

Development of thermodynamic physics e-book with local wisdom of “brick making process” to improve computational thinking skills

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Abstract

Keywords:
Brick making;
Computational thinking;
sE-book; Local wisdom;
Thermodynamic physics;

This study was conducted to determine the characteristics of learning media by producing a thermodynamic physics e-book with local wisdom of STEAM-PjBL-based brick making process that is feasible, practical and effective in improving computational thinking skills in learning for grade XI high school students. This research is a development-research that uses the ADDIE model. Field trials were conducted using pre-test -post-test control group design. The assessment instruments, feasibility and practicality, were validated by 7 experts based on categories; material experts and media experts. A total of 107 students from 3 XI classes of SMA Negeri 1 Cepu became subjects in the field trial consisting of 35 students of experimental class 1, 36 students of experimental class 2, 36 students of control class. The data collection technique used was cluster random sampling. Data were collected through observation and interviews, questionnaires, and computational thinking skills test questions which were analysed by ANOVA test. The results showed that; i) the product of thermodynamic physics e-book with local wisdom of brick making process based on STEAM-PjBL has interactive characteristics, adds students' skills, provides new learning experiences, and improves students' computational thinking skills. Which is proven by the feasibility value in the category of very good on the material 3.85, 3.95 media, 4.00 practicality, and 3.96 readability. ii) proven effective in improving computational thinking skills as evidenced by the results of the ANOVA test which provides a significant difference in the application of the product to computational thinking skills as evidenced by the n-gain score of 0.66 (medium). The implications of this research are; i) to be an innovative solution in physics learning in encouraging character building and computational thinking skills that are relevant in the 21st century. ii) to support the existence of the Merdeka Curriculum and the strengthening of the Pancasila Student Profile through the integration of local culture and IPAS learning (physical science and socio-culture).

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Introduction

The development of computational thinking skills is one of the knowledge developments in the field of science and technology education in the 21st century. Therefore, students must be prepared with computational thinking skills to be utilised against the development of science and technology in solving complex problems in life (Fukuyuma, 2018). The 21st century life skills are known as 4C (Creativity, Critical Thinking, Communication, Collaboration) (Archiyesa, 2019). However, along with the increasing use of technology in learning, the 4C competencies are now increasingly developing into 6C which include; (Critical

Thinking Skills, Creative Thinking Skills, Communication Skills, Collaboration Skills, and Computational Thinking) (UNESCO, 2018).

Computational thinking is the concept of learning to formulate problems computationally and thinking through algorithmic processes systematically by solving problems in various contexts, until a solution is obtained (Cansu, 2019). Computational thinking was chosen because it can help students become the seeds that produce great ideas, foster creativity, express themselves in new ways, and understand the rapidly evolving world by thinking more critically (Papadakis, 2022).

Research on the profile of computational thinking skills of high school students in Indonesia shows that the computational thinking skills of Indonesian students are still relatively low. This is supported research by Litia (2023) which explains that 25% of SMAN 1 Langsa students have low computational thinking ability and only 33.3% have high ability. Then the results of research by Nuvitalia (2022) also explained that the computational thinking ability of junior high school students in Semarang city was still relatively low with a score of 54.97. This means that if at the junior high school level it is not satisfactory, then at the high school level it is feared that students will also experience the same or even more complex difficulties if appropriate learning interventions are not made. This is because at the high school level, computational thinking skills become increasingly strategic to prepare, because this phase is a transition period to the world of higher education and careers that increasingly demand critical thinking, algorithmic, and problem-solving skills covered in computational thinking skills. Therefore, there is a need for innovative learning media that not only facilitates concept understanding, but also develops these high-level thinking skills, one of which is through the integration of the STEAM-PjBL approach in contextual and locally-content e-book media.

Computational thinking can be associated with mathematical literacy because the concept of physics is an important integration in using various mathematical calculations (numeracy). According to data from the PISA (Programme for International Student Assessment) in 2022, the achievement of Indonesian students in mathematical ability obtained a score of 366 (OECD, 2023). Where Indonesia is still in position 69 out of 80 countries. Although ranked high, in 2018 it was only ranked 72 out of 78 countries, with a higher score of 379 (Schleicher, 2019). The factor of the decline in the score was influenced by the Covid-19 pandemic in 2019 to 2020 (Hakim, 2023). So that it can cause the ability of Indonesian students to experience learning loss (Madhakomala et al., 2023). To overcome this in the world of education, the government through the Ministry of Education and Culture launched an emergency curriculum known as the “Merdeka Curriculum”.

