International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1, October, 2019

Effectiveness of Metacognitive Learning's Model in Engineering

Selamat Riadi, Selamat Triono, Syahril Syahril, Dicky Nofriansyah

Abstract*: The Industrial Revolution Era 4.0 is a continuation of the era of society 3.0. One of the fields that experienced obstacles in facing this era was the industry sector. In creating experts in the industrial world, especially machinery, is not easy. One of the efforts made in improving the competence of workers in the field of machinery by adopting an appropriate learning model. During this learning model used in the field of machinery including work based learning and project based learning. These models experience constraints including the lack of relevance to the actual industrial world. This study discusses the effectiveness of the TEFA learning model in improving the quality of learning and ultimately producing machinery workers who have good competence in accordance with bloom's taxonomy at level 5

***Keywords* : Engineeering, TEFA, Bloom Taxonomy, Industrial Revolution 4.0**

I. INTRODUCTION

The problems and challenges of vocational teacher education (Teaching Vocational Education and Training = TVET) are very different from general education, so that they require different responses in terms of competencies that must always be updated along with technological developments and their linkages with the business world and industry. The world of work that changes dynamically with the rapid pace of technological development, has required vocational teacher education (TVET) to focus on efforts to prepare education and training participants to function adequately in the era of the industrial revolution 4.0.paper are fine and satisfactory (Shvetsova & Kuzmina, 2018)(Choi, Kim, & Boo, 2003). In the era of the industrial revolution 4.0, desruption is a key word that must always be observed and watched out for, because it contains the demands of meaning that the task of education and training is to prepare people who are able to think, behave and act creatively in the face of unexpected changes as a disruption to planning which is relatively well established. This is also in line with Wagner's (2008) expression that uncertainty is demand driven in the 21st century work world.

Revised Manuscript Received on October 30, 2019.

* Correspondence Author

Selamat Riadi, Associate Professor. Faculty Engineering of Universitas Negeri Medan. Colleger of Faculty Engineering of Universitas Negeri Paga

Selamat Triono, Professor. Faculty Engineering of Universitas Negeri Medan

Syahril. Associate Professor. Vice Chancellor II of Universitas Negeri Padang

Dicky Nofriansyah. Lecturer. Department of Information System of STMIK Triguna Dharma Medan.

Therefore, changes in future educational needs must be "back-to-basics" by strengthening the adaptability of the "Old World" of classrooms in the "New World" of work. To enter the "new world of work in the 21st century according to Wagner required seven survival skills, namely: (1) critical thinking and problem solving; (2) collaboration across networks and leading by influence; (3) agility and adaptability; (4) initiative and entrepreneurism; (5) effective oral and written communication; (6) accessing and analyzing information; and (7) curiosity and imagination. From the proposed skills, critical thinking and problem solving skills (critical thinking and problem solving) are the fundamental competencies of 21st century life patterns revealed by Wagner. This is caused in the new world order which is characterized by knowledge-based economy, every job is always stated in the form of: tasks, or problems, or the final goal that must be completed. Thus critical thinking and problem solving are very important competencies for every work actor in an industrial society. Therefore, through various learning models, every graduate of higher education must have these competencies as a basis for self-development.

Some learning models that are generally implemented by the world of technology and vocational education are Work Base Learning (WBL), Project Based Learning (Sawitri, Krisnawati, Teknik, & Negeri, 2015) (Irawan, Sagala, & Sofianty P, 2016) (Yadav, 2010), Problem Based Learning, Teaching Industries, Teaching Factory, and other learning models that are generally based on the world of work(Ibrahim & Abd.Halim, 2013; Sawitri et al., 2015)(Vijayaratnam, 2012) . However, the learning model approach that has been implemented above in its implementation emphasizes procedural processes which in the cognitive domain generally only reach the Application level (C3) with a little analysis of the process (C4), meanwhile from the explanation of the above problems, the demands of the characteristics of the current education graduates and what will come is higher order thinking skills (Higher Order Thinking Skill = Analysis / C4) to Create / C6)(Overbaugh, R.C., Schultz, 1990).

II. PHILOSOPHY OF LEARNING

Philosophy is a radical critical reflection. Reflection is an attempt to obtain fundamental knowledge or essential or core elements. To find the essential elements, the philosophical review must meet the ontological rules of factual nature, epistemological rules which means to have a methodology that can be traced, as well as to have axiological rules which means clear purpose and usefulness.

