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THE DEVELOPMENT OF STEM (SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS) BASED INQUIRY LEARNING PACKAGES TO TRAIN STUDENTS' CRITICAL THINKING SKILL

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Abstract

This study aimed to develop STEM based inquiry learning packages on simple machines topics to train students' critical thinking skill. The type of study is Research and Development (R&D) with 4D development model, which consists of defining, designing, developing and disseminating. Learning packages included syllabus, lesson plans, worksheets, handouts and tests of students' critical thinking skill. The research subjects were 28 students of grade VIII in State Junior High School 1 Pamekasan who were obtained by purposive sampling technique. This research based on validity and practicy. Data were collected using validation sheets, teacher activity observation sheets and student activity observation sheets. The validity data was obtained based on the results of the mode assessment done by 3 validators by validation sheet. Descriptive data were analyzed quantitatively. The results of the 3 validators' assessment obtained 4 for mode value which was very valid, and the average of reliability Cronbach's Alpha was 0,848 in the reliable category. The result of implementation learning is 92% and student activity is 88% with very good category. This showed that the development of STEM based inquiry learning packages was categorized as valid and reliable for use based validity and practicy.

Keywords: *learning packages, STEM based inquiry, critical thinking skills*

Abstrak

Penelitian ini bertujuan untuk menghasilkan perangkat pembelajaran inquiry berbasis STEM pada materi pesawat sederhana untuk melatihkan kemampuan berpikir kritis siswa. Jenis penelitian R&D dengan model pengembangan 4D yang terdiri dari mendefinisikan, merancang, mengembangkan dan menyebarluaskan. Perangkat pembelajaran meliputi silabus, RPP, LKS, handout dan tes kemampuan berpikir kritis siswa. Subjek penelitian adalah 28 siswa kelas VIII SMPN 1 Pamekasan yang diperoleh dengan teknik pengambilan sample purposive sampling. Penelitian dilakukan berdasarkan aspek validitas dan kepraktisan. Data validitas diperoleh berdasarkan hasil penilaian modus oleh 3 validator melalui lembar validasi. Data kepraktisan diperoleh berdasarkan hasil penilaian pengamat melalui lembar keterlaksanaan pembelajaran dan lembar aktivitas siswa. Data deskriptif dianalisis secara kuantitatif. Hasil penilaian 3 validator memperoleh nilai modus 4 dengan kategori sangat valid, serta nilai rata-rata reliabelitas 0,848 dengan kategori reliabel. Hasil penilaian pengamat menunjukkan rata-rata keterlaksanaan pembelajaran memperoleh nilai 92% dan rata-rata aktivitas siswa memperoleh nilai 88% dengan kategori sangat baik. Hal ini menunjukkan bahwa pengembangan perangkat pembelajaran inquiry berbasis STEM dikategorikan layak untuk digunakan berdasarkan aspek validitas dan kepraktisan.

Kata Kunci: Perangkat pembelajaran, inkuiri berbasis STEM, keterampilan berpikir kritis

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INTRODUCTION

Learning STEM (Science, Technology, Engineering and Mathematics) is related to the development of learning in promoting 21st century skills (Hernandez et al, 2014). The 21st century skills such as adaptability, communication, problem solving, critical thinking, collaboration, and self regulation (LaForce et al, 2016). Life in the 21st century has ushered the world in an era of technological requirements (Silin & David, 2017). All forms of life in the world are influenced by technology, as well as education in Indonesia. Education is required to be able to increase skilled, capable and insightful Human Resources in dealing with various problems around it (Vidergor & Gottlieb, 2015). The problems of life in the 21st century require the ability of professionalism to overcome them (Thibaut et al, 2018). The ability of professionalism does not only involve scientific or mathematical aspects, but also technological and technical aspects to overcome these problems (Ostler, 2012).

