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Science Literation Ability and Physics Concept Understanding In The Topic of Work and Energy With Inquiry-STEM

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Abstract. This study aimed to determine the effect of inquiry-STEM learning on improving scientific literacy competencies and physics concepts understanding with different classes. The research sample was 40 students. The instrument used was a scientific literacy competency test and concepts understanding as many as 25 and 10 questions. Based on hypothesis testing using the t-test test, it was obtained a comparison of the increase in scientific literacy competencies namely t_{count} (0.29) $<t_{table}$ (1.68) and the comparison test results of concept understanding improvement namely t_{count} (3.085)$>$ t_{table} (1.68). Conclusions from the results of scientific literacy competency research and understanding of concepts show that, 1) Improvement of students' scientific literacy competencies that studied with inquiry-STEM learning was not different compared to students who studied with conventional learning. 2) Improvement of students' concepts understanding with inquiry-STEM learning was higher than students who studied with conventional learning. Thus, the inquiry-STEM learning model can improve scientific literacy competencies and students' physics concepts understanding

INTRODUCTION

Physics is one of the branches of science that studies natural phenomena scientifically and is systematically presented to encourage students' thinking skills [1]. Physics learning requires more constructive principles and understanding of students to apply these principles in the context of in-depth learning [2]. The expected learning patterns in the era of openness are students-centered learning [3]-[4], humanist [5], interactive [6], adaptive [7]-[9], collaborative [10]-[11], group learning [12], developing the potential of each student [13], critical thought [14]-[15] and creative [16]-[17]. The facts in the field show that physics learning in schools still uses conventional models [18]. Conventional learning methods make teachers as learning resources to transfer knowledge as a whole and learners only as listeners & recipients of knowledge [19]-[20]. The role of students in learning is still very lacking so that the skills of students in the process are still low which results in a lack of understanding of the material possessed by students [21]-[22].

The incorrect concepts that are not in accordance with the scientific views of experts are called misconceptions [23]-[25]. Physicists, among others, Aristotle and Galileo have warned that understanding is common to every person. Therefore, many results of research in the field of physics have revised previous views or theories [26]. Some physics topics include physical changes in objects with <60% misconception [27], Geometry Optics [25], The Kinetic Theory of Gas [28]; Newton's Law [29]; Energy [30]; Force and Motion [31]-[32], Thermodynamics [33], Impulses and Momentum [34]; Heat Conductivity [35], Dynamic Electricity [36]-[37] and Waves & Optics [38].

In the implementation of the 2013 curriculum in Indonesia, physics learning was developed using the scientific approach. One learning model that can be used to reduce student physics misconceptions, namely inquiry-STEM

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[39]-[42]. In inquiry-based learning, the knowledge and skills acquired by students are expected not only to remember but can find themselves [43]-[44]. The main mission of inquiry-based learning is to prepare students to form problem, make hypotheses, design experiments, conduct experiments, collect data, analyze data and can make conclusions well [45]. Learning with inquiry model requires students to find concepts by doing practicum in groups, to improve the scientific work of students. Inquiry learning can also help students in constructing physics concepts that are learned through thought processes [46].

The existence of technological developments so fast has an impact on the world of education. Therefore, students must be equipped with an understanding of good physics concepts as the main attributes in developing various technological products. As a goal of good science learning, current learning is expected to increase students' understanding and scientific literacy. Changes in the 1998 reform era made Indonesia worse that makes Indonesia far behind Southeast Asian countries until now such as Singapore and Malaysia in terms of Technology and Education [47]-[48].

One way to catch up with Indonesian education is to implement STEM-based learning (Science, Technology, Engineering and Math). A learning approach that applies integrative thematic learning because it combines four key areas in education, namely science, technology, mathematics, and engineering. Science in work and energy material, namely science that studies the universe, facts, phenomena and events in everyday life. Technology and Engenering in work and energy materials are generators and power plants. Mathematics in the matter of work and energy is in the application of questions. The STEM-based inquiry learning model is the application of learning based on integrative thematic inquiry and learning because it combines four key areas in education, namely science, technology, mathematics, and engineering. Combining the inquiry-STEM learning model is very helpful for students in understanding difficult and technological literacy concepts that result in understanding students' material [49].

Science education encourages students to think in understanding natural phenomena or events with scientific methods such as those carried out by scientists [50]-[51]. The focus that is important in science education is scientific literacy [50], [52]. Science literacy is the ability of students to use science concepts to apply in everyday life, explain scientific phenomena and describe the phenomena based on scientific evidence [53]. Science literacy is a must for everyone to have more opportunities to adapt to the dynamics of life and to improve the development of a nation [54]-[56]. Students' scientific literacy in the dimensions of competence is still low [57]. The scientific literacy of Indonesian students tends to be low on the competency dimension compared to the dimensions of content and context. The low scientific literacy of students' competencies from the results of these studies is supported by observations in “Brawijaya Smart School” High School, Malang-Indonesia, which shows that most students know science concepts, but are unable to explain the relationship between science concepts. This condition indicates the low literacy skills of students' competence.