In this connection, the nature and understanding of Vocational Education according to Unesco (2002) are as follows:

"Technical and vocational education as preparation for an accupational field should provide the foundation for productive and satisfying careers and should lead to acquisition of broad knowledge and generic skills applicable to a number of occupations within a given so that individual is not limited in his / her choice of occupation and is able to transfer from one field to another during his / her working life".

From this understanding it can be interpreted that technical and vocational education is education that prepares people to enter an occupation as well as career achievements. In this regard, further Thomson (1978) also revealed: "Every person is important and has dignity and thus has a right to be educated. Society has a responsibility to give evey youngster the opportunity to develop to the fullest extent of his capabilities ". Every person is important, dignified and potential, they have the right to receive proper education and training, the government and the community are responsible so that every young generation gets education and training, so they can live in the community (Nizwardi, 2013: 7).

The feasibility of implementing the implementation of technology and vocational education according to Charles A. Crosser (Camp and Johnson, 2005: 37 in Djatmiko, 2013) must at least meet some rules or principles to be effective. According to Prosser, the rules / principles of organizing vocational education according to it will be effective if the implementation fulfills 16 principles (Dalil Prosser) as follows:

1. Vocational education will be efficient if the environment in which students are trained is a replica of the environment in which it will work.
2. Effective vocational education can only be given where training tasks are carried out in the same manner, tools and machinery as determined at the workplace.
3. Vocational education will be effective if it trains someone in the habits of thinking and working as required in the work itself.
4. Vocational education will be effective if it can enable each individual to capitalize on their interests, knowledge and skills at the highest level.
5. Effective vocational education for every profession, position or occupation can only be given to someone who needs it, who wants it and who benefits from it.
6. Vocational education will be effective if the training experience to form work habits and correct thinking habits is repeated so that it is appropriate as needed in later work.
7. Vocational education will be effective if the teacher has had successful experience in applying skills and knowledge to the operations and work processes that will be carried out.
8. In every position there is a minimum ability that must be possessed by a person so that he can still work in that position. (Job keeping skills)
9. Vocational education must pay attention to market demand. (demand of the market)
10. The process of fostering effective habits for students will be achieved if training is given to real work (value-filled experience). (Actual job)
11. A reliable source to find out the content of training in a particular occupation is from the experience of the occupational experts.
12. Every job has characteristics of content (body of content) that is different from one another.
13. Vocational education will be an efficient social service if it suits the needs of someone who does need it and is indeed most effective if done through vocational teaching.
14. Vocational education will be efficient if the teaching methods used and personal relationships with students take into account the characteristics of these students. (Social service: Methods and Human relations)
15. Administration of vocational education will be efficient if it is flexible.
16. Vocational education requires certain costs and if it is not met then vocational education must not be forced to operate.(Abdul Rahman, 2018; Hunter & Aiken, 1985; Jones, Simon, & Guthrie, 2018)

From the understanding and some of the principles of vocational education described above it can be concluded that Technology and Vocational Education is specific education so that it requires its own requirements and characteristics in carrying out its functions and objectives. Based on the conclusions of this understanding, the learning model implemented and developed must also be specific. Based on this specificity, Slamet PH (2015) provides an overview of the scope of functions of the Technology and Vocational Education and Training in the form of the following scheme:

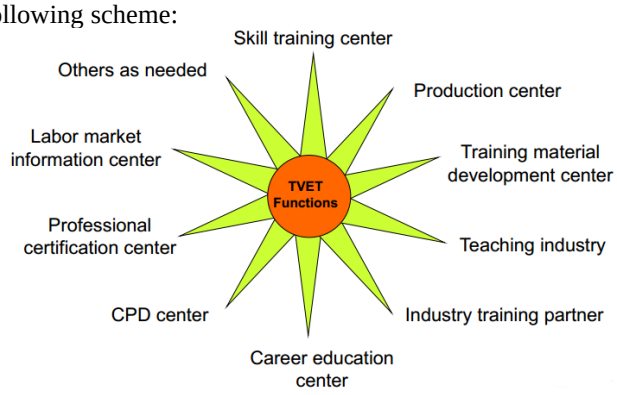

Figure 1: Scope of Technology and Vocational Education Functions

III. LEARNING THEORY

To underlined the implementation of this Skill-Based Metacognitive Teaching Factory Learning Model, the following will be presented a summary of Theory of Learning in this study. In general, learning theories developed in the world of education are:

1. Behavioristic Theory
2. Cognitivistic Theory
3. Constructivistic Theory

Representations of theories (behavioristic) in the learning process include the theory of Stimulus-Response, Reinforced Behavior, Antecedent Behavior Consequence. Likewise, the representation of Cognitivistic theory includes Cognitivistic Learning Perspective, Information Processing, and Mental Models. Meanwhile constructivist theory presents Inquiry-based learning and Discovery learning which is currently being implemented and developed in Indonesia in the framework of implementation, especially technology and vocational education.