STEM integrates several disciplines such as science and technology, science and engineering, science and mathematics or science and three aspecs (Sanders et al, 2011). Brown, et al, (2011) stated that STEM learning is a scientific methodology where the teacher teaches every concept in the aspects of science, technology, engineering and mathematics in an integrated manner, not separately. Activity learning engaged student with integrated concept of STEM as authentic learning (Holmlund et al, 2018). It is aimed to learning STEM literacy (Ciolan & Ciolan, 2014). Learning STEM refers to students as a form of knowledge inquiry and engage in interdisciplinary science that is constructive (Kennedy & Odell, 2014). Inquiry was paradigm shift signal from teacher centered to student centered learning (Ramnarain & Mupira, 2018). Inquiry prepares students to think and to act on the submissions questions, hypotheses and investigations to find the concepts they have learned in an effort to solve an issue in real life (Borich & Ong, 2006).

The fundamental problem in STEM learning is interdisciplinary learning ability. In STEM learning, students learn not only aspects of science and mathematics as happened in Indonesia, but also aspects of technology and engineering. Students in general still face difficulties on scientific concepts and even misconceptions (Erman, 2017). Students will find it difficult to think critically if students still have difficulty in understanding science concepts. The 5M inquiry study applied in Indonesia has difficulty on implementing scientific thinking (Erman et al, 2018). Besides, scientific thinking aims to foster thinking skill in achieving life skill such as critical thinking (Viorel & Viorel, 2015).

One of the things that need to be considered in developing the critical thinking skills of students on 21 century integrated with the education process management (Tunkham et al, 2016). Learning is directed in order to construct knowledge by utilizing various resources and formulating their own questions. Learning science approach Science, Technology, Enginering, Mathematics (STEM) is an effort for students to find innovative solutions to the problems faced consisting of 4C namely creativity, critical thinking, collaboration and communication (Beers, 2011). STEM not only as approachlearning, STEM be necessity for repair learning quility (Sujeewa et al., 2017). STEM provides opportunities for students to be actively involved in learning by applying concepts and knowledge to solve surrounding problems (Baharin et al, 2018). Gnagey (2016) stated that STEM can increase student's achievement learning. STEM has a significant positive effect on student learning outcomes (Becker & Kyungsuk, 2011).

STEM learning develops students' abilities through inquiry, collaboration and the use of technology (Maulucci et al., 2014). STEM based inquiry learning packages is based on inquiry activities with the STEM approach. Learning activities are packaged in order to develop students' critical thinking skill. Learning which applied inquiry could improve critical thinking skill (Khusniati, 2012). Students who think critically are expected to be able to understand and to provide solutions for surrounding problems with rapidly developing technology (Pradana et al., 2020). Students are accustomed to solve problems, with ideas and thinking in context to improve students' critical thinking skill. Through STEM based inquiry learning packages,

science learning can accommodate students actively in building their own concepts by interacting with their environment to improve their critical thinking skill.

In this study, we integrated 5M inquiry learning with STEM aspects in simple machine material to improve students' critical thinking skills. The simple machine material was chosen because the technology products offered were easy for students to find in their surroundings. Through the development of learning packages STEM based inquiry, students will learn and explain the concept of a simple machine before discussing the interdisciplinary materials, which describe aspects of science, technology, engineering, and mathematics in technology products excavator. The development of learning packages STEM based inquiry as well as solutions that STEM can be integrated into the inquiry 5M already familiar with teachers in general and do not need to be done separately to train and improve students' critical thinking skills.

RESEARCH METHOD

The type of study is Research and Development (R&D). Model of development learning packages is model 4D which consists of four stages, there are defining, designing, developing and disseminating (Ibrahim & Wahyusukartiningsih, 2014). Developed learning packages consists a syllabus, lesson plan, worksheet, handout and critical thinking test. This research tested at students of class VIII B SMPN 1 Pamekasan who were obtained by purposive sampling technique.

The methods in this research consits of validation and observation. The instrumen used consists of the validation sheet, the implementation of learning sheet and the student activity sheet. The results of the learning packages validation assessment were analyzed by means of quantitative descriptions by looking for the mode value of each component obtained from three the validator. The interpretation of the learning packages validation assessment score based in Table 1.