Learning that involves understanding phenomena often makes students difficult. The process of learning physics should associate physics concepts with physics phenomena in real life. One of the purposes of physics learning is to understand the concepts of physics. Physics learning emphasizes the giving of direct experience and student-centered. In physics lessons one of the important things is the way students learn concepts of physics. Learners can understand the concept when students are able to find out a concept themselves through activities that require their thinking skills. Growing deep understanding of physics for students is very necessary, because understanding is the main key in learning [58]-[59]. Thus, this study aimed to determine the effect of inquiry- STEM learning on improving scientific literacy competencies and understanding physics concepts with different classes.

METHODOLOGY

Research Background

This research was a quantitative research type of experiment. The experimental design used was a quasi-experimental study design: Pretest-Posttest Control Group Design. The purpose of this study was to determine the effect of the Inquiry-STEM learning model on improving scientific literacy competencies and material understanding of 10th grade students. The quasi-experimental design sought to reveal a causal relationship by involving the control group and the experimental group.

Research Population and Samples

The population in this study were all students of 10th grade in "Brawijaya Smart School" High School. The sample in this study consisted of two 10th grade classes , namely the experimental class and the control class. Determination of the control class and the experimental class was done by cluster random sampling. The material learned was work and energy. The number of samples consisted of experiments class totaling 20 students and control class totaling 20 students. The initial step of this research was initial ability test to ensure that both classes have the same scientific literacy competencies and material understanding. Data on students' initial abilities were obtained from the results of the midterm exam with Newton's law material. This data collection was done before Inquiry-STEM learning was applied. After going through the normality and homogeneity test, the students' initial ability was then analyzed by similarity test. The similarity test of the initial ability with a two-tailed t test because it aims to see the differences between the two classes. Testing the differences in the initial ability of the experimental class and the control class used the following hypothesis. Ho: There was no significant difference on the initial ability of students in the experimental class and the control class were almost the same Ha: there was a significant difference in the initial ability of students in the experimental class and the control class. Test criteria said that if $t_{count} > t_{table}$, Ho was rejected, so it could be stated that there was a significant difference in the initial ability of students in the experimental class and control class. Then, if $t_{count} < t_{table}$, Ho was accepted, so it could be stated that there was no significant difference or the initial ability of students in the experimental class and the control class were almost the same.

Instrument

The scientific literacy competency test was a description test question consisting of 25 questions with the form of assessment shown in Table 1.

TABLE 1. Assessment of Students' Work Results

Criteria	Scoring
Writing down "It is known"	2
Writing down "It is asked"	1
Selection of the appropriate formula	3
Accuracy in counting	2
Accuracy of answer results	2
Total	10

One example of the question of scientific literacy competency can be shown in Table 2.

Table 2. Questions of Science Literacy Competencies

Question	Answer
A ball is located at an altitude of 100 m from the ground (g = 10 m / s^2). What is the speed of the ball at a height of 50 m from the ground, when the ball falls freely?.	*It is known*: $h_1 = 100$ m $h_2 = 50$ m $g = 10$ m/s^2 *It is asked*: *Answer*: $mgh_1 + \frac{1}{2}mv_1^2 = mgh_2 + \frac{1}{2}mv_2^2$ $gh_1 + \frac{1}{2}v_1^2 = gh_2 + \frac{1}{2}v_2^2$ $(10)(100) + \frac{1}{2}(0) = (10)(50) + \frac{1}{2}v_2^2$ $1000+0 = 500 + \frac{1}{2}v_2^2$ $v_2 = 10\sqrt{10}$ m/s (straight down direction)

Physics concept understanding tests consisted of 10 multiple-choice questions accompanied by reasons with assessment forms. It can be shown in Table 3.

TABLE 3. Assessment of Students' Work Results

Criteria	Scoring
The score of "option answer score is correct-the reason is correct"	3
The score of "option answer score is correct-the reason is incorrect"	2
The score of "option answer score is incorrect-the reason is correct"	1
The score of "option answer score is incorrect-the reason is incorrect"	0

A question example of understanding physics concepts can be seen in Table 4.

TABLE 4. Questions For Understanding Physics Concepts

Question	Answer and Reason
A golf ball and bowling ball move and have the same speed. The mass of a bowling ball is greater than the mass of a golf ball. Then, the ball that has greater kinetic energy is ... A. Golf ball B. Bowling ball C. Golf balls and bowling have the same kinetic energy D. The kinetic energy of golf balls and bowling balls is zero because it has the same speed E. Golf balls and bowling have the same work	Answer: B *Reason: because a bowling ball has a mass that is greater than a golf ball so that the bowling ball will have greater kinetic energy at the same speed.*

Data Analysis

The data analysis used in this study was statistical analysis while the data to be analyzed was scientific literacy of students' competency and material understanding. The steps of data analysis used were to conduct a prerequisite test of data analysis in the form of Normality and Homogeneity Tests. The next was the Hypothesis Test of Science Literacy Competence and Concept Understanding.

