24 (4), 2023, 944-957

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

The Development of STEM-based Physics e-Workbook with Project-based Learning Activities

Ria Rahma Nida*, Eveline Siregar & Uwes Anis Chaeruman

Department of Educational Technology, Universitas Negeri Jakarta, Indonesia

Abstract: The Development of STEM-based Physics e-Workbook with Project-based Learning Activities. Objective: There are various media that are effective in helping students understand learning material at school but teachers have not used them optimally. This study aims to develop digital workbooks with a feasible and effective project-based learning approach in physics subjects. **Methods:** This development uses the ADDIE model which consists of analysis, design, development, implementation, and evaluation. The product feasibility test was carried out through the assessment of media experts, material experts, and was tested on class VII students at SMPN 1 Bandar Lampung. **Findings:** The results of the effectiveness test were obtained through the pretest and posttest. The results of the due diligence by material experts and media experts obtained a proportion of reporting rates of 85.71% and 95.45% so that digital workbooks fall into the category of appropriate use. The one-to-one trial shows that digital workbooks are in the very good category with an average proportion of sales rate of 91.66%. In addition, the small group trial also showed an average proportion of the reporting rate of 89.74%, so it was included in the very good category. The results of the effectiveness test by calculating the n-gain score obtained a result of 60.8 so that the digital workbook can be said to be quite effective. **Conclusion:** Based on these results, it can be interpreted that STEM-based digital Physics workbooks with a project-based learning approach for junior high school students are appropriate and effective for use.

Keywords: ADDIE, digital workbook, project-based learning, STEM

▪ INTRODUCTION

Stimulating student knowledge can be optimized through learning resources and learning media. There are various media that are effective in helping students understand the concepts of physics material in junior high school, one of which is a workbook or a collection of a number of student worksheets (Putra et al., 2019). Various developments have been carried out regarding workbooks (Adora, 2019; Benitez, 2020; Darman et al., 2017; Haloho & Pasaribu, nd; Maruyama & Kurosaki, 2021; Nainggolan, 2020; Rogayan Jr. & Dollete, 2019) and sheets work (Barniol & Zavala, 2016; Cabrera & Navarro, 2021; Ningrum et al., 2019; Sinuraya et al., 2019; Wulantri et al., 2020; Yanto, 2019). Based on the development carried out by (Nurzaman et al., 2021), there was a significant increase in students' high-level thinking abilities who used worksheets. (Romli et al., 2018) in its development stated that students need innovative learning resources in the form of open-ended based worksheets which can provide opportunities for students to develop various solutions related to physics problems so that students' creative thinking abilities can be improved. Several variables were observed in previous developments such as communication and collaboration abilities (PM Sari et al., 2021), high-level thinking abilities (Nurzaman et al., 2021; Putra et al., 2019; YS Sari et al., 2019), creative thinking abilities (Asrori, 2020; Romli et al., 2018), representation abilities (Nuha et al., 2021), scientific process skills (Algiranto et al., 2019), science process skills (Limatahu et al., 2018; Nugraha et al., 2018), and so on. In fact, in studying material, students also need

Ria Rahma Nida
*Email: ndrhmrie@gmail.com

DOI: http://dx.doi.org/10.23960/jpmipa/v24i4.pp944-957
Received: 28 November 2023
Accepted: 30 December 2023
Published: 25 July 2024

generic skills that can make it easier for them to understand and solve existing problems. Therefore, there is a need to further evaluate the development of sheets or workbooks that optimally emphasize students' generic skills.