Table 1. Interpretation of Learning Package Assessment Scores

Score Mode	Category	Information
4	Very valid	Can be used without revision
3	Valid	Can be used with minor revisions
2	Less valid	Can be used with multiple revisions
1	Invalid	Not yet usable and requires consultation

(Modified Ratumanan & Laurens, 2011)

The reliability was calculated by using the Cronbach's Alpha test of SPSS. If the value of Cronbach's Alpha is 0.60 and less than 1, then the instrument was reliable (Basuki & Hariyanto, 2014). The results of the learning packages practicion assessment were analyzed by means of quantitative descriptions by looking for the average value of each component obtained from two observers. The interpretation of the learning packages practicion are: 1) the value less than 26 is less category; 2) the value is 26 and less than 51 is moderate category; 3) the value is 51 and less than 76 is good category; 4) the value is 76 and less than equals 100 is very good category.

RESULTS AND DISCUSSION

Validity of Packages Learning

The result of the validation stated that the development of the packages including the syllabus, lesson plans, worksheets, handouts and tests of students' critical thinking skill was feasible in terms of validity. The results of the validity of the syllabus can be shown in Table 2. Based on Table 2. The average syllabus validation results in each aspect of validation had very valid criteria. The value of reliability Cronbach's Alpha was 0,770 which showed that syllabus being reliable to use. These results indicated that the syllabus developed was generally in the feasible category for use in learning after going through the revision stage according to suggestions from the validator. The revision included adjusting learning indicators with indicators of critical thinking.

Table 2. Recapitulation of Syllabus Validation Results by Validators

	Aspects that are validated	Score Mode	Criteria
1	Formulation of Competency Achievement Indicators and Integration of STEM Aspects	4	Very Valid
2	Formulation of Learning Activities	4	Very Valid
3	Assessment	3	Valid
4	Time	4	Very Valid
5	Learning Resources	4	Very Valid
6	Language	3	Valid

The syllabus that has been developed has met the principles of syllabus preparation including identity (subject, class, semester, time), basic competency indicators of learning outcomes for learning activities, packages or resources, assessment (form or technique) (Kurniawan, 2014). In the syllabus, the 5M inquiry learning activity was integrated with the STEM aspects in developing students' critical thinking skills. In line with the opinion of Erman et al (2020), stated that many inquiry activities in Indonesia are carried out with 5M activities. At the stage of observing, students observed several examples of the lever type including excavator. At the questioning stage, students asked about the type, working principle of the lever, mechanical advantages and the role of the lever on the excavator in everyday life. At the information seeking stage, students searched for various information through the learning resources provided, other references and even the internet about the questions asked. At the information processing stage, students processed the information obtained to solve problems in everyday life about levers including excavators. At the stage of communicating the students presented the results of the discussion about the levers including the excavator.

Lesson plan STEM based inquiry on simple plan material was developed to enhance the critical thinking skills of students. The results of lesson plan validation are presented in Table 3 below this:

Table 3. Recapitulation of Lesson Plan Validation Results by the validator

	Aspects that are validated	Score Mode	Criteria
1	Formulation of Competency Achievement Indicators	4	Very Valid
2	Selection and Organizing of Teaching Materials	4	Very Valid
3	Time	3	Valid
4	Learning Activities	4	Very Valid
5	Assessment	3	Valid
6	Language	4	Very Valid

Data in Table 3 shows that the average result of lesson plan validation was categorized as very valid. The value of reliability Cronbach's Alpha was 0,941 which showed that lesson plan being reliable to use. These results indicated that the lesson plans developed were generally in the feasible category for use in learning after going through the review stage according to the suggestions of the validator. STEM based inquiry lesson plan is prepared by filling in the identity column, determining the allocation of face to face time 4 times, determining basic competition, and formulating learning indicators based on STEM aspects, formulating learning indicator objectives, identifying lever teaching materials integrated with STEM aspects and will be discussed on learning. Lever is not only taught in the scientific aspect, but its integrated into the STEM aspect in developing students' critical thinking skills. The lever is taught more in real life on the high tech packages students can find around them (excavators). This is in line with the opinion of Ghaemi & Mirsaeed (2017) that engagement in real contexts can be encouraged

by inquiry learning. The insertion of technology in the inquiry learning activity will help students in the thought process to seek and find a concept they are learning (Borich & Ong, 2006). STEM based inquiry was create meaningful science learning process, student was active in thinking, behavior and attitude (Drake, 2014). Furthermore, determining the learning approach, model and method, determining learning steps based on the 5M inquiry stage which consists of initial, core and final activities and determining learning resources that can be explored through the handouts provided, the internet, and even excavator experts. Lesson plan also compiles an assessment in the form of techniques and assessment criteria.