RESULT AND DISCUSSION

Before learning activities using Inquiry-STEM, the steps taken were to provide initial tests to test students' physics abilities using Newton's law material. A summary of the data on students 'initial abilities can be shown in Table 5. In addition, the research data on the tests of scientific literacy skills and the understanding of students' concepts are shown in Tables 6 and 7.

TABLE 5. Summary of Data On Students' Initial Abilities

Class	N	Mean	Std. Dev	Minimum	Maximum
Experiment	20	64.7	13.002	44	80
Control	20	61.9	11.32	41	81

TABLE 6. Summary of The Results of Tests of Scientific Literacy Competencies

Description	Scientific Literacy Competencies					
	Pretest		Posttest		Improvement	
	Experiment	Control	Experiment	Control	Experiment	Control
Students	20	20	20	20	20	20
Average Score	41.25	41.05	76.6	75.75	35.35	34.7
Max. score achieved	50	61	89	89	48	45
Min. score achieved	33	28	64	64	25	19
Std. Dev	5.01	10.69	7.25	7.15	6.40	7.69
Percentage of completeness			55%	55%		

TABLE 7. Summary of Concept Understanding Test Results

Description	Concept Understanding					
	Pretest		Posttest		Improvement	
	Experiment	Control	Experiment	Control	Experiment	Control
Students	20	20	20	20	20	20
Average Score	42.95	45.65	81.65	73.75	38.7	27.75
Max. Score achieved	60	67	100	87	66	47
Min. Score achieved	27	27	60	60	20	6
Std. Dev	10.22	10.70	11.33	9.33	12.40	9.91
Percentage of completeness			65%	40%		

Normality Test Data for Initial Capabilities of Students in Experimental Class and Control Class.

Based on the calculation data of the normality test of the students' initial ability in the experimental class, it was obtained t_{count} of 0.13225 and t_{table} 0.1981. Therefore, the data was normally distributed since obtained t_{count} (0.13225) < t_{table}, (0.1981). Meanwhile, the calculation of the initial ability test of students in the control class obtained t_{count} of 0.17147 and t_{table} of 0.1981. Therefore, it was obtained t_{count} (0.17147) < t_{table}, (0.1981).

Normality Test Results Data of Scientific Literacy Competencies Improvement and Material Understanding of Students in the Experimental Class and Control Class.

Based on the data calculation of the normality test on scientific literacy competency of the experimental class students, it was obtained t_{count} of 0.1516 and t_{table} 0.1981. Therefore, the data obtained was normally distributed since obtained t_{count} (0.1516) <t_{table} (0.1981). Meanwhile, the data calculation of the normality test on scientific literacy competency of the control class students obtained t_{count} of 0.0963 and t_{table} 0.1981. Therefore, the data obtained was normally distributed since obtained t_{count} (0.0963) <t_{table} (0.1981).

Based on the data calculation of the normality test on material understanding of the experimental class students, it was obtained t_{count} of 0.1977 and t_{table} 0.1981. Therefore, the data obtained was normally distributed since obtained t_{count} (0.1977) <t_{table} (0.1981). Meanwhile, the data calculation of the normality test on material understanding of the control class students obtained t_{count} of 0.1641 and t_{table} 0.1981. Therefore, the data obtained was normally distributed since obtained t_{count} (0.1641) <t_{table} (0.1981)

Homogeneity Test Results Data of Scientific Literacy Competencies Improvement and Material Understanding

Based on the homogeneity test of competency science literacy, it was obtained F_{count} of 1.44 and F_{tabel} of 4.41. Therefore, the competency science literacy data came from homogeneous samples since obtained F_{count} (1.44) <F_{table} (4.41). Based on the homogeneity test of material understanding, it was obtained F_{count} of 1.56 and F_{tabel} of 4.41.

Therefore, the data of material understanding came from homogeneous samples since obtained F_{count} (1.56) $< F_{table}$ (4.41).

After going through the prerequisite test, namely the normality test and homogeneity test, the data on the students' ability in experimental class and control class were declared normally distributed and have the same or homogeneous variance. Then, it was proceeded with the initial similarity test using the two-tailed t test with the following hypothesis. The results of the comparison test of scientific literacy competencies improvement showed no differences as shown in Table 8.