Apart from choosing the right learning media, it is no less important to use an approach that can support learning outcomes. Currently, there have been many developments that try to integrate STEM approaches into learning in K-12. (Ha et al., 2020) evaluated the scientific results of STEM learning in the ASEAN region through a total of 175 publications from the Scopus database which shows that the STEM development trend has increased quite significantly in the last three years. The majority of the aims of these developments are development and innovation in face-to-face learning. These findings provide input on the development and trends of STEM education to develop STEM approaches to other learning throughout the world. (Abdurrahman et al., 2019) in its development explains that inquiry-based STEM learning strategies can improve the abilities of gifted students in accordance with the 21st century learning framework. However, this development is limited to one case and indicates the need for confirmation in more cases. STEM learning not only focuses on STEM-related subjects and students' interests but also on 21st century student learning outcomes such as higher-order thinking skills and problem-solving abilities (Lee et al., 2019b). The STEM approach in Asia specifically improves student learning outcomes, especially critical thinking abilities. The application of science, design practices, and technology offers students opportunities for hands-on learning (Tsai et al., 2018). Previous development carried out by Aldemir & Kermani (2017) stated that STEM which is embedded through learning activities is able to help students develop a strong understanding so that the development carried out by Sari et al., (2021) aims to analyze students' perspectives on learning physics and teachers' views on electronic worksheets suggest developing an electronic student worksheet with a STEM approach, especially on physics material.

Furthermore, STEM integrated with project-based learning into the curriculum has received special attention among educators. Research conducted by (Lee, Y., et al., 2019) states that this is due to its power in increasing student engagement and helping students understand and apply concepts. STEM-PjBL activities allow students to demonstrate recorded understanding regarding how to apply STEM concepts to real-world problems (Han et al., 2016).

Based on these things, by trying to overcome the limitations in the development that has been carried out regarding the development of student worksheet or workbooks, the researcher developed a digital workbook for STEM-based Physics Subjects with a project-based learning approach which can be accessed via a website and can be students fill in or do it directly in the section provided with the various activities presented. Developing STEM-based worksheets for junior high school students can have positive effects, including helping develop students' critical thinking skills, fostering students' interest in learning science and mathematics, as well as interest in things related to STEM, fostering curiosity and solving skills. problems, giving students a broad experience of the world around them (YS Sari et al., 2019).

▪ METHOD

Participants

The population in this study were all class VII students at Junior High School 1 Bandar Lampung for the 2022/2023 academic year. The sample used was class 7.1 with a total of 20 students which was taken using the cluster random sampling technique.

Research Design and Procedures

This research is research and development (R&D) with a qualitative and quantitative approach which aims to produce learning products in the form of digital workbooks that are integrated with the PjBL-STEM approach. The instruments in this research are expert validation questionnaires, student response questionnaires, and test sheets. The validity of the instrument developed is first tested to find out whether the instrument is valid or not. This development research uses the ADDIE model work reference framework which consists of five steps, namely Analyze, Design, Development, Implementation, and Evaluation. The product resulting from this research is a STEM-Based Digital Physics Workbook with a PjBL Approach for class VII junior high school students.

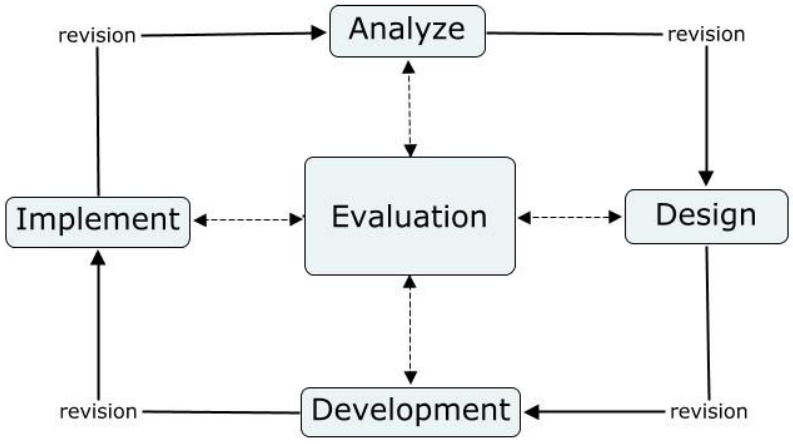

Figure 1. ADDIE Model

Analysis

In the analysis stage, the developer carries out activities to collect data about existing and supposed conditions as a comparison material for the product being developed. This stage includes needs analysis, literature study, student analysis, and material analysis. Needs analysis was obtained through a preliminary study to find out the problems that occurred through interviews and observation sheets in the form of questionnaires addressed to teachers and students. Literature study analysis aims to obtain data regarding the theoretical basis that can strengthen the product to be developed. At this stage the developer reviews the curriculum, which includes content standards (Core Competencies and Basic Competencies), process standards, and various theoretical foundations and results of developments that have been carried out by previous researchers. This is used to collect information on the causes of problems, in this case related to digital workbooks. After the problem is found, the next step is setting goals. Analysis of student characters such as knowledge, skills and general character which is then used as a basis for developing the Digital Workbook being developed. Apart from that, at this stage material selection is also carried out. The materials used are temperature,