The validated student worksheets consist of worksheet 1 on types of levers, worksheet 2 on working principles and mechanical advantages of levers and worksheet 3 on working principles and mechanical advantages of excavators. Validated worksheets are prepared to improve students' critical thinking skills. The results of the worksheet validation are presented in Table 4.

Table 4. Recapitulation of Worksheet Validation Results by Validators

	Aspects that are validated	Score Mode	Criteria
1	Clarity of instructions	3	Valid
2	Alignment and involvement of content with the inquiry activity and STEM aspects	4	Very Valid
3	Develop students' critical thinking skills	4	Very Valid
4	The sequence of activities is according to STEM -based inquiry	3	Valid
5	Suitability of questions with learning objectives and support the concept	4	Very Valid

The data in Table 4 shows the average results validity worksheet aspects were validated get the criteria very valid. The value of reliability Cronbach's Alpha was 0,828 which showed that worksheet being reliable to use. These results indicate that the worksheets developed are generally in the feasible category for use in learning after going through the revision stage according to suggestions from the validator. The revision includes the addition of learning indicators in each worksheet, references and table names to each table in the worksheet.

STEM based inquiry worksheets contained students' guides for conducting STEM based inquiry learning activities on the subject of levers. Worksheet was prepared for each 5M stage with several activities to develop critical thinking skill. This was in accordance with the opinion Tomkin et al, (2019) that STEM is emphasized in shaping students' cognitive abilities to be able to think critically well. Astuti & Setiawan (2013) stated that questions in worksheet aimed to make students work optimally in group. Critical thinking indicators including basic clarification, decision, inference, advanced clarification and supposition and integration were included in some of the worksheet provided. Worksheet 1 regarded with the concept of levers and types of levers, there were students' activities with critical thinking indicators of basic clarification and advanced clarification. Worksheet 2 regarded with the work principle and the mechanical advantages of levers, there were students' activities with basic clarification, decision, inference, and supposition and integration indicators. Worksheet 3 regarded with the working principle and mechanical advantages of the lever on the excavator, there were student activities with indicators of basic clarification, inference, advanced clarification and supposition and integration. Vygotsky's theory states that learning with social interaction, namely the interaction of individuals with other people, is the most important factor that can encourage or trigger a person's cognitive development where critical thinking skill will be well formed by interaction in groups (Lee et al., 2015). This was consistent with the STEM based inquiry learning activities carried out in groups.

Validated handouts were teaching materials related to simple machine materials. The results of handout validation are presented in Table 5.

Table 5. Recapitulation of Handout Validation Results by Validators

	Aspects that are validated	Score Mode	Criteria
1	Suitability of material with indicators	4	Very Valid
2	The suitability of writing with the concept	4	Very Valid
3	Clarity of writing sentences	4	Very Valid

Data in Table 5 showed the average results of the validation handout on aspects that were validated got very valid criteria. The value of reliability Cronbach's Alpha was 0,750 which showed that handout being reliable to use. These results indicated that the handouts developed were generally in the feasible category for use in learning after going through the revision stage according to suggestions from the validator. The revision included adding references, examples of applying Mathematics and Engineering and clarifying every aspect of STEM.