The Merdeka curriculum gives schools the freedom to shape students to face global competition by utilising information technology to support learning. One of the special aspects determined by the government as Indonesia's identity in the independent curriculum is the development of student character through; the Pancasila Student Profile Strengthening Project, known as “P5” (Kemdikbud, 2022). P5 in the independent curriculum is an interdisciplinary project based on the context of community needs as well as analogies of issues in the environment.

Local wisdom is the result of knowledge, wisdom, values and practices passed down from predecessors in a particular community or society. It is usually related to; ways of life,

traditions, norms, beliefs and knowledge systems that develop locally in a region or culture (Simajuntak et al., 2014). One form of local wisdom found in each region such as; making batik tulis Yogyakarta and making gamelan related to traditional aspects and art that form a local identity (Setianingrum & Jumadi, 2023). In addition, the process of making roof tiles in Kudus district is a source of knowledge derived from local identity (Najib, 2018). The making of pottery and furniture in the Jepara region as a result of research Anisa (2017) also revealed that it can improve critical thinking skills in students.

In physics learning at school, it can also integrate local wisdom by linking culture and hereditary activities. One of them is the process of making bricks (Mufidah et al., 2023). According to Najib (2018), local wisdom can be used as an additional teaching material in physics learning that is appropriate for improving students' reasoning and problem solving skills. The two research results are supported by preliminary research that has been conducted in the pilot school, confirming that, 95% of physics teachers in the Cepu city area and 89% of students out of 107 total students agree if integrating the potential of local wisdom in physics learning, 95% of physics teachers and 87% of students agree if physics learning uses e-books containing local wisdom of the brick making process (Putri & Rosana, 2024). This is not only limited to integrating local wisdom of regional culture in physics, but has many relevances as written by Putri & Rosana (2024), including; 1) from visualisation and contextualisation of thermodynamic physics concepts, 2) relevance to everyday life with the integration of local wisdom makes learning more meaningful and students can relate theory to practice, so that students experience a structured and systematic thinking process in solving problems, 3) strengthening the Pancasila student profile that helps students recognise and appreciate cultural heritage, 4) increasing interest in learning because interactive e-books are rich in animation and visualisation so as to support their independence and creativity. So this is in line with the understanding of the concept of computational thinking and the application of the independent curriculum.

Physics phenomena that are closely related to everyday life besides mechanics, light and sound are also thermodynamics. Thermodynamics is an understanding of physics concepts, such as; systems, environment, work, heat and temperature changes that have practical applications in the real world. One of the home industries related to the understanding of thermodynamics that can improve production efficiency is the brick making process (Naibaho et al., 2023). Professor Smith (2022) book, an expert in thermodynamics, found that applying the principles of thermodynamics in managing the temperature in a kiln (oven) has the potential to manage the energy consumption required during the firing process more efficiently, resulting in a higher quality product. With this, aspects of Thermodynamic Physics are present in the brick making process.

E-books are electronic or digital versions of books that contain interactive material and can be operated with an android or computer. The e-book in question currently has epub, html5, rtf, swf, and QR Code formats. In addition, Matloob (2015) explains that e-books have differences with ordinary printed books, namely; there are text, images, animations, sounds, and other multimedia combinations. The use of e-books involves the use of technological tools to access them (Al Saadi et al., 2017), such as mobile phones, computers and laptops. Most e-books used to be easily accessible on hardware are in pdf form. However, the disadvantage is

that pdfs are not interactive & do not offer multimedia, because pdfs are like ordinary printed books that are only moved on hardware to make it easier for readers.

Some previous studies have shown that the integration of local wisdom in learning has a positive impact on student learning outcomes. Research by Ardianti (2019) provides information that a learning system that applies local potential (ethno-edutainment) can improve student learning outcomes by integrating existing regional potential. Research by Huda (2020) also found that using additional teaching materials based on local wisdom proved effective in improving high school physics learning outcomes. Research by Setianingrum (2023) shows that using local wisdom e-book media for making gamelan with the STEAM-POE approach can improve student learning outcomes in science lessons. Similarly, Herianto (2020) stated that using interactive e-book learning media based on local wisdom of gamelan making can help facilitate and improve science learning outcomes. However, of the four studies, no one has specifically developed thermodynamic physics learning media that contains local wisdom of the brick making process with the STEAM-PjBL approach. This is where the novelty of this research lies, namely; combining local cultural elements of the brick-making process in an interactive physics e-book with the STEAM-PjBL approach that not only improves learning outcomes, but also develops and then measures computational thinking skills.