expansion and heat. In this material, many students' average scores are still below the minimum completeness criteria. The material on temperature, expansion and heat was chosen because it is closely related to everyday life and can improve students' generic skills in applying scientific methods to learning.

Design

At the design stage, the activity carried out by the developer is designing a digital workbook. This activity includes the formulation of GBIM which consists of basic competencies and learning objectives, activities in digital workbooks, selection of media used, and formulation of research instruments. Basic competencies in this material are obtained from the Syllabus developed by the Research and Development Agency of the Ministry of Education and Culture, namely "After studying temperature and heat material, students can analyze the concepts of temperature, expansion, heat, heat transfer, and their application in everyday life". Learning objectives are formulated based on the main material that students must master, namely temperature and its transfer, expansion, heat and heat transfer.

After formulating learning outcomes and objectives, at this stage the developer also designs a flowchart of the structure of the Digital Workbook and first designs an Outline of Media Content and determines the activities in the Digital Workbook according to the aspects of PjBL-STEM proposed by Diana Laboy-Rush which consist of reflection, research, discovery, application, and communication. In this case, the developer determines the appearance that is designed based on moral decency norms. The developer also designs the interface and its functions, which consist of page composition and element consistency. Apart from that, a development team was determined at this stage consisting of experts and developers to design research evaluation instruments and validate them with experts.

Development

The development stage includes map out the product development design carried out in the previous stage into a real product by first determining the platform used. In determining the platform used, developers pay attention to matters relating to the appearance, ease of access, and existing features. The platform chosen is a website with the domain liveworksheets.com. On this site there are features that make it easier for students to carry out activities in the digital workbook, such as being able to fill in questions directly in the columns provided. Then get feedback from the teacher on the sheet.

At this stage, the development of a Digital Workbook is carried out which is composed of the syntax of the PjBL-STEM approach according to Laboy Rush. The Digital Workbook consists of three major parts, namely introduction, body and conclusion. The introductory section consists of an introduction to the workbook, study instructions, and overall learning objectives. The contents of the workbook consist of three chapters, namely Chapter 1: temperature and its measurement, Chapter 2: expansion, and Chapter 3: heat and its transfer. The closing section consists of a bibliography and author profile. Each chapter contains the learning objectives for each chapter, students' initial provisions for studying the material, steps for PjBL-STEM activities consisting of reflection, research, discovery, application, and communication, as well as practice questions. The developer also provides related links or videos that

students can access anytime and anywhere.

Next, validation of the Digital Workbook is carried out with the aim of determining the feasibility of the product being developed. This activity was carried out by media experts and material experts. Assessments and input from validators become a reference for whether or not there are improvements to the product being developed.

Implementation

At the implementation stage, the Digital Workbook which is the result of the development stage is implemented or tested on students. Students are given a questionnaire as a user response regarding the Digital Workbook. In this case the researcher recorded all the obstacles and shortcomings that occurred when the product was implemented. This stage is part of the testing stage for users, namely class VII junior high school students.

Evaluation

The evaluation stage is carried out by researchers at each stage of development as a formative evaluation. Researchers made slight modifications by conducting an expert review first before implementation was carried out. The evaluation results are used as feedback to improve the product, which is carried out not only on the final product but also starting from the analysis, design, development stages. The forms of evaluation related to the products being developed are evaluations carried out by experts on the products being developed and evaluations carried out based on trials with students. In the analysis stage, an assessment of the results of the literature study and preliminary study was carried out with the supervisor. Next, an assessment is carried out on the product design such as GBIM, flowcharts, platform appearance and also the elements in the digital workbook such as the type of font, images and videos used.