Table 8. Comparative Test Results of Scientific Literacy Competencies Improvement

Class	Mean	T Stat	t Critical one-tail	Note
Experiment	35.35	0.29	1.68	No Differences
Control	34.7			

Table 8. shows the test results that the t-test statistics produced are 0.29. This means that t_{count} (0.29) $< t_{table}$ (1.68). Thus, it can be stated that increasing the scientific literacy of the competencies of students who learn using the STEM-inquiry learning model is no different from conventional learning. This means that this study has not been able to prove the proposed hypothesis.

The testing criteria mention if thitung above t table then Ho is rejected and Ha is accepted. So that it can be stated that an increase in material understanding of students who learn with the STEM-based inquiry learning model is higher than that of students who learn with conventional learning models as a result of comparative testing of increased understanding of experimental class and control class can be seen in Table 9.

Table 9. Comparative Test Results For Increasing Understanding of Material

Class	Mean	T Stat	t Critical one-tail	Note
Experiment	38.7	3.085	1.68	No Differences
Control	27.75			

Table 9. shows the results of t test statistic is 3,085. This means t_{count} (3.085)$>$ t_{table} (1.68) and there are differences between the experimental class and the control class. From the average value obtained, the average score of experiment class was greater than the control class so that the material understanding improvement of students who learn using the inquiry-STEM learning model was higher than conventional learning.

These following physics questions were to analyze the relationship between work and kinetic energy and the concept of gravitational potential energy on springs in everyday life.

1. Maluku as one of the regions that has thousands of islands with marvelous maritime charm. A sailboat race from Darwin to Ambon is done almost every year to commemorate the birthday of Ambon City. Right at the beginning of August there were two sailboats from Darwin and Belgium conducting trials before the match began. Both boats have m and $2m$ masses, and identical screens, so that the wind gives the same constant force on each boat and it is assumed that the friction force is ignored. If the sailboat moves from the start line to across the finish line as far as s, how big is the kinetic energy of sailboats with mass m and $2m$?.

Some student assumptions include the following.

a. The kinetic energy of iceboats with a mass of m is greater than iceboats with a mass of $2m$.
b. The kinetic energy of iceboats with a mass of $2m$ is greater than the iceboats with mass m.
c. The kinetic energy of iceboats with a mass of m and iceboats with a mass of $2m$ are the same.
d. The kinetic energy of iceboats with a mass of m and iceboats with a mass $2m$ are zero.
e. The kinetic energy of iceboats with a mass m and iceboats with a mass $2m$ are different because the work is different.

"When it reaches the finish line, the two sailboats have the same kinetic energy. This is because they travel the same distance that is as far as s from the start position until reaching the finish line and there is only a horizontal force F in the direction of motion that works in both sailboats. Therefore, the total effort made from start to finish line is the same for each sailboat $W_{tot} = F.s$ *Bearing in mind that the kinetic energy of a particle is*

equal to the total effort made to accelerate particles from a stationary state, it can be concluded that the two sailboats also have the same amount of kinetic energy, because mass doesn't affect the size of an energy".

2. Bian is one of the outstanding students in tennis that represents the region to take part in the competition almost every year. Once in physics subject, Brian was told by the teacher to do an experiment. The activity carried out was to investigate the potential energy of the ball by dropping it on the surface of plasticine from different heights such as the following data.

Ball	Ball Mass (gr)	Height (m)
A	500	3
B	400	5
C	300	7

Based on the results of observations made by Bian, explain which ball that falls into plasticine from the most shallow to the deepest.

Some student assumptions include the following.

a. Ball A > Ball B > Ball C
b. Ball A > Ball B < Ball C
c. Ball A < Ball B < Ball C
d. Ball A < Ball B > Ball C
e. Ball A = Ball B = Ball C

"In this proble, we can use the equation to determine the gravitational potential energy namely Ep = mgh. Based on the data obtained in the table, we can calculate the gravitational potential energy as follows:.

$Ep_A = m_A\ g\ h_A$

$Ep_A = 0{,}5\ (10)\ (3)$

$Ep_A = 15$ joule

"In the same way, EpB = 20 joules and EpC = 21 joules are obtained. Based on these results, the potential energy of the ball C is greater than ball B and ball A. The greater the potential energy, the deeper the fall distance of the ball. This can be represented that the size of the potential energy produced shows the depth of the ball falling into plasticine. The depth of the ball falling into plasticine represents the amount of the gravitational potential energy produced by the ball from each different height: Ball A <Ball B <Ball C".

Based on the results of students' answers to the two existing questions, it was proven that students still had various alternative answers. Students' scientific arguments for work and energy still need to be straightened out, so that students do not have alternative answers that are still far from the correct concept or answer. Thus, a teacher has the main task to direct students with the correct concept in accordance with the scientific view. To direct the correct concept, each teacher must have good knowledge. Good knowledge can be formed by reading various kinds of literature related to physics concepts.