The main principles of Behaviorism Theory is Learning occurs when the correct response is shown after the presentation of a specific environmental stimulus, the emphasis is on observable and measurable behavior. Whereas the main principle of the Cognitivism theory stream states that Learning is a change in the state of knowledge, Knowledge acquisition is described as a mental activity that requires internal coding and structuring by students, Students are seen as active participants in the learning process, Emphasis is on knowledge building blocks (eg identifying prerequisite relationships content), Emphasis on structuring, organizing and sorting information to facilitate optimal processing.

The Main Principles of Constructivism theory flow: Students build personal interpretations of the world based on experience and interaction, Knowledge embedded in the context of its use (authentic tasks in meaningful realistic settings), Create new and specific understanding of situations by "gathering" knowledge from various sources in accordance with existing problems (use of flexible knowledge).

From the main principles of learning theory above, the learning objectives in the Behaviorism theory flow are: Communicating or transferring behavior that represents knowledge and skills to students (do not consider mental processes), Learning is to get the desired response from students who are given target stimuli , Students must know how to implement an appropriate response and the conditions under which the response is carried out. Learning uses the consequences and reinforces learning behavior.

Whereas the learning targets in the Cognitivism theory flow are Communicating or transferring knowledge in the most efficient and effective way (mind-independent, can be mapped to students), The focus of teaching is to create learning or change by encouraging students to use appropriate learning strategies, Outcomes learn when information is stored in memory in an organized and meaningful way, the teacher / designer is responsible for helping students organize information optimally so that it is easy to assimilate.

The purpose of learning in the flow of the theory of Constructivism is to build a personal interpretation of the world based on the experience and interaction of individuals (always open to change, can not reach the predetermined "right" meaning, knowledge appears in relevant contexts), Learning is an active building process rather than gaining knowledge, Learning is a process to support the construction of knowledge rather than communicating knowledge. Don't arrange learning for the task, but learn the actual use of tools in real-world situations.

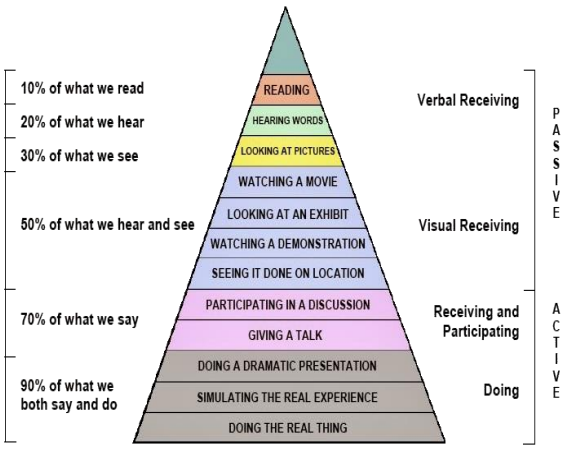

Figure 2: Edgar Theory

IV. ASSESMENT OF TEACHING FACTORY

Innovative vocational education learning technology and productive practices are concepts of educational methods that are oriented towards the management of learners in learning to be in line with the needs of the business / industrial world. It is very important, this educational / training institution has a close partnership with several companies engaged in fields that are in line with professional education studies. Teaching Factory is an implementation of the Production Based Training learning model. In another sense that production-based learning is a process of learning expertise or skills that are designed and implemented based on actual work procedures and standards (real job) for produce goods or services in accordance with market or consumer demands(Handayani, Azizah, & Indahsari, 2019; Mourtzis, 2018; Putra, Kusumah, Komaro, Rahayu, & Asfiyanur, 2018). In other words, the goods produced can be in the form of products that can be sold or that can be used by the community, schools or consumers. This is the opposite of production-based learning in the old paradigm that only prioritizes the quantity of products or services, but the results of the production are not used or marketed, but merely to produce value in teaching and learning. In other words, Teaching factory is an implementation of the Production Based Training learning model which in the learning process of students is directly involved in the production process.