Therefore, it is very important to examine how the development of thermodynamic physics e-books with local wisdom of the brick making process can be applied to high school students. The development in question is an attempt to improve students' computational thinking skills through additional teaching materials in the form of e-books. The type of learning model applied in this e-book is STEAM-PjBL. The combination of learning approaches and learning models has a complementary syntax when applied in learning with local wisdom, adjustments to the independent curriculum (supporting 21st century progress) and computational thinking (Ifriiliya et al., 2022; Setianingrum & Jumadi, 2023; Taylor, 2016). This research has problem formulations including; i) How feasibility, practicality, and effectiveness of thermodynamic physics e-book with local wisdom of brick making process can improve students' computational thinking ability? ii) Does the treatment with thermodynamic physics e-book with local wisdom have differences in pre and post test scores of computational thinking ability of high school students separately in each experimental class?

Method

This type of research is research and development (R&D). R&D research is research used to develop a particular product to support and facilitate all forms of human activity. The development model used in this research is the ADDIE development model. The ADDIE model has 5 stages, including; analysis, design, development, implementation, and evaluation (Branch, 2009). The following is presented in Figure 1 which is a scheme of the core ADDIE model development research procedures carried out.

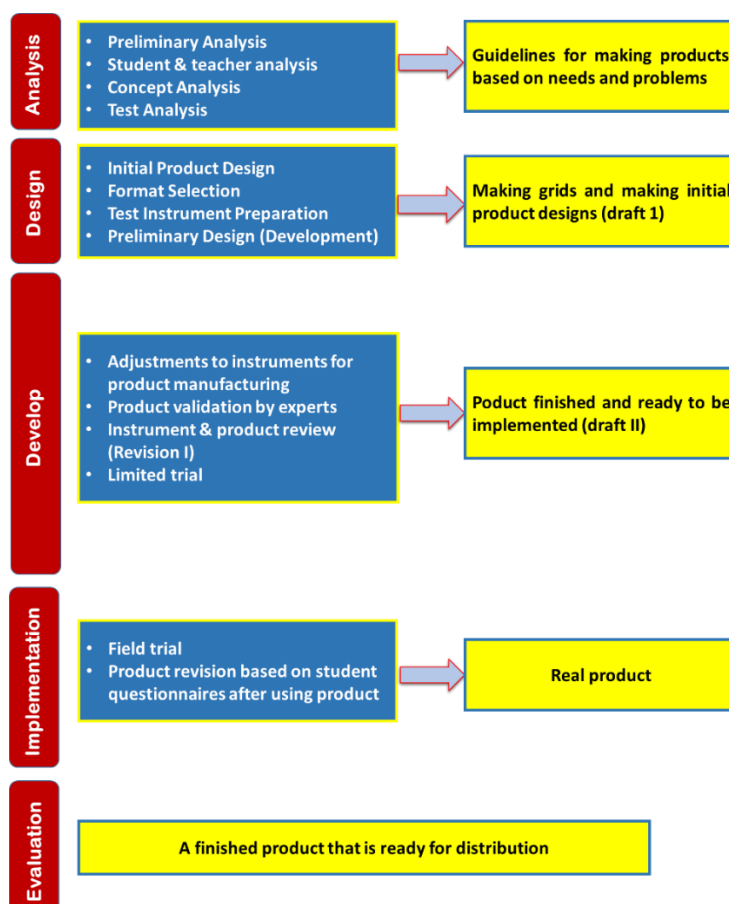


Figure 1. Schematic of The ADDIE Model Development Research Procedure

The components of the e-book development and its instruments have been validated by 5 expert lecturers and 2 practitioners (physics subject teachers). The use of 7 validators in the process of validating products and research instruments is based on the principle of expert triangulation which aims to ensure the content validity of the components developed. Where the 7 validators act as; learning media experts, learning evaluation assessment experts, indigenous knowledge in science experts and physics material experts. While 2 of the 7 practitioners as validators act as physics teachers who provide a practical perspective on the media before implementation, and media when implemented in terms of product practicality in learning at school.

