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Implementation of STEM and MI Based Physics Learning in Vocational Schools

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Abstract: ***The purpose of this study was to determine the impact of STEM and MI-based physics learning on the cognitive-affective and TEL integrated skills of vocational students. This study uses one group pretest-posttest design research design by giving pretest at the beginning of the meeting and posttest at the end of the meeting. The sample in this study was class X students of computer engineering and informatics skills programs in one private vocational school in Bandung with a total of 29 people. The results showed that the application of physics learning models based on STEM and Multiple Intelligences could improve the cognitive-affective and TEL integrated vocational students' TEL skills in the theme of electric energy conservation.***

Keywords: STEM and MI-based learning, cognitive-affective integrated ability, TEL, electrical energy conservation

1. Introduction

Energy limitation is one of the crucial issues that is currently emerging in almost all countries in the world. Even this crucial issue is one of the targets that is expected to be overcome and realized in 2030, in addition to other crucial issues related to poverty and climate change. These targets are listed in the 2030 Sustainable Development Goals (SDGs) agreed by world leaders [1]. Besides, this crucial issue is also a very serious concern for Indonesia, given data from the ASEAN Center for Energy (ACE) in 2013 stated that Indonesia is the country with the highest level of waste of electricity at this time [2]. Even though electricity supply in Indonesia is currently in a critical and alert condition because there are not enough reserves remaining. As reported in the Technology Assessment and Application Board (BPPT) in 2014 by PT PLN (Persero), in the last five years the growth of power plant construction, at 6.5% per year, was unable to catch up to 8.5 electricity demand growth % per year [2].

In several other countries, efforts to save (efficiency) electricity which is one of the most inexpensive, fast and environmentally friendly ways to overcome the limitations of electrical energy compared to having to build a supply of electrical energy resources has entered the policy level such as reducing the use of electrical energy for purposes industry. This means that only 20% of industrial activity uses electricity, while the rest uses natural energy (solar thermal energy, gas energy, wind energy, tides, etc.). As for Indonesia, although it has not yet reached the regulation on the percentage of electricity used for industrial purposes, various efforts have been taken by the government to reduce a large number of electricity usage, through a 10% movement campaign. The movement aims to educate the public regarding the use of electricity during the day, turn off the lights when not in use, and even use energy-saving lamps. However, the culture of people who still like to turn on the lights during the day or use electricity for things that are not important still occur. Based on the report on the implementation of exploratory research and the implementation of the campaign, the campaign activity of the 10% cut movement is considered to be less efficient and effective in increasing public awareness about saving electricity because the campaign on saving electricity is felt only as an insert, not as the main message to be conveyed [3]. Based on this, more efforts need to be changed. One of them is through structured, systematic and massive education in the school-age community that can provide a positive impact on the broader community.

Physics is one part of science held in order to develop thinking skills in solving problems related to surrounding events that occur in society, both qualitatively and quantitatively, and can develop skills and attitudes of confidence. This is in line with the objectives of physics at the secondary school level [4].

From the description above it appears that the administration of physics at the secondary school level is intended as a vehicle or means to equip students to be able to master the knowledge, concepts, and principles of physics. In the process of learning, physics not only emphasizes cognitive mastery (content) but also should contain all four things, namely: content or products, processes or methods, attitudes, and technology so that students' understanding of physics is intact and can be useful to overcome problems that are confronted him [5]. Content or product means that in physics, there are facts, laws, principles, and theories whose truth has been accepted. Process or method, meaning physics is a process or method for gaining knowledge. Attitude means that physics can develop scientific attitudes such as diligent, thorough, open and honest. Technology means that physics is related to improving the quality of life.

Judging from these objectives, physics is very good for students if it can be carried out as expected. However, in reality, what happens on the ground is still not following the expected goals.

Data from the distribution of questionnaires to several students shows that physics is a subject that is less liked by students. Only 26.41% of students liked physics, the rest 73.59% answered that they did not like it. The reason students dislike physics is that students assume that in physics lessons too many formulas are memorized by 35.90%, boring learning methods by 53.85%, and for 10.26% students assume physics lessons have nothing to do with competency skills they choose. Furthermore, from the results of the questionnaire distribution, it was obtained 52.83% of students considered physics as a problematic subject, 43.40% of students considered physics as an ordinary subject of difficulty, and only 3.77% of students considered physics an easy subject.

