET DATA ANALYSIS

Domain Learning	Indicator	Average Score	TCR value (%)
Cognitive	8	38,14	95,36
Psychomotor	4	18,86	94,28
Affective	4	18,71	93,57
Average			94,40
Category			Very relevant

VI. CONCLUSION

Practical learning of material technology is needed to sharpen understanding not only in the cognitive and psychomotor domains but also in the affective domain. This can be seen from the TCR value obtained from the assessment of 7 experts. So that it produces measurable and authentic assessments.

REFERENCES

[1] P. Sudira, TVET Abad XXI Filosofi, Teori, Konsep, dan Strategi Pembelajaran Vokasional. Yogyakarta: UNY Press. 2016

[2] N. Heraty, M.J. Morley, and A. McCarthy, "Vocational Education and Training in the Republic of Ireland: Institutional Reform and Policy Developments Since the 1960s". Journal of Vocational Education & Training. Vol 52: 177-199. 2000.

[3] S.S. Nathan, M. Berahim, R. Ramle, "Rubric for Measuring Psycomotor and Affective Learning Domain". Pertanika J.Soc.Sci.&Hum. Vol.25, 101-108. 2017.

[4] K. Wijaya, Ganefri, F. Rizal, and S. Siregar. "Development of Product Oriented Modules On Learning Building Materials For Civil Engineering Students". International Journal Of Scientic & Technology Research. Vol. 8: 122-124. 2019.

[5] F. Fadhilah, Z.M. Efendi, R. Ridwan, "DILA Learning Model based on Contextual Teaching and Learning in Applied Physics Course at Mining Engineering". ASSEHR. 201: Atlantis Press. 2018.

[6] E. Reyes and J.C. Galvez, "Introduction of Innovations into The Traditional Teaching Construction and building Materials". Journal of Professional Issues in Engineering Education and Practice. January: 28-37. 2011

[7] A. Ishida, "Tactility at 1:1: Media and Context in learning about Building Materials". Paper presented at the 2016 National Conference on the Beginning Design Student (NCBSD) at Cal Poly San Luis Obispo.

[8] Ganefri. "The Development of Production-Based Learning Approach to Enterpreneurial Spirit for Engineering Students". Journal Asian Social. Science; 9 (12). ISSN 1911-2017 E-ISSN 1911-2025. 2013

[9] L. Yan, "Application of Research Study in The Teaching of Civil Engineering". International Conference on Education Technology, Management and Humanities Science (ETMHS 2015): 545-549. 2015

[10] G. Kasilingam, M. Ramalingam, and E. Chinnavan, "Assessment of learning domain to improve student's learning in higher education". Journal of Young Pharmacists. Vol.6: 27-33. 2014.

[11] E. Budiastuti, P. Karomah, A. Martanti, and D. Fatmawati. "Pengembangan Instrumen Self Assessment pada Praktik Menjahit Rok Berfuring". Jurnal Pendidikan Teknologi dan Kejuruan: 29-35. 2014.

[12] R. Hamid, S. Baharom, N. Hamzah, W. H. W. Badaruzzaman, R. Atiq, O.K. Rahmat, and M. R. Taha. "Assessment of Psychomotor Domain in Materials Technology Laboratory Work". Procedia-Social and Behavioral Sciences. Vol. 56: 718-723. 2012.