Instruments

The data collection tools used in this development are expert validation questionnaire, student response questionnaire, and test sheets. The construct and content validation questionnaire for the STEM-Based Digital Physics Workbook with the PjBL Approach contains written questions for experts. The validation questionnaire aims to obtain responses from validators regarding products with material developed by the developer. The results from the validator are used as a reference for whether the product being developed is valid or not.

The aspects and indicators of each instrument were prepared based on existing theories and validated by an expert, namely Mrs. Dra. Suprayekti, M.Pd. The instrument grid can be seen in the tables below.

Table 1. Digital workbook assessment questionnaire grid by media experts

Aspek	Indikator	Butir Item	Skala Penilaian
Program	a. Compatible	1.2	Skala 4
	b. Accessibility	3.4	
	c. *Reusable*	5	
	d. Operational	6	
Graphics	e. Font	7.8	

	f. Colouring	9
	g. Layout	10.11
	h. Content Illustration	12

Table 2. Assessment questionnaire grid by material experts

Aspek	Indikator	Butir Item	Skor
Content	a. Material suitability	1	4
	b. Material quality	2.3.4.5	
	c. Learning approach	21.22	
	d. Encourage curiosity	6.7.15	
Presentation	a. Presentation technique	8	
	b. Continuity of thought flow	9	
	c. Learning presentation	10.16.17.18.19.20	
Language	a. Straightforward	11.12	
	b. Interactive	13	
	c. Language rules	14	

Student response questionnaires were used to collect opinions regarding responses regarding the attractiveness and readability of the STEM-Based Digital Physics Workbook product with the PjBL Approach. Student trials are carried out after a feasibility test by experts. The instrument used is in the form of a questionnaire with four rating scales. The instrument grid is as follows.

Table 3. Student response instrument grid

Aspect	Indicator	Item
Material	Information is easy to understand	1.2
Component	Study instructions are clear	3
Language	Words	5
	Font	7
Appearance	Picture	6. 8
	Color	8
Presentation	Activities	4
Motivation	Student motivation	9. 10
Accessibility	Ease of access	12. 13

The instrument developed is first tested for validity to find out whether the instrument is valid or not. The instrument validity tests carried out are Questionnaire Validity and Validity of Question Items. The questionnaire validity is carried out by experts by assessing the questionnaire instruments developed and providing suggestions. Validity of Question Item is carried out by distributing question items to students and continuing with analysis of the answer results using bivariate analysis in SPSS. The category guidelines are as in table 4. below.

Table 4. Question item validity category

Range	Category
$0.80 < r_{xy} \leq 1.00$	Very high (Highly Valid)

$0.60 < r_{xy} \leq 0.80$	High (Valid)
$0.40 < r_{xy} \leq 0.60$	Fair
$0.20 < r_{xy} \leq 0.40$	Low (Less valid)
$0.00 < r_{xy} \leq 0.20$	Very low (Invalid)

Appropriateness Test Procedure

Product suitability assessment is carried out using a feasibility test. This test is carried out by experts and tested on students. Digital Workbook products that have been developed are assessed by experts such as media experts and material experts according to their respective fields. Media experts provide assessments regarding the media being developed and material experts provide assessments and suggestions regarding the material substance in the Digital Workbook. The assessment is given through an assessment instrument according to the assessment field. Moreover, One to One Trial was carried out on three class VII students at SMPN 1 Bandarlampung with different levels of ability. Subsequently, revisions were made based on the results obtained during the trial. After completing the one-to-one trial, a small group trial was carried out on six class VII students. Furthermore, revisions were made to the results obtained based on these data.

Effectiveness Test Procedure

Effectiveness Testing is carried out to find out whether the product being developed is effective, in this case the assessment of the Digital Workbook in improving student learning outcomes. This test was carried out by giving a pre-test before using the Digital Workbook and a post-test after using it to 20 students and analyzing the results obtained. The influence of the product being developed when used is indicated by the difference in pre-test and post-test scores.