The initial ability of students based on existing data proved that the average students in the experimental class and the control class has the same academic ability. This was evidenced that in the process of admitting new students to class division was determined based on the value or level of entry test results when junior high school students enter "Brawijaya Smart School" High School, so that when conducting research and conducting initial tests the average ability of students is the same. So that it can be said that administratively, Brawijaya High School in class division was adjusted to students' abilities or knowledge.

The inquiry model can improve students 'understanding of concepts, as well as improve students' cognitive learning outcomes [60]-[61]. In addition, inquiry-based learning can improve student learning independence. STEM is able to influence students' literacy skills and understanding physics concepts that can support students' HOTS by integrating knowledge, skills, and problem solving skills in everyday life.

The results of the study proved that there was no difference in the learning outcomes of students' scientific literacy skills between the experimental class and control classes. This was because students have been provided with a lot of knowledge either at school or at home. Conditions in the field proved that "Brawijaya Smart School" High School was one of the good schools in Malang City by providing additional assignments from teachers such as

Olympiad training, extracurricular activities and science courses from home teachers as supporting students knowledge so that it influences students learning at school.

In addition to scientific literacy skills, what needs to be considered is improving the understanding of physics concepts. The research shows that students' concept understanding was higher when learning used the STEM-learning than conventional learning. This was because Inquiry-STEM encouraged students to be able to work independently or in groups in designing, developing and utilizing technology, honing cognitive, psychimotive and affective abilities, and applying knowledge [62]-[63]. Therefore, the application of Inquiry-STEM is used in physics learning. Inquiry-STEM-based learning can train students to construct their knowledge to create designs as a form of problem solving using technology. STEM-based learning has been replicated by several advanced countries including the United States, Hong Kong, Japan, Finland, Australia and Singapore. STEM was initiated by the National Science Foundation. One purpose of implementing STEM in the United States was to make these four fields (science, technology, engineering, and mathematics) the main career choices of students [64]. This happens because the United States has experienced a scientific crisis in the STEM field. Therefore, the seriousness of the United States government to overcome these problems was by establishing and developing STEM Education and providing scholarship assistance to prospective students who choose one of the STEM fields [65]. However, in recent years, STEM has been adopted in various fields, education levels and even in learning. This is indicated by the results of the study stating that with the implementation of STEM students' academic and non-academic achievements increase [66]-[68]. Therefore, in the beginning, learning with STEM only aimed to increase students' interest in the STEM field. However, STEM began to develop and be applied in learning and was able to improve understanding of concepts and apply knowledge aimed at solving problems, and encourage students to create something new original.

With STEM learning applied to the experimental class, students can do one process in good learning, this was evidenced by an increase in students' understanding of concepts because students are trained to conduct scientific investigations and engineering investigations with STEM [69]. Based on the results of the posttest in the research, there was improvement for scientific literacy skills and understanding of physics concepts with a value of 76.6 and 81, 65 for the experimental class and 75.75 and 73.75 for the control class. This further makes it clear that inquiry-STEM learning can enhance the dimensions of scientific literacy and understand concepts of physics. Components of the advantages of STEM are scientific inquiry and the existence of an engineering process [70]. Like scientists, engineers must identify relevant variables, decide how they will measure, and collect data to analyze [69].

CONCLUSION

Conclusions from the results of scientific literacy competency research and understanding of concepts show that, 1) improvement of scientific literacy competencies of students who learn with inquiry- STEM learning was no different compared to students who study with conventional learning. 2) Improvement of concept understanding of students with inquiry- STEM learning was higher than students who study with conventional learning. Thus, inquiry-STEM learning can be recommended in improving scientific literacy skills and understanding students' physics concepts. The implication of this study is to provide valuable information in the development of STEM in Indonesia and to improve education from the basic level of education to higher education in science learning. Research still has limitations in providing information on the process. Therefore, the suggestions in the next study can measure student activity at each meeting by science literacy skills instrument and understanding physics concepts with inquiry-STEM models on other physics topics.

REFERENCES

[1] E. Wiwin, and R. Kustijono, 2018. The use of physics practicum to train science process skills and its effect on scientific attitude of vocational high school students. *IOP Conf. Series: Journal of Physics: Conf. Series*, vol. **997**, pp. 1-9

[2] J. Dunlosky, K. A. Rawson, E. J. Marsh, M. J. Nathan, and D. T. Willingham, 2013. Improving students' learning with effective learning techniques: promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, vol. **14**, pp. 4-58