Handout included simple machine learning materials (levers) which would be studied through STEM based inquiry. Handouts were prepared to integrate concepts in the aspects of science, technology, engineering and mathematics in one lever subject. Handouts were based on concepts to be taught with STEM aspects. This was in accordance with the opinion of Reeve (2013) that STEM learning integrates the fields of science, technology, engineering and mathematics which are used as guidelines in preparing generations who are able to create innovative solutions to real problems in the surronding environment. Prastowo (2015) that is packaged teaching materials for students to find referrals that are structured to grasp the material provided. These are display sample of handout STEM based inquiry:

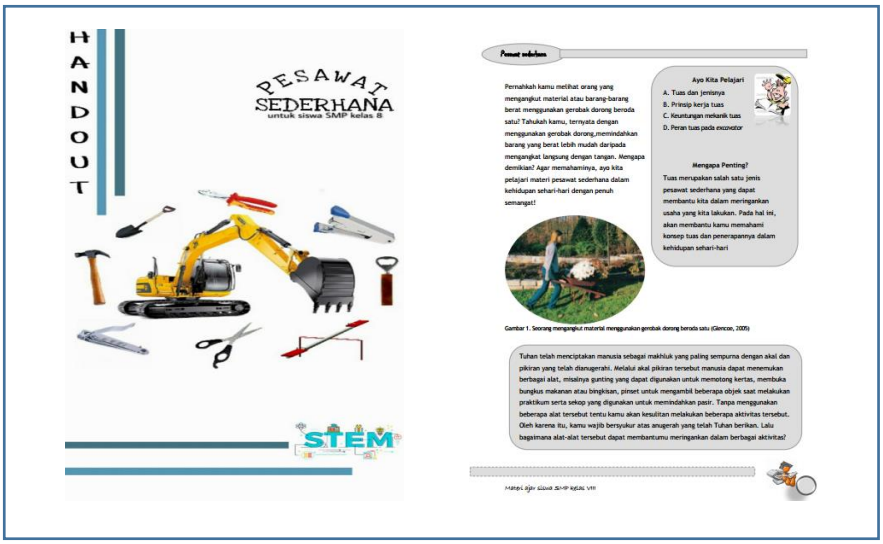

Figure 1. Sample of handout STEM based inquiry "simple machine" materials

The question is a learning package in the form of a learning outcome test that is used to determine the ability of student absorption which is described by the completeness of learning outcomes on the indicators developed. The indicator of critical thinking used (Ennis, 1993) The questions can find out how far the students have reached the expected goals. According to the opinion Trianto (2015) the learning outcome test is an item used to determine student learning outcomes after participating in teaching and learning activities. According to Ratumanan (2011) the basic principles of learning outcome tests must contain items that are suitable and appropriate to the purpose of their use and must be reliable and interpreted carefully. The results of the question validation are presented in Table 6.

Table 6. Recapitulation of Question Validation Results by Validators

	Aspects that are validated	Score Mode	Criteria
1	Suitability of indicators with material	4	Very Valid
2	Clarity, accuracy and appropriateness of writing questions	4	Very Valid
3	Writing communicative sentences and not causing multiple interpretations	4	Very Valid

Table 6 showed the average validity results of the critical thinking skills test on the validated aspects got very valid criteria. The value of reliability Cronbach's Alpha was 0,952 which showed that the critical thinking skills test being reliable to use. These results indicated that the questions developed were generally in the feasible category for use in learning after going through the revision stage according to suggestions from the validator. The revision included adjusting the realm of the questions with learning indicators, and item legibility.

The test was developed with critical thinking questions. The critical thinking test was arranged in the form of a multiple choice test accompanied by arguments. There were 12 critical thinking test items developed, including 3 basic clarification items, 2 decision items, 2 inference items, 3 advanced clarification items and 2 supposition and integration questions. Based on data from the results of validation by 3 experts, the validity of the syllabus, lesson plans, student worksheets, handouts, and questions of critical thinking skill developed were very valid.