Data Analysis

Qualitative Descriptive Analysis

This analysis technique is used to process data resulting from reviews from experts and student responses. This technique is carried out by grouping information from qualitative data such as comments and suggestions in the questionnaire with the following steps; Collect verbal data; Transcribe written verbal data; Collect, select, classify written verbal data; Analyze data; Formulate conclusions from the analysis results as a basis for taking action on the product. The results are used to revise the product being developed, namely the Digital Workbook.

Quantitative Descriptive Analysis

This technique is used to process the data obtained in percentage form. The expert test assessment instrument uses a Likert scale consisting of answer choices according to the question content. The assessment scale starts from (1) not feasible, (2) quite feasible, (3) feasible, (4) very feasible. The criteria for achieving validity and n-gain criteria refer to the table below can be seen in the table below.

Table 5. Criteria for achieving product validity

Test Results		Follow Up
Percentage	Qualification	
86% - 100%	Highly feasible	Implementation
76% - 85%	Feasible	Implementation
56% - 75%	Decent enough	Revised
<55%	Infeasible	Revised

Table 7. N-Gain effectiveness criteria

Percentage (%)	Criteria
< 40	Ineffective
40 - 55	Less Effective
56 - 75	Quite Effective
> 76	Effective

▪ RESULT AND DISSCUSSION

Stage 1: Analysis

Needs analysis

Based on the results of preliminary research conducted with class VII students and teachers at SMPN 1 Bandar Lampung, data was obtained that 84% of students had difficulty learning Physics Science material and 89% of students needed learning media that could support learning activities. Apart from that, interviews conducted with teachers showed that students did not have digital workbooks so that the assignment activities carried out during online learning were less than optimal. One of them is when giving assignments, teachers instruct students to work in notebooks and then collect answers by targeting them so that learning activities become less effective.

Apart from that, Physics lessons require students to have generic science skills in understanding the material. This can be supported by activities in the form of a project.

Student Analysis

The results of observations with teachers show that the average age of class VII students is thirteen years. Apart from that, the analysis shows that students have easy access to information and communication through the devices they own as well as the availability of internet facilities at school and at home.

Stage 2: Design

At this stage, the developer designs a Media Content Outline according to the activities contained in the Digital Workbook and the instruments that will be used in the research. After that, the developer designs the activities in the digital workbook according to the aspects proposed by Diana Laboy-Rush and the developer designs a Digital Workbook structure flowchart. The design aspects of PjBL-STEM presented in each activity are as follows.

Table 8. Design results of STEM aspects in digital workbooks

Aspect	Activity	Activity Indicator

PjBL	STEM		
Reflections	***Science***	***Reflections*** Examples of temperature and heat events	Given an example of temperature and heat events in everyday life, students continue to fill in the column provided
		Describe temperature, expansion, and heat	Students explain the meaning of each concept regarding temperature and heat in the columns provided
Research	***Technology***	*Browsing* between *platforms*	Examples are presented along with explanations regarding temperature, expansion and heat events via video media on *YouTube*
Discovery	***Engineering***	Designing prototype experiments related to temperature and heat	Students design, test, and redesign temperature and heat prototypes
Application	***Mathematics***	Tabulating data and making graphs	Students complete the table provided and create a graph in the space provided in the Digital Workbook
		Carry out calculations related to temperature and expansion	

Stage 3: Development

At the development stage, the process of developing a real product from a previous design is carried out by first selecting the platform used. The digital workbook prototype consists of several parts, namely the home page, log in page, workbook collection page, workbook introduction page, contents page, and last page, namely bibliography and author profile.

(a)

(b)

(c)

Figure 2. Part of digital workbook prototype (a) workbook introduction page (b) contents page (c) last page

After that, detailed product development is carried out which produces a product that is ready to be tested.

Stage 4: Implementation

In developing the digital workbook, before the implementation stage, the researcher first carried out an expert review to determine the validity of the construct being developed. After obtaining an assessment from experts, the implementation stage is carried out. Implementation is carried out one to one , consisting of three people and small groups consisting of six students. Next, a field trial was carried out to find out whether the digital workbook was effective to use by looking at its effect on student learning outcomes .