[3] K, Smit, C. T. de Brabander, and R. L. Martens, 2014. Student-centred and teacher-centred learning environment in pre-vocational secondary education: Psychological needs, and motivation. *Scandinavian Journal of Educational Research*, vol. **58**, pp. 695-712
[4] S. Krishnan, 2015. Student-centered learning in a first year undergraduate course. *International Journal of Learning, Teaching and Educational Research*, vol. **11**, pp. 88-95
[5] Sudarto, and A. Aco, 2018. The syntax of humanist learning science model based gender and optimization of the right brain - the left brain function of the learners with the TIMSS/PISA assessment type. *IOP Conf. Series: Journal of Physics: Conf. Series.* vol. **1028**, pp. 1-6
[6] A.L. Rudolph, B. Lamine, M. Joyce, H. Vignolles, and D. Consiglio, 2014. Introduction of interactive learning into French university physics classrooms. *Physical Review Special Topics - Physics Education Research,* vol. **10**, pp. 1-8
[7] C. M. Verrelli, 2011. Adaptive learning control design for robotic manipulators driven by permanent magnet synchronous motors. *International Journal of Control*, vol. **84**, pp. 1024-1030
[8] M. Hou, and C. Fidopiastis, 2017. A generic framework of intelligent adaptive learning systems: from learning effectiveness to training transfer. *Theoretical Issues In Ergonomics Science*, vol. **18**, pp. 1-17
[9] A. Mavroudi, M. Giannakos, and J. Krogstie, 2018. Supporting adaptive learning pathways through the use of learning analytics: developments, challenges and future opportunities. *Interactive Learning Environments*, vol. **26**, pp. 1-15
[10] A. El Mhouti, A. Nasseh, M. Erradi, and J. M. Vasquez, 2017. Enhancing collaborative learning in Web 2.0-based e-learning systems: A design framework for building collaborative e-learning contents. *Education and Information Technologies*, vol. **22**, pp. 2351-2364.
[11] H, Al-Samarraie, and N. Saeed, 2018. A scoping review of cloud computing tools for collaborative learning: Opportunities and challenges to the blended-learning environment. *Computers & Education*, vol. **124**, pp. 77-91.
[12] L. C. Hodges, 2018. Contemporary Issues in group learning in undergraduate science classrooms: a perspective from student engagement. *CBE-Life Sciences Education*. vol. **17**, pp. 1-10.
[13] P. A Ertmer, and T. J. Newby, 2018. Behaviorism, cognitivism, constructivism: comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, vol. **262**, pp. 43-71
[14] L. J. Fero, J. M. O'Donnell, T. G. Zullo, DeVito, A. Dabbs, J. Kitutu, J. T. Samosky, and L. A. Hoffman, 2010. Critical thinking skills in nursing students: comparison of simulation-based performance with metrics. *Journal of Advanced Nursing*, vol. **66**, pp. 2182-2193
[15] W. Wartono, M. N. Hudha, and J. R. Batlolona, 2018. how are the physics critical thinking skills of the students taught by using inquiry-discovery through empirical and theorethical overview?. *Eurasia Journal of Mathematics, Science and Technology Education*, vol. **14**, pp. 691-697
[16] S. Zubaidah, N. M, Fuad, S. Mahanal, and E. Suarsini, 2017. Improving creative thinking skills of students through differentiated science inquiry integrated with mind map. *Journal of Turkish Science Education*. vol. **14**, pp. 77-91
[17] W. Wartono, M. Diantoro, J. R. Batlolona, 2018. Influence of problem based learning model on student creative thinking on elasticity topics a material. *Jurnal Pendidikan Fisika Indonesia*. vol. **14**, pp. 32-39
[18] J. R. Batlolona, Wartono, and M. Diantoro, 2017. *Model mental dan keterampilan berpikir kreatif fisika siswa melalui model pembelajaran problem based learning (PBL) Pada Materi Elastisitas*. Tesis yang Tidak Dipublikasikan. Pascasarjana, Universitas Negeri Malang
[19] J. Elen, G. Clarebout, R. Le´onard, and J. Lowyck, 2007. Student-centred and teacher-centred learning environments: what students think. *Teaching in Higher Education*, vol. **12**1, pp. 105-117
[20] S. Dole, S. Bloom, and K. Kowalske, K. 2016. Transforming pedagogy: changing perspectives from teacher-centered to learner-centered. *Interdisciplinary Journal of Problem-Based Learning*. **vol**. 10, pp. 1-15
[21] M. Leasa, M. Talakua, and J. R. Batlolona, 2016. The development of a thematic module based on numbered heads together (NHT) cooperative learning model for elementary students in Ambon, Moluccas-Indonesia. *New Educational Review*, vol. **46**, pp. 174-185
[22] M. Leasa, A. D. Corebima, Ibrohim, and Suwono. 2017. Emotional intelligence among auditory, reading, and kinesthetic learning styles of elementary school students in Ambon Indonesia. *International Electronic Journal of Elementary Education*, vol. **10**, pp. 83-92.
[23] A. Alwan, 2011. Misconception of heat and temperature Among physics students. *Procedia Social and Behavioral Sciences*, vol. **12**, pp. 600-614.