The trial subjects in this study were divided into two types, namely; limited trials and field trials. The limited trial involved 1 class at SMA Negeri 1 Cepu Blora which was divided into 3 categories, namely; 5 high ability students, 5 medium ability students, and 5 low ability students. Meanwhile, the field trial involved 107 students with 3 test groups, which included; control class, experimental class 1, and experimental class 2. The field trial was conducted at SMA Negeri 1 Cepu class XI semester 2 of the 2023/2024 school year, each of which consisted of; 35 students in experimental group 1, 36 students in experimental group 2, and 36 students in the control group.

The research design consisted of; experimental group 1 using e-book physics thermodynamics charged with local wisdom of brick making process, experimental group 2

using a brief power point about physics thermodynamics charged with local wisdom of brick making process, and control group using conventional media and methods commonly used by teachers. The sampling technique used was cluster random sampling with a pretest-posttest control group design. The following Table 1 shows the research design.

Table 1. Pre-test-Post-test Control Group Design

Group	Pretest	Treatment	Posttest
E1	O ₁	X ₁	O ₂
E2	O ₁	X ₂	O ₂
C	O ₁	X ₃	O ₂

Modified from (Chawla & Sodhi, 2018)

Information: (E1: Experiment 1; E2: Experiment 2; C: Control)

This study aims to determine the feasibility of thermodynamic physics e-book with local wisdom of brick making process in improving computational thinking ability and the effect of developing thermodynamic physics e-book with local wisdom of brick making on improving students' computational thinking ability. This study consists of one independent variable (the use of media in the form of e-books) and one dependent variable (computational thinking ability). At the end of the 4th meeting, the use of e-book media was compared with teaching media in the form of power point and convention books commonly used by teachers. It is intended to see which media is more influential on students' computational thinking ability.

This study used two techniques in data collection, namely in the form of tests and non-tests. The test was used to measure the ability of computational thinking after the use of physical e-book of thermodynamics with local wisdom of brick making. The test questions used were in the form of multiplechoice questions as a measuring tool for cognitive abilities of computational thinking, which consisted of 25 items per package. There are 2 packages of questions with 5 anchor items in it. Anchor items are items used to link package A and package B so that the score can be equalised, between package A and package B. The maximum number of anchor items is 20%. The maximum number of anchor items is 20% of the total items in each package. Furthermore, for the indicators of computational thinking ability before being used, researchers synthesised indicators first from several experts. So that researchers found the indicators used, namely; abstraction, decomposition, algorithmic thinking, pattern generalisation, and evaluation.

While for non-test data collection, namely in the form of a questionnaire used in evaluating the feasibility and practicality of the material aspects and media aspects in the e-book developed. Critical thinking skills assessment instruments and product validation, including; feasibility assessment sheets by media experts and material experts, practicality assessment sheets by physics subject teachers and student computational thinking assessment sheets.

The data analysis technique used consists of; 1) qualitative results data in the form of suggestions and comments as material improvements coming from material experts, media experts, and practitioners during the development process and product trials of thermodynamic physics e-books loaded with local wisdom of the STEAM-PjBL-based brick making process. 2) quantitative result data in the form of scores which are then calculated and interpreted

descriptively, which comes from validation and assessment of media quality in the form of thermodynamic physics e-books with local wisdom in the STEAM-PjBL-based brick making process by media experts, material experts and practitioners. 3) to determine the pretest-posttest differences in computational thinking skills in each treatment, using the SPSS 23 programme with ANOVA analysis of variance test. Before conducting ANOVA analysis, the assumption test was conducted first to determine normality and homogeneity. The results can be seen in Table 2.