Practicy of Packages Learning

Implementation of Learning Process

The result of the implementation of learning using STEM based inquiry at meeting I, II, III and IV showed below (Figure 2):

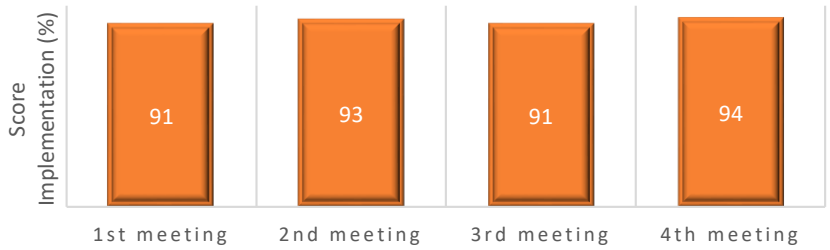

Figure 2. Implementation of Learning

Based on Figure 2 knowable implementation of learning in VIII B have a very good category. STEM based inquiry is a group learning consisting of a series of activities which packaged so that students can carry out the learning competencies. Students are expected to be able integrate knowledge, skills and values in science learning through inquiry learning in a real context. These learning accordance with the paradigm of constructivism theory where students acquire their own knowledge by being directly involved in the learning process (student centered). The learning process makes students active with the teacher as a facilitator.

In science learning with STEM based inquiry, students were taught simple machine material (lever) which taught not only in the scientific aspect. Learning were carried out by integrating 4 aspects of learning including science, technology, engineering and mathematics. Therefore, science learning was not only concerned with students' mastery of these facts, concepts and theories. In science learning, students carry out of 5M activities as a means of discovering their concepts. In line with the learning theory of Jean Piaget, students of class VIII SMP were at the formal operational stage Slavin (2011). At these stage, there was a transition

from the use of concrete operations to formal operations in reasoning. Students were directed to think towards the formal operational stage through the concrete operational stage as an introduction.

In the preliminary activity, students were asked questions related to concepts that have been obtained and given pictures related to the concepts to be studied as motivation. Students were involved in the stages of observing, asking questions, gathering information, processing information and communicating which they have done in their learning activities. In accordance with Jean Piaget's learning theory where students use concrete objects (observing, gathering information) as a means of concept discovery to solve problems as a result of concept findings.

STEM refers to students as a form of inquiry knowledge and involved in a constructive interdisciplinary science. STEM was integrated in science learning for triggering student's interest in learning and student's achievement (Gnagey, 2016). Learning activities are accommodated to students actively acquire their own knowledge through interaction with their groups. This is in line with the learning principle put forward by Vygotsky that students are in the ZPD (Zone of Proximal Development). In this zone students can solve problems faced with support from the others.

Student Activity

The result of student activity using STEM based inquiry at meeting I, II, III and IV showed in Figure 3.

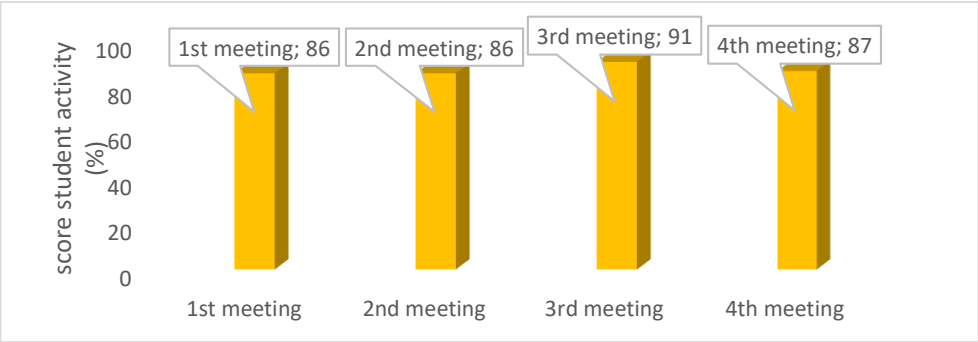

Figure 3. Student Activity

Based on Figure 3 knowable student activity in VIII B have a very good category. Activities in STEM based inquiry learning were able to train students' critical thinking skills well. These was in line with the opinion of Borich et al. (2006) that inquiry learning orientation concerns students' ability to solve a problem so that it focuses on students' critical thinking and on developing students' intellectual abilities. Students were trained and accustomed to critical thinking in learning process. Based on Bruner's theory, students were given the opportunity to find a concept during learning. In line with Ramnarain & Mupira (2018) opinion, that inquiry is a student centered learning paradigm. In the learning activities, students do not only learn the science and mathematics aspects of the lever material. Students learn the technological and engineering aspects that are learned from the role of levers in excavators. This is consistent with the statement of LaForce et al. (2016) that STEM involves various learning fields that emphasize the concept of learning with authentic contexts and students' experiences using science, technology, engineering and mathematics.