Stage 5: Evaluation

The evaluation stage resulted in assessments and suggestions from experts regarding the STEM-based Digital Physics Workbook with the PjBL Approach for Middle School Students. The results of the expert assessment of the questionnaire instrument used obtained an average score of four out of a maximum of five. Apart from that, the expert gave a comment, namely "The instrument items are suitable for use and do not need improvement" so that the instrument can be used in research. The results of the validity of the question instrument test with N= 20 and α= 0.05, then rtable= 0.444 and it can be seen that of the ten questions, five questions have a Pearson Correlation > 0.444 so that the five questions are declared valid and can be used, whereas the other five questions were invalid so they were not used. The results of the media expert's assessment of the results of the development of the digital workbook obtained the 85.71% of evaluation score. Furthermore, the feasibility results obtained from media experts show that the Digital Workbook is suitable for use. Based on the results of the feasibility assessment by material experts, evaluation score reached 95.45%. The feasibility results obtained from material experts are in the range of 86%-100%, indicating that the Digital Workbook is very suitable for use.

Apart from the quantitative test results above, media experts suggest using the Sans font, replacing the illustration on the cover, repairing several parts that have broken resolution, and paying attention to layout composition, while material experts suggest including supporting media from several sources. Based on this, the developer revised the development design based on suggestions from experts and then tested it on students.

The results of one to one trials and small group trials respectively obtained an average of 91.66% and 89.74%. Therefore, the development of a STEM-based Digital Physics Workbook using the PjBL approach from the aspects of material, workbook components, language, appearance, learning motivation and accessibility is included in the very good category for use in learning. Apart from that, the results of the effectiveness test on students after using the development product through the N-Gain Score calculation showed that there was an increase in learning outcomes by 61%. Referring to Table 7 regarding the criteria for achieving the N-Gain score, this means that the STEM-based

Physics digital workbook product with the PjBL approach is in the "effective enough" category.

▪ CONCLUSION

Research into the development of a STEM-based digital physics workbook using a project-based learning approach for junior high school students has produced a digital workbook that can be accessed via a link. Digital workbooks help teachers make learning more optimal by not having time and space limitations in providing assignments and exercises. Digital workbooks can support the science textbooks used so that students better understand the material being studied. The development model used is the ADDIE model which consists of analyze, design, development, implementation and evaluation.

The researcher recommends other researchers to develop similar products on other subjects in class VII science lessons using other, more detailed instructional design models so that development can be more optimal. Researchers recommend that teachers use digital workbooks that have been developed to support classroom learning. Students can use digital workbooks that have been developed to better master the material on temperature, expansion and heat.

▪ REFERENCES

Abdurrahman, Ariyani, F., Maulina, H., & Nurulsari, N. (2019). Design and validation of inquiry-based STEM learning strategy as a powerful alternative solution to facilitate gifted students facing 21st century challenging. Journal for the Education of Gifted Young Scientists, 7(1), 33–56. https://doi.org/10.17478/jegys.513308

Adora, A. L. (2019). Development and validation of a basic drawing workbook. International Journal of Innovative Science and Research Technology, 4(6), 129–140. www.ijsrt.com

Aldemir, J., & Kermani, H. (2017). Integrated STEM curriculum: improving educational outcomes for Head Start children. Early Child Development and Care, 187(11), 1694–1706. https://doi.org/10.1080/03004430.2016.1185102

Algiranto, Sarwanto, & Marzuki, A. (2019). The development of students worksheet based on Predict, Observe, Explain (POE) to improve students' science process skill in SMA Muhammadiyah Imogiri. Journal of Physics: Conference Series, 1153(1). https://doi.org/10.1088/1742-6596/1153/1/012148

Andriyani, L., Budi, E., & Astra, I. M. (2019). Developing of modified inquiry-based laboratory worksheet on optical topic. Journal of Physics: Conference Series, 1185(1). https://doi.org/10.1088/1742-6596/1185/1/012040

Asrori, A. (2020). Design of probability e-LKPD according to problem based learning model to enhance creative thinking skills. International Journal of Scientific & Technology Research. Volume 9(03).