Teaching factory as one of the learning strategies has several objectives. In a paper published by the American Society for Engineering Education Annual Conference and Exposition, Alptekin, et al (2001: 1) states that the purpose of teaching factory is: produce graduates who are professional in their fields, develop curricula that focus on modern concepts, demonstrate appropriate solutions for challenges faced by the industrial world, as well as technology transfer from industries that are partners with students and educational institutions. While the development of teaching factories at Penn State University, The University of Puerto Rico-Mayagues, The University of Washington, and Sandia Natinal Labs aims to provide tangible experience in the design, manufacture and realization of products designed and develop a curriculum that has a balance between knowledge theory and analysis with manufacturing, design, business activities, and professional skills
(Jorgensen, et al. 2995: 2)

In learning with the Teaching Factory approach, the ideal cooperative relationship between the business / industry world and technology and vocational education institutions that are interrelated and beneficial as illustrated by the scheme shown in Figure 3 (Moerwismadhi, 2009):

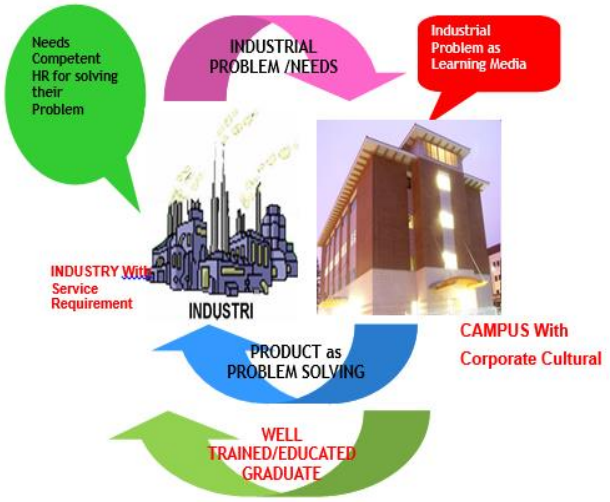

Figure 3: Relation Model

Teaching Factory (TEFA) as an effective learning activity model the concept of TEFA learning can deliver learners to reach a certain competency stage, which is a stage where students deserve to be given authority because has been considered capable. Innovations in teaching activities have been carried out by applying the 6-step TEFA model (Dadang, Model TF-6M). This learning model will allow to change the atmosphere of the academic environment into the atmosphere in the industry. Educators act as assessors and consultants, while students act as workers in the industry according to their respective duties and responsibilities. The following table shows the syntax of the TEFA teaching approach model.

According to Livingstone (1997) stated that metacognition includes two components, namely: (1) metacognitive knowledge, and (2) metacognitive experience / regulation (metacognitive experience or regulation) or also called metacognition strategy. Then Schraw & Moshman, (1995: 323) explain in more detail that the component of metacognition, namely knowledge about cognition (knowledge about cognition) and regulation of cognition. Knowledge about cognition consists of declarative knowledge, procedural knowledge and conditional knowledge. While the regulation of cognition (regulation about cognition) consists of: a) planning, b) information management strategies, c) comprehension monitoring, d) debugging strategies, and e) evaluation. This opinion is further strengthened by Desoete (2001) who concluded that metacognitive components have been described in the form of the following table:

Table 1. Elements of Metacognitive

METACOGNITIVE	
Declarative Knowledge Procedural Knowledge Conditional Knowledge	**METACOGNITIVE KNOWLEDGE**
Planning Monitoring Evaluation	**METACOGNITIVE SKILLS**
Self-Concept Self-Efficacy Motivation Attribution Conception of intelligence and Learning	**METACOGNITIVE BELIEFS**

According to the metacognition theory that students who learn have certain skills to regulate and control what they learn. These skills differ from one individual to another according to the ability of the thought process. Furthermore Woolfook (Uno, 2009) explains there are four types of skills, namely: problem solving, decision making, critical thinking, and creative thinking (1) Problem solving skills, namely a student's skill in using his thought process to solve problems through gathering facts, analyzing information, compiling various alternative solutions, and choosing the most effective problem solving, (2) Decision-making skills, namely the skill of a person using his thought process to choose the best decision from the various choices available through information gathering, comparison of the merits and shortcomings of each alternative, information analysis, and the best decision-making based on rational reasons, (3) Critical thinking skills, namely one's skills in using his thought process to analyze arguments and provide interpretations based on valid perceptions through logical interpretations, analysis of assumptions and biases of arguments and logical interpretations, and (4) Creative thinking skills, namely one's skills in using his thought process to produce a new, constructive, and good idea based on concepts, rational principles, as well as perception and intuition.