CONCLUSION

Based on the results of the study, it can be concluded that the development of STEM based inquiry learning packages on simple machine material was categorized as very valid and reliable so that it was feasible and reliable for use in learning. The implementation of learning have 92% score with very good category and student activity have 88% score with very good

category. The implication of this research is the learning packages of STEM based inquiry learning on simple machine material for train students' critical thinking skills in junior high school from the aspect of validity and practicy. Even though, the learning packages necessary to implementation in classes to verivy from the aspect of effectivity to improve students' critical thinking skills. Further research can be carried out for other lesson in science, moreover to levels of education.

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REFERENCES

Astuti, Y & Setiawan, B. (2013). Pengembangan Lembar Kerja Siswa (LKS) berbasis pendekatan inkuiri terbimbing dalam pembelajaran kooperatif pada materi kalor. *Jurnal Pendidikan IPA Indonesia*, **2**(1), 88-92.

Baharin, N., Kamarudin, N., & Manaf, U.K.A. (2018). Integrating STEM education approach in enhancing higher order thinking skills. *International Journal of Academic Research in Business and Social Sciences*, **8**(7), 810-821.

Basuki, I & Hariyanto. (2014). *Asesemen pembelajaran*. Bandung: PT. Remaja Rosdakarya.

Becker, K & Kyungsuk, P. (2011). Effects of integrative approaches among Science, Technology, Engineering, and Mathematics (STEM) subjects on students' learning, a preliminary meta analysis. *Journal of STEM Education, Innovations & Research*, **12**(6), 23-37.

Beers, S. (2011). *21st century skills: Preparing students for their future*. Retrieved from: https://cosee.umaine.edu/files/coseeos/21st_century_skills.pdf.

Borich, G.D & Ong, A. (2006). *Teaching strategies that promote thinking models and curriculum approaches*. Singapore: The McGraw-Hill Companies, Inc.

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM current perceptions. *Technology & Engineering Teacher*, **70**(6), 5-9.

Ciolan, L & Ciolan, L.E. (2014). Two perspectives, same reality? How authentic is learning for students and for their teachers. *Procedia - Social and Behavioral Sciences*, 142, 24-28.

Drake, J.R. (2012). A critical analysis of active learning and an alternative pedagogical framework for introductory information systems courses. *Journal of Information Technology Education*, **11**(1), 39-52.

Ennis, R.H. (1993). Critical thinking assessment. *Theory into Practice*, **32**(3), 179-186.

Erman, E. (2017). Factors contributing to students' misconception in learning covalent bonds. *Journal of Research in Science Teaching*, **54**(4), 520-537.

Erman, Wasis, Susantini, E., & Azizah, U. (2018). Scientific thinking skills: Why junior high school science teachers cannot use discovery and inquiry models in classroom. *International Conference on Science and Technology*, **1**(1), 201-204.

Erman, E., Liliasari, L., Ramdani, M., & Wachidah, N. (2020). Addressing macroscopic issues: helping student form associations between biochemistry and sports and aiding their scientific literacy. *International Journal of Science and Mathematics,* **18**(5), 831–853.

Ghaemi, F & Mirsaeed, S.J.G. (2017). The impact of inquiry-based learning approach on critical thinking skill of EFL students. *EFL Journal*, **2**(2), 89-102.

Gnagey, J. (2016). The impact of inclusive STEM high schools on student achievement. *AERA*, **2**(2), 1–21.

Hernandez, P.R. et al. (2014). Connecting the STEM dots, measuring the effect of an integrated engineering design intervention. *International Journal of Technology and Design Education*, **24**(1), 107-120.

Holmlund, T.D., Lesseig, K., & Slavit, D. (2018). Making sense of "STEM Education" in K-12 contexts. *International Journal of STEM Education,* **5**(32), 1-12.

Ibrahim, M & Wahyusukartiningsih. (2014). *Model pembelajaran inovatif melalui pemaknaan*. Surabaya: Unesa University Press.