Barniol, P., & Zavala, G. (2016). A tutorial worksheet to help students develop the ability to interpret the dot product as a projection. Eurasia Journal of Mathematics, Science and Technology Education, 12(9), 2387–2398. https://doi.org/10.12973/eurasia.2016.1271a

Benitez, I. P. (2020). Development of workbook to enhance students' competency in computer networking fundamentals. International Journal of Educational Sciences, 31(1–3), 129–136. https://doi.org/10.31901/24566322.2020/31.1-3.1165

Cabrera, V., & Navarro, V. (2021). Chemosphere A worksheet-based tool to implement reactive transport models in COMSOL Multiphysics. 266. https://doi.org/10.1016/j.chemosphere.2020.129176

Darman, D. R., Wibowo, F. C., Putra, A., Fisika, P., Fisika, P., & Negeri, U. (2017). *Pengembangan buku kerja fisika berbasis kontekstual pada konsep suhu dan kalor.* 3(2), 120–133.

Diah Pamelasari, S., Md Yunus, M., Fibriana, F., & Vita Amalia, A. (2018). Developing workbook science plus english to improve students' mastery of science content in english. International Journal of Engineering & Technology, 7(2.29), 570. https://doi.org/10.14419/ijet.v7i2.29.13820

Ha, C. T., Thi, T., Thao, P., Trung, N. T., Thi, L., Huong, T., & Dinh, N. Van. (2020). A Bibliometric review of research on STEM Education in ASEAN : Science Mapping the Literature in Scopus Database , 2000 to 2019. EURASIA Journal of Mathematics, Science and Technology Education, 16(10).

Haloho, F. K., & Pasaribu, A. (n.d.). *Pengembangan buku kerja siswa berbasis inkuiri materi optika geometri kelas x sekolah menengah atas.* 1–7.

Krisdiana, I., Masfingatin, T., Murtafiah, W., & Widodo, S. A. (2019). Worksheet-based learning research to improve creative thinking skills. Journal of Physics: Conference Series, 1254(1). https://doi.org/10.1088/1742-6596/1254/1/012054

Lee, M. H., Chai, C. S., & Hong, H. Y. (2019). STEM education in asia pacific: challenges and development. Asia-Pacific Education Researcher, 28(1), 2–5. https://doi.org/10.1007/s40299-018-0424-z

Limatahu, I., Suyatno, Wasis, & Prahani, B. K. (2018). The effectiveness of CCDSR learning model to improve skills of creating lesson plan and worksheet science process skill (SPS) for pre-service physics teacher. Journal of Physics: Conference Series, 997(1). https://doi.org/10.1088/1742-6596/997/1/012032

Lutfi, Ismail, & Azis, A. A. (2017). *Pengaruh project based learning terintegrasi stem terhadap literasi sains , kreativitas dan hasil belajar peserta didik effect of project-based learning integrated stem against science literacy , creativity and learning outcomes on environmental pollution.* Prosiding Seminar Nasioanal BiologiDan Pembelajarannya, 189–194.

Maruyama, T., & Kurosaki, T. (2021). Do remedial activities using math workbooks improve student learning? Empirical evidence from scaled-up interventions in Niger. World Development, 148, 105659. https://doi.org/10.1016/j.worlddev.2021.105659

Nainggolan, B. (2020). Developing innovative chemistry laboratory workbook integrated with project – based learning and character-based chemistry. 13(3), 895–908.