Table 2. The Normality and Homogeneity Test

Group	Pretest		Posttest	
	Normality	Homogeneity	Normality	Homogeneity
E1	0,200		0,914	
E2	0,065	0,486	0,318	0,857
C	0,062		0,074	

Based on the results of table 2 shows that, all assumption tests have been met, that ($p > 0.05$), so that means it can be continued with ANOVA analysis. Meanwhile, the effectiveness analysis technique of learning using e-book physics thermodynamics media, power point media and conventional media usually carried out by teachers is calculated based on the n-gain score value using the equation belonging to (Hake, 1999) which is shown as follows:

$$\langle g \rangle = \frac{\text{posttest Score} - \text{Pretest score}}{\text{Max Score} - \text{Pretest Score}}$$

Then the results are determined by the criteria of how far the improvement in students' computational thinking. The criteria for the normalised gain value $\langle g \rangle$, are as follows:

Table 3. Gain Normalisation Value Categories $\langle g \rangle$

Effect Size	Categories
$g \geq 0,7$	High
$0,3 \leq g < 0,7$	Medium
$g < 0,3$	Low

(Hake, 1999)

Then for the data analysis technique used in processing the results of the feasibility and practicality test refers to Mardapi (2018), which is then made an assessment conversion on a scale of four. The results of the score analysis can be shown in Table 4 below.

Table 4. Formulation of Media Eligibility and Practicality Criteria Based on Average Score Conversion into Categories

No.	Formula	Interval Score	Categories
1	$X \geq \bar{X} + 1.5 SB_X$	$X \geq 3.00$	Very Good
2	$\bar{X} + 1.5 SB_X > X \geq \bar{X}$	$3.00 > X \geq 2.50$	Good
3	$\bar{X} > X \geq \bar{X} - 1.5 SB_X$	$2.50 > X \geq 2.00$	Fair
4	$X < \bar{X} - 1.5 SB_X$	$X < 2.00$	Deficient

Information:

X = score achieved

\bar{X} = average overall score ($\frac{1}{2}(\text{max score} + \text{min score})$)

SB_x = standard deviation of overall score ($\frac{1}{6}(\text{max score} - \text{min score})$)

Learning products containing local wisdom in the form of e-books are said to be feasible if they fulfil at least the “good” category.

Results and Discussion

Product Characteristics Description

The development of media in the form of e-book Physics Thermodynamics with local wisdom of brick making process based on STEAM-PjBL aims to produce products that are able to become additional media in the physics learning process. In addition, it can introduce teachers and students to the characteristics of the media developed with conventional learning media. Because the media developed is interactive, collaborative, and forms students to be able to solve everyday life problems with computational thinking skills through local wisdom of the brick making process.

The main characteristics of the media in the form of this e-book, include; the material is contextual, contains local wisdom, namely the process of making bricks, diverse media interactions that make students more active, then the focus of product development on computational thinking skills applied to the brick making process which aims to train logarithmic thinking skills in students. Adopting between approaches and learning models in facilitating learning, namely with the STEAM approach and project-based learning model (PjBL). Because the STEAM approach (Science, Technology, Engineering, Art, Mathematic) provides knowledge as well as skills that are not only in the scientific aspect, but also art to train students' skills, creativity and imagination (Cross et al., 2016; Pratidhina et al., 2022). Meanwhile, the PjBL learning model supports the STEAM approach, which can encourage students to be actively involved in conducting learning projects and train their skills to create and produce something independently, and solve problems independently to support the progress of the 21st century (S. Lestari, 2021; Setyani et al., 2024). Thus, through the combination of this approach and learning model can train students from the cognitive and psychomotor aspects. The following Figure 2 shows the display of the results of the development of learning media in the form of an e-book of thermodynamic physics of the brick making process.



wisdom of brick-making process based on project with STEAM approach. The topic was raised with the aim of triggering students to think computationally and creatively by applying their science knowledge to solve problems in life. It aims to help train students' problem solving, think more structurally, and add to their skills. In line with the research of Ifriilya (2022 & Pratidhina (2022) which revealed that project-based physics learning and the application of STEAM can help improve students' skills in improving students' computational thinking ability (algorithmic thinking).

Product Eligibility

The results of the validation of the thermodynamic physics e-book with local wisdom of the STEAM-PjBL-based brick making process, obtained from research and validation by material experts and media experts. The validation process is carried out to ensure that the materials and media developed are in accordance with the standards and have good quality to support learning. Material experts assessed the quality of the visual display, the suitability of the learning design principles used, the suitability of the media with the technology used, and the interactivity. Meanwhile, the material experts assessed the aspects of; content suitability to the curriculum, material accuracy, depth and breadth of material, linkage to local wisdom of the brick making process, suitability to the chosen learning model. The results of the validation by the material expert group can be displayed in Table 5 below.