[24] L. M. B. Foisy, P. Potvin, M. Riopel, and Masson. 2015. Is inhibition involved in overcoming a common physics misconception in mechanics?. *Trends in Neuroscience and Education.* vol. **4**, pp. 26-36
[25] D. K. Gurel, A. Eryilmaz, and L. C. McDermott, 2016. Identifying pre-service physics teachers' misconceptions and conceptual difficulties about geometrical optics. *European Journal of Physics*, vol. **37**, pp. 1-30
[26] I. A. Halloun, and D. Hestenes, D. 1985a. Common sense concepts about motion. *American Journal of Physics*, vol. **53**, pp. 1056-1065
[27] M. Stein, T. G. Larrabee, and C. R. Barman, 2008. A Study of common beliefs and misconceptions in physical science. *Journal of Elementary Science Education*, vol. **20**, pp. 1-11
[28] T. Nurhudha, D. Rusdiana, and W. Setiawan, 2017. Analyzing students' level of understanding on kinetic theory of gases. *IOP Conf. Series: Journal of Physics: Conf. Series.* **812**, pp. 1-6
[29] Atasoy, S., & Ergin, S. 2017. The effect of concept cartoon-embedded worksheets on grade 9 students' conceptual understanding of Newton's Laws of Motion. *Research in Science & Technological Education,* vol. **35**, pp. 58-73.
[30] S. Bezen, C. Bayrak, and I. Aykutlu, 2016. Physics teachers' views on teaching the concept of energy. *Eurasian Journal of Educational Research*, vol. **64**, pp. 109-124.
[31] T. M. Blas, L. Seidel and A. S. Fernández, 2010. Enhancing Force Concept Inventory diagnostics to identify dominant misconceptions in first-year engineering physics. *European Journal of Engineering Education*, vol. **35**, pp. 597-606.
[32] H. N. B. Salameh, 2017. How persistent are the misconceptions about force and motion held by college students?. *Physics Education*, vol. **52**, pp. 1-7.
[33] S. Foroushani, S. 2018. Misconceptions in engineering thermodynamics: A review. International *Journal of Mechanical Engineering Education*, vol. **0**, pp. 1-15.
[34] A. B. Sarioglan, and H. Kucukozer, 2014. Comparison of high school students' ideas about momentum and impulse conceptions before and after instruction. *Procedia - Social and Behavioral Sciences*. vol. **116**, pp. 3771-3775.
[35] M. Prince, M. Vigeant, and K. Nottis, 2016. Repairing student misconceptions in heat transfer using inquiry-based activities. *Chemical Engineering Education*, vol. **501**, pp. 52-61.
[36] H. Kucukozer, and S. Kocakulah, 2007. Secondary school students' misconceptions about simple electric circuits. *Journal of Turkish Science Education*, vol. **4**, pp. 101-115.
[37] Y. L. Chen, P. R. Pan, Y. T. Sung, and K. E. Chang, 2014. Correcting misconceptions on electronics: effects of a simulation-based learning environment backed by a conceptual change model. *Educational Technology & Society*, vol. **16**, pp. 212-227.
[38] B. Tompo, A. Ahmad, and M. Muris, 2016. The development of discovery-inquiry learning model to reduce the science misconceptions of junior high school students. *International Journal of Environmental & Science Education*. vol. **11**, pp. 5676-5686.
[39] K. J. Crippen, and L. Archambault, 2012. Scaffolded inquiry-based instruction with technology: a signature pedagogy for STEM education. *Computers in the Schools*, vol. **29**, pp. 157-173.
[40] L. S. Nadelson, J. Callahan, P. Pyke, A. Hay, M. Dance, and J. PfiesteR, 2013. Teacher STEM perception and preparation: inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research*. vol. **106**2, pp. 157-168.
[41] S. Psycharis, 2016. The Impact of Computational experiment and formative assessment in inquiry-based teaching and learning approach in stem education. *Journal of Science Education and Technology*, vol. **25**, pp. 316-326.
[42] M. Schmidt, and L. Fulton, 2016. Transforming a Traditional Inquiry-Based Science Unit into a STEM Unit for Elementary Pre-service Teachers: A View from the Trenchess.
[43] D. O. Maxwell, D. T. Lambeth, and J. T. Cox. 2015. Effects of using inquiry-based learning on science achievement for fifth-grade students. *Asia-Pacific Forum on Science Learning and Teaching*. vol. **16**, pp. 1-31.
[44] M. Voet, and B. De Wever, 2017. Preparing pre-service history teachers for organizing inquiry-based learning: The effects of an introductory training program. *Teaching and Teacher Education*, vol. **63**, pp. 206-217.
[45] Yusrizal, A. Halim, and Junike, 2017. The effect of inqury based learning on the procedural knowledge dimension about electric and magnet concept. *Jurnal Pendidikan Fisika Indonesia*, vol. **13**, pp. 88-93.
[46] D. J. Belton, 2016. Teaching process simulation using video-enhanced and discovery/inquiry based learning: Methodology and analysis within a theoretical framework for skill acquisition. *Education For Chemical Engineers*, vol. **17**, pp. 54-64.