Kennedy, T.J & Odell, M.R.L. (2014). Engaging students in STEM education. *Science Education International*, **25**(3), 246-258.

Khusniati, M. (2012). Pendidikan karakter melalui pembelajaran IPA. *Jurnal Pendidikan IPA Indonesia*, **1**(2), 204-210.

Kurniawan, D. (2014). *Pembelajaran terpadu tematik (teori, praktik dan penilaian).* Bandung: Alfabeta.

LaForce, M. et al. (2016). The eight essential elements of inclusive STEM high schools. *International Journal of STEM Education*, **3**(21), 1-11.

Lee, D., Huh, D., & Reigeluth, C. M. (2015). Collaboration, intra group conflict, and social skills in project-based learning. *International Journal of the Learning Sciences*, **43**(5), 561-590.

Maulucci, M.S.R., Brown, B.A., Grey, S.T., & Sullivan, S. (2014). Urban middle school students' reflections on authentic science inquiry. *Journal of Research in Science Teaching*, **51**(9), 1119-1149.

Ostler, E. (2012). 21st century STEM education: A tactical model for long-range success. *International Journal of Allied Science and Technology*, **2**(1), 28-33.

Pradana, D., Nur, M., & Suprapto, N. (2020). Improving critical thinking skill of junior high school students through science process skills based learning. *Jurnal Penelitian Pendidikan IPA*, **6**(2), 166-172.

Prastowo, A. (2015). *Panduan kreatif membuat bahan ajar inovatif.* Yogyakarta: Diva Press Yoga.

Ramnarain, U & Mupira, P. (2018). The effect of inquiry based learning on the achievement goal-orientation of grade 10 physical sciences learnes at township schools in south Africa. *Journal of Research in Science Teaching*, **55**(6), 810-825.

Ratumanan, G.T & Laurens. (2011). *Evaluasi hasil belajar pada tingkat satuan pendidikan*. Surabaya: UNESA University Press.

Reeve, J. (2013). How students create motivationally supportive learning environments for themselves: The concept of agentic engagement. *Journal of Educational Psychology*, **105**(3), 579-595.

Sanders, M., Hyuksoo, K., Kyungsuk, P., & Hyonyong, L. (2011). *Integrative STEM (science, technology, engineering, and mathematics) education*: contemporary trends and issues. *Secondary Education*, **59**(3), 729-762.

Silin, Y & David, K. (2017). A study of students' attitudes towards using ICT in a social constructivist environment'. *Australasian Journal of Educational Technology*, **33**(5), 50–62.

Slavin, R.E. (2011). *Psikologi pendidikan teori dan praktik jilid 1*. Jakarta: PT. Indeks.

Sujeewa, A., Polgampala, V., Shen, H., & Huang F. (2017). STEM teacher education and professional development and training: Challenges and trends american. *Journal of Applied Psychology,* **6**(5), 93-97.

Thibaut, L., Stijn, C., & Haydee, D.L. (2018). Integrated STEM education: A systematic review of instructional practices in secondary education. *European Journal of STEM Education*, **3**(1), 1-12.

Tomkin J.H., Beilstein S.O., Morphew J.W., & Herman G.L. (2019). Evidence that communities of practice are associated with active learning in large STEM lectures. *International Journal of STEM Education,* **6**(1), 1-15.

Tunkham P., Donpudsa, S., & Dornbundit, P. (2016). Development of STEM activities in chemistry on "protein" to enhance 21st century learning skills for senior high school students. *Journal of Social Sciences, Humanities, and Arts,* **15**(3), 217-234.

Trianto. (2015). *Model pembelajaran terpadu dalam teori dan praktik.* Jakarta: Prestasi Pustaka.

Vidergor, H.E & Gottlieb, M. (2015). High order thinking, problem based and project based learning in blended learning environments. *In Applied Practice for Educators of Gifted and Able Learners*, 217–232.

Viorel, D & Viorel, M. (2015). Scientific literacy in school. *Journal of Social and Behavioral Sciences*, **209**(1), 167-172.