Table 5. Results of Expert Validation of Thermodynamic Physics E-Book Material Aspects

Aspect	Score Average	Value	Categories
E-Book Components	3,92	A	Very Good
Content Eligibility	3,95	A	Very Good
Language	3,71	A	Very Good
Presentation	3,85	A	Very Good
Coverage of STEAM Approach	3,85	A	Very Good
Coverage of the PjBL Model	3,80	A	Very Good
Achievement of Local Wisdom in the Brick Making Process	3,92	A	Very Good
Coverage of Computational Thinking Skills	3,88	A	Very Good
Average Total	3,85	A	Very Good

Based on the results in Table 5, it can be seen that the feasibility of learning materials in the form of thermodynamic physics e-books with local wisdom in the STEAM-PjBL based brick making process was validated by 7 validators based on their expertise in the material before being tested. The e-book was developed, to be a supporting medium for the learning process of thermodynamic physics. The value of the feasibility of the material in the e-book is based on aspects; the components contained in the e-book are complete, content feasibility, language, presentation, coverage of the STEAM approach, coverage of the PjBL learning model, coverage of computational thinking skills and coverage of local wisdom in the brick making process.

The results of the learning material assessment provide information related to all aspects assessed by the 7 expert validators by showing scores tend to be stable. The average score of

the 7 validators was 3.85 with a very good category, which can mean that the materials that have been developed are suitable for use in learning. There are several suggestions from material experts to make product improvements, including; the need to pay attention to the systematic writing of quantities and units in equations in e-books and question packages, making computational thinking questions into 2 packages to avoid cheating on student answers complete with the arrangement of each aspect, aspect indicators, grids & question indicators, and answer keys. Based on this description, it can be concluded that the material developed in the e-book of thermodynamic physics is very good and suitable for testing after going through the revision stage based on suggestions from validators.

Table 6. Results of Expert Validation of E-Book Physics Thermodynamics Media Aspects

Aspect	Score Average	Value	Categories
Language	3,92	A	Very Good
Presentation	4,00	A	Very Good
Graphics	3,85	A	Very Good
Distinctive features of thermodynamic physics e-books	4,00	A	Very Good
Average Total	3,95	A	Very Good

Based on Table 6, it can be seen that the thermodynamic physics e-book media loaded with local wisdom of the STEAM-PjBL-based brick making process was validated by 7 validators based on their expertise on the media before being tested. The average score obtained was 3.95, categorised as very good. This means that the developed thermodynamic physics e-book is reliable and can be used as an additional medium for learning thermodynamic physics to measure the computational thinking ability of high school students. In addition, in the development of thermodynamic physics e-book with local wisdom content, it can not only convey physics material contained in the process of making bricks, but also must be able to provide student enthusiasm and be interactive to be able to add their skills so that students do not get bored quickly in learning. Media experts conducted an assessment of aspects; language, presentation, grammar, and characteristics of thermodynamic physics e-books.

So that there are several suggestions from media experts to make product improvements, including; no need to include pre-test-post-test into the developed e-book and can be replaced with formative tests, mix and match shapes on the front cover title to make it look neater, need to pay more attention to the placement of product navigation buttons. Based on this description, it can be concluded that the media developed in the form of thermodynamic physics e-books are very good and are suitable for testing after going through the revision stage based on suggestions from validators.

Practicality and Legibility of the Product

The assessment of product eligibility is not only assessed by lecturers of material experts and media experts, but also its practicality is assessed by practitioners, namely physics teachers at the high school level. The data was obtained using a questionnaire to determine the practicality of the thermodynamic physics e-book with local wisdom content that has been developed with the aim of being an additional media for physics learning. In the practicality

questionnaire there are 7 aspects that are assessed, including; appearance, presentation of material, benefits, STEAM approach components, PjBL model components, local wisdom, and computational thinking skills. Table 4 below shows the results of the practicality assessment by physics subject teachers.

Table 7. Results of Practicality Assessment of Thermodynamic Physics E-Book by Physics Teachers

Aspect	Average Score	Value	Categories
View	3,95	A	Very Good
Material presertation	3,83	A	Very Good
Benefit	4,00	A	Very Good
STEAM approach components	4,00	A	Very Good
PjBL model components	4,00	A	Very Good
Local Wisdom	4,00	A	Very Good
Computational Thinking skills	4,00	A	Very Good
Total Average	3,97	A	Very Good

Table 7 shows that the practicality of the thermodynamics physics e-book enriched with local wisdom on the brick-making process is appropriate and aligned with the listed aspects and current technological developments. The teacher commented that, in terms of content, the thermodynamics e-book is excellent because it does not only focus on cognitive aspects but also emphasizes students’ psychomotor skills by encouraging learning through hands-on experience, thereby enhancing their skills. To support this learning activity, the student worksheet (LKPD) is designed in such a way that it aligns with the syntax of the STEAM-PjBL model, particularly through project-based learning centered on brick making.