[47] Raihani. 2007. Education reforms in Indonesia in the twenty-first century. *International Education Journal*, vol. **81**, pp. 172-183.
[48] N. Suprapto, 2016. What should educational reform in Indonesia look like? - Learning from the PISA science scores of East-Asian countries and Singapore. *Asia-Pacific Forum on Science Learning and Teaching*, vol. **17**, pp. 1-21.
[49] S. Sergis, D. G. Sampson, M. J. R. Triana, D. Gillet, L. Pelliccione, and T. de Jong, 2017. Using educational data from teaching and learning to inform teachers' reflective educational design in inquiry-based STEM education. *Computers in Human Behavior*, vol. **30**, pp. 1-15.
[50] American Association for the advancement of Science AAAS, 1993. *Benchmarks for science literacy*. New York: Oxford University Press.
[51] National Research Council, 1996. *National science educational standards.* Washington, DC: National Academy Press.
[52] National Research Council, 2000. *Inquiry and the national science educational standards*. Washington, DC: National Academy Press.
[53] Z. Fang, and Y. Wei, 2010. Improving middle school students' science literacy through reading infusion. *The Journal of Educational Research*. vol. **103**, pp. 262-273.
[54] H. Turgut, 2007. Scientific literacy for all. *Journal of Faculty of Educational Sciences*. vol .**40**, pp. 233-256.
[55] K. Jurecki, M. C. V. Wander, 2012. Science literacy, critical thinking, and scientific literature: guidelines for evaluating scientific literature in the classroom. *Journal of Geoscience Education*. vol. **60**, pp. 100-105.
[56] M. Genc, 2015. The effect of scientific studies on students' scientific literacy and attitude. *OMU Journal Fac. Educ*. vol. **34**, pp. 141-152.
[57] A. Dahtiar, Pembelajaran levels of inquiry untuk meningkatkan literasi sains siswa SMP pada konteks energi alternatif. Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains 2015: 197-200. Bandung: Institut Teknologi Bandung.
[58] N. Demirci, 2005. A study about students' misconceptions in force and motion concepts by incorporating a web-assisted physics program. *Turkish Online Journal of Educational Technology*, vol. **4**, pp. 40-48.
[59] A. Rahhou, F. Kaddari, A. Elachqar, and A. Oudrhiri, 2015. The role of the history of science in the understanding of the concept of light. *Procedia - Social and Behavioral Sciences*. vol. **191**, pp. 2593-2597.
[60] P. Lestasri, S. Wardani, and Susilogati, 2018. Influence of guided inquiry model on students cognitive learning outcome in stoichiometry topic. *Journal of Innovative Science Education*, vol. 7, pp. 130-135.
[61] W. Wartono, A. Suyudi, and J. R. Batlolona, 2018. Students' problem solving skills of physics on the gas kinetic theory material. *Journal of Education and Learning* (EduLearn), vol. **12**, pp. 319-324.
[62] V. Kapila, and M. Iskander, 2014. Lessons learned from conducting a K12 project to revitalize achievement by using instrumentation in Science Education. *Journal of STEM Education*, vol. **15**, pp. 46-51.
[63] A. Samarapungavan, L. Bryan, and J. Wills, 2017. Second graders' emerging particle models of matter in the context of learning through model-based inquiry. *Journal of Research in Science Teaching*, vol. **548**, pp. 1-36.
[64] S. Han, R. Capraro, and M. M. Capraro, 2014. how science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education*, vol. **13**, pp. 1-25.
[65] L. C. Jones, J. R. Tyrer, and N. P. Zanker, 2013. Applying laser cutting techniques through horology for teaching effective STEM in design and technology. *Design and Technology Education*, vol. **18**, pp. 21-34.
[66] P. Lam, D. Doverspike, J. Zhao, J. Zhe, ad C. Menzemer, 2008. An evaluation of a STEM program for middle school students on learning disability related IEPs. *Journal of STEM Education*, vol. **9**, pp. 21-29.
[67] S. J. Lou, Y. H. iu, and R. C. Shih, 2011. The senior high school students' learning behavioral model of STEM in PBL. *International Journal of Technology and Design Education*, vol. **21**, pp. 161-183.
[68] D. Reynolds, N, Yazdani, and T. Manzur, 2013. STEM high school teaching enhancement through collaborative engineering research on extreme winds. Journal of STEAM Education. vol. **14**, pp. 12-19.
[69] R. W. Bybee, 2011. *Scientific and Engineering Practices in K-12 Classrooms: Understanding A Framework for K-12 Science Education*, NSTA press; Arlington, Virginia.
[70] T. Torlakson, T. 2014. *INNOVATE: ABlueprint for Science, Technology, Engineering, and Mathematics in California Public Education*. California. California Departement of Education.

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