Data from interviews with one of the physics teachers, it is known that the problems often faced by teachers, namely students having difficulty in understanding and implementing the subject matter that has been taught. Also, the methods often used by teachers in learning physics in class are lecture methods, discussion/question and answer, drilling questions, and if possible, through practical activities.

As for the results of observations of physics learning in class, it is known that teachers more often explain concepts and provide reinforcement at the end of learning. After explaining the concept, students are given exercises to practice and to practice courage and check the understanding of one of the students working on the board, then the teacher discusses it.

By looking at the results of preliminary studies that have been carried out, it can be analyzed that most of the learning process in the classroom is still teacher-centred and is the transfer of knowledge from teacher to the student so that learning is only directed at students' ability to remember information. Students are more directed to remember various information and not understand the information they get and are not positioned as constructors of knowledge. As a result, when students return to the community, they do not know the meaning of the theory learned.

Also, based on the results of preliminary studies, it can be analyzed that the learning process in the classroom is only oriented towards students' cognitive abilities. Even if there is an orientation towards affective abilities or attitudes, it is still separate and constrained to individual scientific attitudes such as bold and honest, but even then it has nothing to do with the context of the teaching material being delivered. In fact, in the taxonomy of educational objectives (book two affective domain), Krathwohl explains three types of relationships between the cognitive domain and the affective domain in learning. One of them is cognitive objectives as means to affective goals, namely the cognitive domain learning process that has affective domain goals (called cognitive-affective ability). Based on this context, the material presented is not contextual or not sought to be associated with important issues that exist in the daily environment. As stated by DeBoer, the purpose of understanding physics or science is not solely for the sake of learning, but to further activate and motivate citizens to contribute and be involved in society [6]. In addition, the learning process that does not place students as constructors of knowledge and is not contextual with the issues in the surrounding community results in low student Technology and Engineering Literacy (TEL), which is an understanding or ability related to the use of technology and engineering in order to solve problems in daily life [7].

Finally, based on the results of the preliminary study, it can also be analyzed that in the learning process the teacher is more dominant in accommodating students who have multiple intelligence that includes language and logical mathematics. Whereas based on the results of the pretest using a standardized test adapted from "The Rogers Indicator of Multiple Intelligences (RIMI) Test" shows that the compound intelligence profile of students in the class is quite diverse with the percentage of linguistic intelligence 25%, musical intelligence 8.33%, mathematical logical intelligence 36.11%, spatial intelligence 19.44%, kinesthetic intelligence 13.89%, intrapersonal intelligence 19.44%, interpersonal intelligence 16.67%, and naturalist intelligence 13.89% [8].

In connection with these problems, it is necessary to make efforts to improve or innovate the learning process so that students are more involved in learning and feel the various challenges they have to find solutions to the various problems they face in the surrounding environment. With the involvement of students in the learning process like that, it will be easier for them to find and understand the concepts learned, improve their TEL ability, and no less important to make them more sensitive and able to behave the best in a variety of problems in the surrounding environment they.

One alternative effort to answer these problems is through a learning process based on science, technology, engineering, and mathematics (STEM), which accommodates multiple intelligence (MI) it has (Model PBSTEM-MI). STEM becomes an essential issue in the current educational trend [9-10]. STEM has been applied in various countries such as America, the United Kingdom, and Japan. Bybee stated the purpose of STEM education, so that students have scientific literacy, technology, engineering, and mathematics appear from reading, writing, observing, and doing science so that if they later get involved in society, they will be able to develop the competencies they already have to be applied in dealing with problems in everyday life related to STEM science [11]. Presentation of content material in STEM is integrated into one with the field of mathematics used as tools to facilitate the fields of science, engineering and technology. STEM education can develop when it is associated with the environment so that learning that presents the real world (real life) experienced by students in their daily lives is realized [12].

Besides, in the learning process, it is necessary to be able to understand students' abilities personally, acknowledge their existence with all their abilities, appreciate their talents and the results of their work. Several researchers [13-20] affirm that student success in class depends on the proper use of the various intelligence they have. Compound intelligence does not only include language (linguistics) and mathematical logic but also includes aspects of kinesthetic, musical, visual-spatial, interpersonal, intrapersonal and naturalist which are adjusted to the characteristics of the concepts being studied. These types of intellectual intelligence are known as multiple intelligences which are introduced and developed by Howard Gardner [21].

Based on the description above, the purpose of this study is to find out how the impact of physics learning using STEM and MI-based learning models to improve the cognitive-affective and TEL integrated vocational students' ability in electrical energy conservation.