The practicality of the learning model undertaken is obtained from the assessment of lecturers and students, the results of direct reviews (observations in the field) and interviews conducted with stakeholders involved to see the response or feedback on the implementation of the TEFA Learning's Model. From a number of data examined, some data were obtained from the results of the assessment and direct observation in the field by filling out the practicality and observation assessment sheets.

In describing production machine learning data, data processing is done by processing data from information obtained from respondents by analyzing descriptively to see the trends of each population or sample in spreading the data.

1. Pre-test Value in Learning Subjects

Based on the picture, the data related to the pretest for the trial class is limited to the number of samples or a population of 21 students. The following are the results of the analysts from the pretest data of the limited trial class, namely:

Table 2 : Pre-Test Frequency Distribution From Limited Trial Class Data

No	Interval Class	Absolut Frequency	Frequency Percentage Absolut (%)
1	30 - 37	2	9.52
2	38 - 45	7	33.33
3	46 - 53	5	23.81
4	54 - 61	2	9.52
5	62 - 70	5	23.81

The data on the percentage value of absolute frequency can be seen in the pie chart as follows:

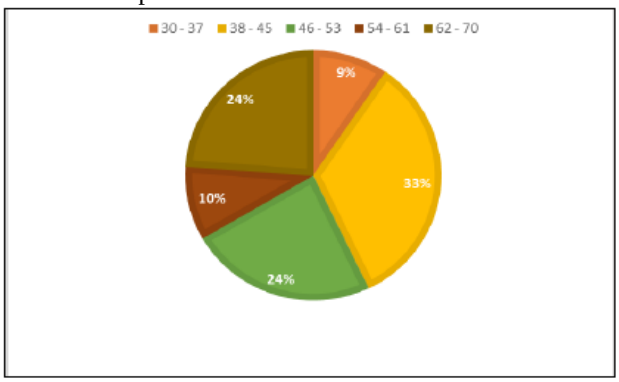

Figure 4: Circle Diagram of Pretest Class in Limited Trials

With the above value distribution with an average value of 50.4762, with a median value of 50 and with a module value of 40 with a standard deviation or standard deviation of 12.639696. Looking at the conditions where the average score, median and mode values do not exceed the standard deviation values, it can be stated that the pretest value of the control class is normal.

2. Post-test Value in Learning Subjects

Based on the results of data processing from 21 students, the following is the frequency distribution of post test scores on a limited test, as follows:

Table 3 : Pre-Test Frequency Distribution From Limited Trial Class Data

No	Interval Class	Absolut Frequency	Frequency Percentage Absolut (%)
1	60 - 66	1	4.76
2	67 - 73	4	19.05
3	74 - 80	7	33.33
4	81 - 87	3	14.29
5	88 - 95	6	28.57

Based on table and the histogram can be explained that there are scores between 60-66 of 1 student with an absolute frequency percentage of 4.76%, a value of 67-73 of 4 students with a percentage of absolute frequency of 19.05%, a value of 74-80 of 7 students with the percentage of absolute frequency was 33.33%, 81-87 there were 3 students with an absolute frequency percentage of 14.29% and 88-95 scores were 28.57 students with an absolute frequency percentage of 28.57%. The data on the percentage value of absolute frequency can be seen in the pie chart as follows:

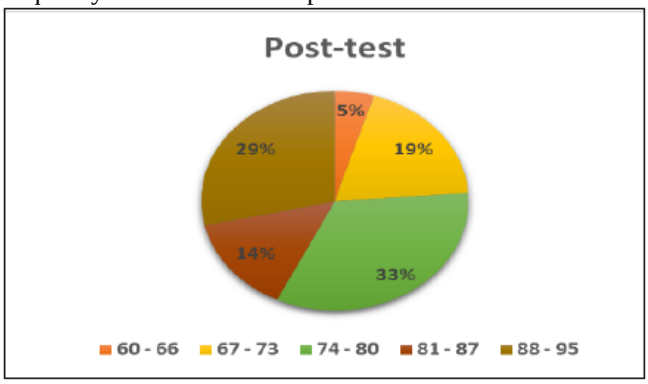

Figure 5 : Circle Diagram of Posttest Class in Limited Trials

From the pre-test and post-test results of the limited trial class, the following is the average value of the learning outcomes of the production machine courses in the limited trial test.