Table 8. Results of Analysis Readability Thermodynamic Physics E-Book by Student

Aspect	Average Score	Value	Categories
Language	3,86	A	Very Good
Material presentation	3,93	A	Very Good
Graphical	3,93	A	Very Good
STEAM approach components	4,00	A	Very Good
PjBL approach components	4,00	A	Very Good
Local Wisdom	4,00	A	Very Good
Computational Thinking skills	4,00	A	Very Good
Total Average	3,96	A	Very Good

Table 8 presents the results of the readability analysis of the thermodynamics physics e-book enriched with local wisdom on the brick-making process. The e-book had been revised based on expert suggestions before being subjected to a limited trial with students. The media was tested on 15 eleventh-grade students from SMA Negeri 1 Cepu and evaluated using a 4-point Likert scale questionnaire. The 15 students were selected based on their academic abilities: 5 high-performing students, 5 average-performing students, and 5 low-performing students, as categorized by the physics teacher using parallel subject mapping.

This trial aimed to assess the readability of the developed thermodynamics e-book based on student responses. The overall average score given by the students was 3.96, indicating that the developed e-book was of very high quality. However, the language aspect received a

slightly lower average score of 3.86, as some students were reluctant to read the information provided in the e-book. Upon reviewing all seven assessed aspects, one contributing factor may be the students' low reading habits and a stronger preference for visual content over text, which influenced their perception of the e-book's readability. This is supported by the graphical aspect, which received a score of 3.93.

Field Testing Results

The thermodynamics physics e-book, which had undergone revisions based on input from several experts, was subsequently implemented in the field trial phase. The purpose of the field trial was to evaluate the effectiveness of the thermodynamics e-book—integrated with local wisdom through the brick-making process and based on the STEAM-PjBL approach—in enhancing computational thinking skills among high school students. The field trial involved 107 eleventh-grade students at SMA Negeri 1 Cepu, Central Java. The classes involved in the field trial included: Experimental Class 1 with 35 students, Experimental Class 2 with 36 students, and a Control Class with 36 students. The data obtained from this field trial consisted of cognitive data related to students' computational thinking skills.

The initial step in the field trial was administering a pre-test on computational thinking skills. The purpose of the pre-test was to determine the students' initial level of ability. The results of the pre-test data for each computational thinking indicator are presented in Figure 2 below.

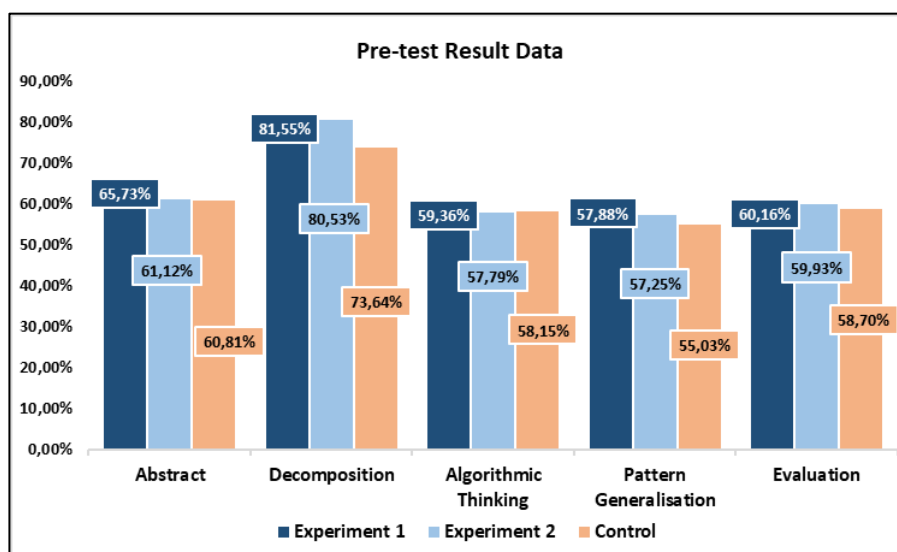


Figure 2. Results of Pre-test for Each Computational Thinking Skill Indicator in Each Class

After the pre-test was administered, the students were given treatment through instruction in each class according to the predetermined conditions. The final step was administering a post-test in the form of a computational thinking skills assessment. The purpose of the post-test was to determine the students' final abilities after receiving the respective treatments in each experimental class. The results of the post-test data for each computational thinking indicator are presented in Figure 3 below.