2. Method

The research method used in this study is a quasi-experimental method with the research design used in this study is one group pretest-posttest design [22]. This study uses one class that was taken by random cluster sampling from class X, amounting to four classes. One class consists of 29 students who will receive learning treatment using STEM and MI-based learning models (PBSTEM-MI models). The pattern of one group pretest-posttest design is shown in Table 1.

Table 1: Research Design *One Group Pretest - Posttest Design*

Group	Pretest	Treatment	Posttest
Eksperimen	T_1	X	T_2

Information:

T_1 = *pretest to measure students' cognitive abilities.*

X_1 = *treatment in the form of the application of learning based on STEM and MI.*

T_2 = *posttest to measure students' cognitive abilities.*

The instrument has given when the posttest (T2) is the same as the pretest (T1). The instrument used as a pretest and posttest in this study is an instrument to measure students' cognitive-affective and TEL integrated abilities consisting of 33 items with five choices that refer to indicators for direct current electricity teaching materials which are oriented towards the values and attitudes of electrical energy conservation. The test instrument was tested for eligibility with a reliability of 0.88 tests and very high criteria.

Analysis of the increase in students' cognitive-affective and TEL integrated abilities is done by measuring the <g> value and interpretation of the improvement based on the pretest and posttest scores obtained by each student. Measurement of the N-gain value and interpretation of the data is done using the help of Microsoft Excel 2013 data processing software.

3. Result and Discussion

The results of the pretest scores obtained illustrate that the ability of students to study direct current electricity needs to be developed. The range of cognitive-affective and TEL integrated ability scores is in the range 12.12 - 42.42 with an average score of 24.35. The posttest score of students is in the range 54.55 - 93.94 with an average score of 79.10. Figures 1 and 2 describe the distribution of the results of the pretest and posttest of vocational students on aspects of cognitive-affective and TEL integrated abilities in the conservation of electrical energy.

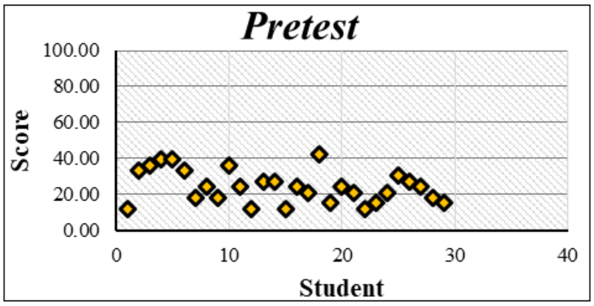

Figure 1: Distribution of Pretest Scores of Vocational Students in the Aspect of Cognitive-Affective and TEL Integrated Ability in the Conservation of Electric Energy

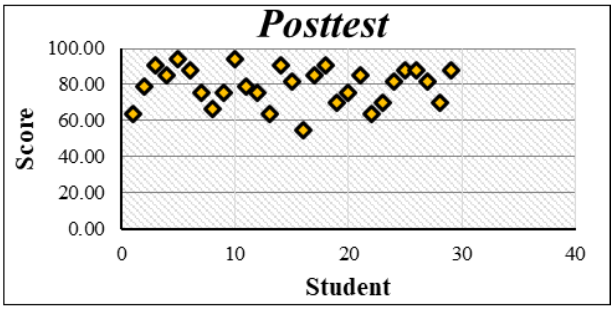

Figure 2: Distribution of Vocational High School Student Posttest Scores on the Aspect of Cognitive-Affective and TEL Integrated Capabilities in Electric Energy Conservation

The mean score of the posttest results obtained by students illustrates that in general students have integrated cognitive-affective and TEL abilities in functional electrical energy conservation after participating in physics learning using PBSTEM-MI models. The positive tendency obtained by students in this study was strengthened by the average score of pretest, posttest, and normalized gain <g> which can be seen in Table 2.

Table 2: Recapitulation of Pretest, Posttest, and <g> Average Cognitive-Affective and Student TEL

Test	Xideal	Xmin	Xmax	$\bar{X}$	G	<g>
Pretest	100	12,12	42,42	24,35	54,75	0,72
Posttest	100	54,55	93,94	79,10		
Improvement Criteria						High

Based on Table 2, it can be seen that the average score of cognitive-affective integrated ability and TEL has increased from 24.35 to 79.10. So, the average score of increased cognitive-affective and TEL integrated abilities is 54.75. Normalized average gain score <g> of 0.72 is included in the increase with high criteria.