Ningrum, M. V., Yulkifli, Abdullah, R., & Nasution, V. Y. (2019). Preliminary study in the student worksheet development using inquiry based learning model with science process skills approach for physics learning of second grade high school. Journal of Physics: Conference Series, 1317(1). https://doi.org/10.1088/1742-6596/1317/1/012163

Nugraha, M. G., Utari, S., Saepuzaman, D., & Nugraha, F. (2018). Redesign of students' worksheet on basic physics experiment based on students' scientific process skills analysis in Melde's law. Journal of Physics: Conference Series, 1013(1). https://doi.org/10.1088/1742-6596/1013/1/012038

Nuha, A. A., Kuswanto, H., Apriani, E., & Hapsari, W. P. (2021). Learning physics with worksheet assisted augmented reality: the impacts on student's verbal representation. Proceedings of the 6th International Seminar on Science Education (ISSE 2020), 541(Isse 2020), 461–469. https://doi.org/10.2991/assehr.k.210326.066

Nurzaman, R. F. R., Yuningsih, E. K., Agustina, R. D., Zakwandi, R., Dirgantara, Y., & Kuntadi, D. (2021). An optical instrument worksheet in physics class. Journal of Physics: Conference Series, 1869(1). https://doi.org/10.1088/1742-6596/1869/1/012169

Putra, A., Lufri, Festiyed, & Ellizar. (2019). How student worksheet oriented of content complexity and cognitive processes can improve conceptual understanding and critical thinking skill of student in physics learning in high school. Journal of Physics: Conference Series, 1185(1). https://doi.org/10.1088/1742-6596/1185/1/012045

Rogayan Jr., D. V., & Dollete, L. F. (2019). Development and validation of physical science workbook for senior high school. Science Education International, 30(4), 84–290. https://doi.org/10.33828/sei.v30.i4.5

Romli, S., Abdurrahman, A., & Riyadi, B. (2018). Designing students' worksheet based on open-ended approach to foster students' creative thinking skills. Journal of Physics: Conference Series, 948(1). https://doi.org/10.1088/1742-6596/948/1/012050

Samsudin, M. A., Jamali, S. M., & Zain, A. N. (2020). The effect of stem project based learning on self-efficacy among high-school physics students. 17(1), 94–108. https://doi.org/10.36681/tused.2020.15

Sari, P. M., Herlina, K., & Abdurrahman. (2021). Preliminary research: developing physics electronic student worksheet based on expression model with the STEM approach. IOP Conference Series: Earth and Environmental Science, 1796(1). https://doi.org/10.1088/1742-6596/1796/1/012080

Sari, Y. S., Selisne, M., & Ramli, R. (2019). Role of students worksheet in STEM approach to achieve competence of physics learning. Journal of Physics: Conference Series, 1185(1). https://doi.org/10.1088/1742-6596/1185/1/012096

Sinuraya, J., Wahyuni, I., & Panggabean, D. D. (2020). The ICARE practice based on worksheet and physics experimental to improve student creativity. Journal of Physics: Conference Series, 1428(1). https://doi.org/10.1088/1742-6596/1428/1/012048

Sinuraya, Jurubahasa, Wahyuni, I., Demonta Panggabean, D., & Tarigan, R. (2019). Optimize use of icare based student worksheet (ICARE-BSW) in physics learning at the introduction level. Journal of Physics: Conference Series, 1317(1). https://doi.org/10.1088/1742-6596/1317/1/012161

Tsai, H. Y., Chung, C. C., & Lou, S. J. (2018). Construction and development of iSTEM learning model. Eurasia Journal of Mathematics, Science and Technology Education, 14(1), 15–32. https://doi.org/10.12973/ejmste/78019

Wahono, B., Lin, P., & Chang, C. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. International Journal of STEM Education, 1, 1–18.

Wulantri, Distrik, I. W., Suyatna, A., & Rosidin, U. (2020). The effectiveness of creative-inquiry-based student worksheet in improving physics self-efficacy and problem solving of senior high school students. Journal of Physics: Conference Series, 1467(1). https://doi.org/10.1088/1742-6596/1467/1/012036

Yanto, F. (2019). Development of problem-based student worksheet with authentic assessment to improve student's physics problem solving ability. Journal of Physics: Conference Series, 1185(1). https://doi.org/10.1088/1742-6596/1185/1/012075

Yildirim, B., & Turk, C. (2018). The effectiveness of argumentation-assisted STEM practices. Cypriot Journal of Educational Sciences, 13(3), 259–274. https://doi.org/10.18844/cjes.v13i3.3457