Table 4. Score Difference of Pre-Test and Post-Test

No	Value	Mean
1	Pre-Test	50.47
2	Post-Test	81.19
	Score Difference	30.72

V. CONCLUSION

Based on the results of testing the effectiveness associated with the control class and the experimental class in getting the TEFA learning model System can be declared EFFECTIVE from the perspective of students and lecturers.

REFERENCES

1. Abdul Rahman, A. M. (2018). English Writing Performance Using Blended Learning in Tvet Education. LANGUAGE LITERACY: Journal of Linguistics, Literature, and Language Teaching, 2(1), 28–36. https://doi.org/10.30743/ll.v2i1.445
2. Choi, I.-C., Kim, K. S., & Boo, J. (2003). Comparability of a paper-based language test and a computer-based language test. Language Testing. https://doi.org/10.1191/0265532203lt258oa
3. Handayani, S., Azizah, D. N., & Indahsari, E. L. (2019). The Implementation Evaluation of Teaching Factory Learning Model on APT Productive Learning at SMK Negeri 2 Subang. 299(Ictvet 2018), 557–561. https://doi.org/10.2991/ictvet-18.2019.125
4. Hunter, B., & Aiken, R. (1985). Computer literacy and vocational education: Dilemmas and directions. Education and Computing, 1(4), 221–228. https://doi.org/10.1016/S0167-9287(85)92625-1
5. Ibrahim, N., & Abd.Halim, S. (2013). Implementation of Project Oriented Problem Based Learning (POPBL) in Introduction to Programming Course. International Research Symposium on Problem Based Learning (IRSPBL) 2013. Retrieved from http://vbn.aau.dk/da/publications/pbl-across-cultures(5ce5393d-4200-46a8-bd65-fa47a304ea78).html
6. Irawan, A., Sagala, W. H., & Sofianty P, W. (2016). Influence of Igniter Component to The Burning of Bio Briquette Rice Husk Torrefactio. Proceeding of the First International Conference on Technology, Innovation and Society, 674–679. https://doi.org/10.21063/ICTIS.2016.1102
7. Jones, A., Simon, L., & Guthrie, H. (2018). Vocational education for the twenty-first century. (August), 1–11.
8. Mourtzis, D. (2018). Development of Skills and Competences in Manufacturing Towards Education 4.0: A Teaching Factory Approach BT - Proceedings of 3rd International Conference on the Industry 4.0 Model for Advanced Manufacturing (J. Ni, V. D. Majstorovic, & D. Djurdjanovic, eds.). Cham: Springer International Publishing.
9. Overbaugh, R.C., Schultz, L. (1990). Bloom's Taxonomy - illustration. Bloom's Taxonomy, 1956. Retrieved from https://www.odu.edu/content/dam/odu/col-dept/teaching-learning/docs/blooms-taxonomy-handout.pdf
10. Putra, R. C., Kusumah, I. H., Komaro, M., Rahayu, Y., & Asfiyanur, E. P. (2018). Design Learning of Teaching Factory in Mechanical Engineering. IOP Conference Series: Materials Science and Engineering, 306(1). https://doi.org/10.1088/1757-899X/306/1/012104
11. Sawitri, S., Krisnawati, M., Teknik, F., & Negeri, U. (2015). EFEKTIVITAS MODEL PEMBELAJARAN BERBASIS PROYEK KULIAH PENGEMBANGAN DESAIN. 2(2), 45–60.
12. Shvetsova, O. A., & Kuzmina, A. D. (2018). Development of Engineering Personnel in the Era of the Fourth Industrial Revolution. 2018 Third International Conference on Human Factors in Complex Technical Systems and Environments (ERGO)s and Environments (ERGO), 45–48. https://doi.org/10.1109/ERGO.2018.8443927
13. Vijayaratnam, P. (2012). Developing Higher Order Thinking Skills and Team Commitment via Group Problem Solving: A Bridge to the Real World. Procedia - Social and Behavioral Sciences, 66, 53–63. https://doi.org/10.1016/J.SBSPRO.2012.11.247

14. Yadav, S. S. (2010). Integrated Project Based Learning in Software Engineering Education Implementation : (Icent), 34–36.

AUTHORS PROFILE

Selamat Riadi, Associate Professor. Faculty Engineering of Universitas Negeri Medan. Colleger of Faculty Engineering of Universitas Negeri Paga

Selamat Triono, Professor. Faculty Engineering of Universitas Negeri Medan

Syahril. Associate Professor. Vice Chancellor II of Universitas Negeri Padang

Dicky Nofriansyah. Lecturer. Department of Information System of STMIK Triguna Dharma Medan.