The positive tendency shown by students in the learning process can also be seen from the percentage of correct answers given by students in the posttest of each aspect for integrated cognitive-affective abilities and TEL.

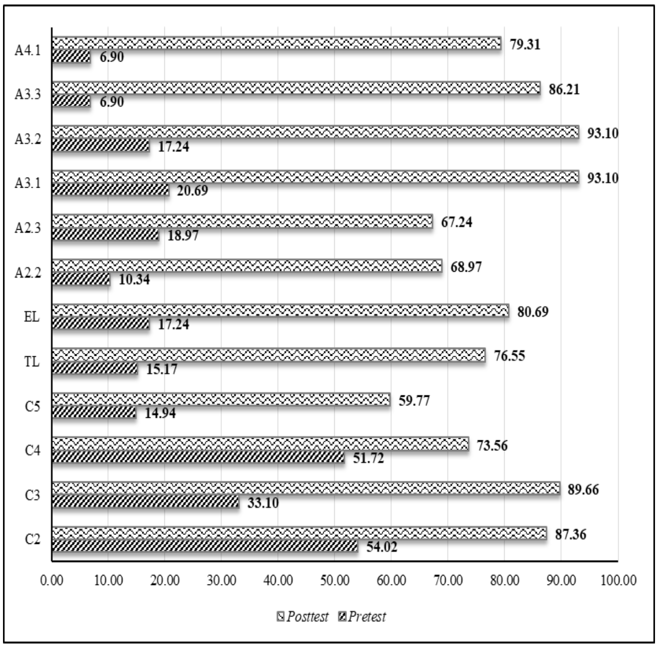

Figure 3: Improving the Average Ability of Students in Every Aspect of Cognitive-Affective and TEL Integrated Abilities Based on Pretest and Posttest Results

As can be seen in Figure 3 shows that in every aspect of the cognitive-affective and TEL integrated abilities of students before learning is still very weak. This can be seen in every aspect of the cognitive ability which includes the processes of understanding (C2), applying (C3), analyzing (C4), and evaluating (C5) the percentage of students who answered correctly no more than 54.02%.

Likewise for every aspect of TEL capabilities, be it technology literacy (TL) which includes the ability to analyze the strengths and weaknesses that exist, analyze and compare the advantages and disadvantages of proposed solutions, as well as presenting innovative and sustainable solutions, as well as engineering literacy (EL) that includes explaining the characteristics of different materials to be used as materials in accordance with the product, developing hypothesized techniques, and representing data in the form of graphs, tables, and models the percentage of students who answer correctly is not more than 17.24%. Whereas in every aspect of useful ability which includes the desire to respond (A2.2), confidence in responding (A2.3), acceptance of value (A3.1), choice for a value (A3.2), commitment (A3.3) , and conceptualization of grades (A4.1) the percentage of the number of students who answered correctly is not more than 20.69%.

The percentage increase in the average score of students' correct answers on each aspect of cognitive-affective integrated ability and TEL was corroborated with a score <g> which can be seen in Table 3.

Table 3: Improving the Average Ability of Students in Each Aspect of Cognitive-Affective and TEL Integrated Abilities by <g>

Integrated Capability		Score		<g>	Interpretasi
		Pretest	*Posttest*		
Cognitive	C2	54.02	87.36	0.73	High
	C3	33.10	89.66	0.85	High
	C4	51.72	73.56	0.45	Moderat
	C5	14.94	59.77	0.53	Moderat
TEL	TL	15.17	76.55	0.72	High
	EL	17.24	80.69	0.77	High
Affective	A2.2	10.34	68.97	0.65	Moderat
	A2.3	18.97	67.24	0.60	Moderat
	A3.1	20.69	93.10	0.91	High
	A3.2	17.24	93.10	0.92	High
	A3.3	6.90	86.21	0.85	High
	A4.1	6.90	79.31	0.78	High

Based on the data in Table 3 it can be seen that the increase in every aspect of cognitive-affective and TEL integrated ability which is shown by the <g> score is in the range of 0.45 - 0.92. This range of scores shows that every aspect of cognitive-affective and TEL integrated abilities has increased in moderate and high criteria.

Based on the data in Table 3, it can also be seen the development of every aspect of cognitive-affective and TEL integrated abilities that occur in students shifts from the range 6.90 - 54.02 to the range 59.77 - 93.10. This shows the positive impact of using the PBSTEM-MI model on the integrated cognitive-affective ability and TEL Vocational School students in Physics learning related to direct current electricity teaching materials oriented towards the conservation of electrical energy.

4. Conclusion

Based on the analysis of the research data, it can be concluded that the application of STEM and MI-based physics learning models (PBSTEM-MI models) can improve the cognitive-affective and TEL integrated vocational students' abilities in Physics learning related to direct current electricity teaching materials oriented towards energy conservation electricity.

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References

[1] United Nations Development Programme. (2016). *Sustainable Development Goals 2030*.

[2] Badan Pengkajian dan Penerapan Teknologi. (2014). *Indonesia Energy Outlook 2014*. Jakarta: Perpustakaan Nasional RI.
[3] Kementerian Energi dan Sumber Daya Mineral. (2017). *Laporan Pelaksanaan Riset Eksplorasi dan Evaluasi Pelaksanaan Campaign*. Jakarta: ESDM.
[4] Depdiknas. (2010). *Kurikulum Sekolah Menengah*. Jakarta: Depdiknas.
[5] Depdiknas. (2010). *Strategi pembelajaran MIPA*. Jakarta: Direktorat Tenaga Kependidikan Direktorat Jenderal Peningkatan Mutu Pendidik Dan Tenaga Kependidikan.
[6] DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, *37*(6), 582-601.
[7] National Assessment and Educational Progress (2012). *Technology and Engineering Literacy (TEL) Assessment*. [Online]. Diakses dari: http://nces.ed.gov/nationsreportcard.
[8] Kurniawan, A., Rustaman, N. Y., Kaniawati, I., & Hasanah, L. (2017). Profile of cognitive ability and multiple intelligence of vocational students in application of electric energy conservation. *Journal of Physics: Conference Series*, *895*, 012165.
[9] Becker, K., & Park, K. (2011). Effect of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. Journal of STEM Education, 12, 23-37.
[10] Kuenzi, J. J. (2008).Science, Technology, Engineering, and Mathematics (STEM) Education: Background, federal policy, and legislative action. Congressional Research Service Report for Congress.
[11] Bybee, R. (2013). STEM Education Challenges and Opportunities.Virginia: NSTA Press.
[12] National Research Council. (2014). *STEM Integration In K-12 Education: Status, Prospects, and An Agenda for research*. Washington, DC: National Academies Press.
[13] Abdi, Laei, dan Ahmadyan. (2013). The Effect of Teaching Strategy Based on Multiple Intelligences on Students' Academic Achievement in Science Course. *Universal Journal of Educational Research*. I (4), hlm: 281-284.
[14] Ghazi, Shahzada, Gilani, Shabbir, dan Rashid. (2011). Relationship Between Students' Self Perceived Multiple Intelligences and Their Academic Achievement. *International Journal of Academic Research*. 3 (2), hlm: 619-623.
[15] Hanafin. (2014). Multiple Intelligences Theory, Action Research, and Teacher Professional Development: The Irish MI Project. *Australian Journal of Teacher Education*. 39 (4), hlm: 126-142.
[16] Nnamdi dan Udogu. (2013). Effect Of Multiple Intelligence Teaching Strategies On Students Achievement and Retention In Chemistry. *The International Journal Of Engineering And Science*. 2 (7), hlm: 30-34.
[17] Obianuju, Akuezuilo, dan Josephine. (2015). Effect of Multiple Intelligence-Based Instructional Technique (MIBIT) On Students' Interest in the Learning of Difficult Biology Concepts. *IOSR Journal of Research & Method in Education*. 5 (3), hlm: 01-09.
[18] Rajan. (2014). Lesson Planning: The Crux of Teacher Education. *Educational Extracts*. II (1), hlm: 3-15.
[19] Shahzada, Khan, Islam, dan Faqir. (2014). Interrelation of Multiple Intelligences and their Correlation with Students' Academic Achievements: A Case Study of Southern Region, Khyber Pakhtunkhwa. *FWU Journal of Social Sciences*. 8 (2), hlm: 59-64.
[20] Yalmanci dan Gozum. (2013). The Effects of Multiple Intelligence Theory Based Teaching On Students' Achievement And Retention of Knowledge (Example of The Enzymes Subject). *International Journal on New Trends in Education and Their Implications*. 3 (4), hlm: 27-36.
[21] Gadner. (1999). *Intelligence Reframed: Multiple Intelligences for the 21st Century*. New York: Basic Books.
[22] Fraenkel, J. R. and Wallen, N. E. (2007). *How to Design And Evaluate Both In Education, 6th Edition*. Singapore: McGraw-Hill.

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