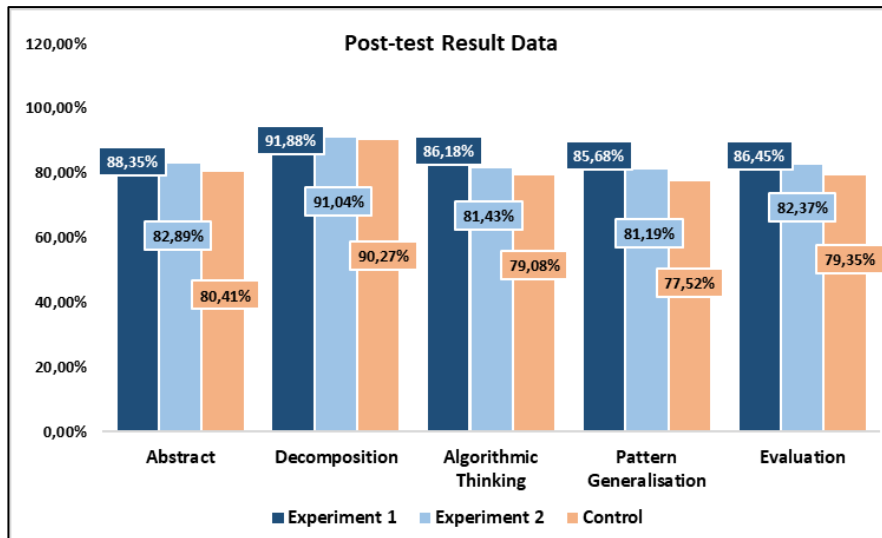


Figure 3. Post-test Results for Each Computational Thinking Indicator in Each Class

Based on the information from Figures 2 and 3, differences in the improvement levels for each experimental class can be observed across every computational thinking indicator. More detailed data regarding the differences in the average N-Gain scores of students' computational thinking skill in each class are presented in Figure 4 below.

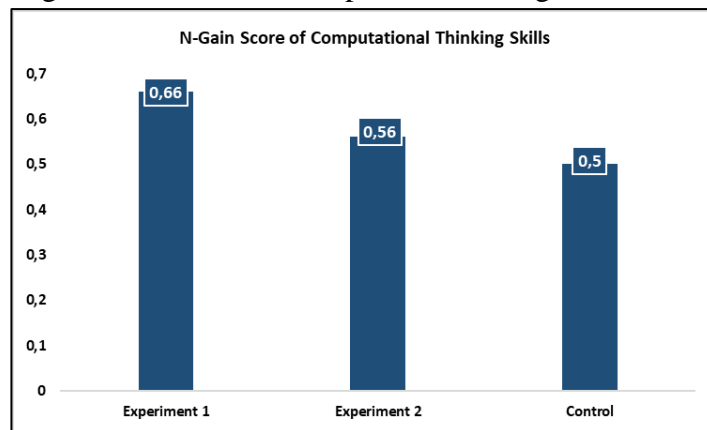


Figure 4. Differences in N-Gain Scores of Computational Thinking Ability in Each Class

The results show that the computational thinking ability in Experimental Class 1 had a higher N-Gain score compared to Experimental Class 2 and the Control Class. This means that the use of the thermodynamics physics e-book media effectively improves students' computational thinking skills. This finding aligns with the research by Herianto (2020) and Setianingrum (2023), which states that using e-books enriched with local wisdom, combined with appropriate learning models and approaches, can have a positive impact and improvement on science learning. Therefore, the goal of enhancing computational thinking skills can be successfully achieved in physics education.

Through computational thinking, students can be trained to improve their learning independence, be able to solve problems with complex and algorithmic thinking, critically and creatively, and train students' skills with project-based learning models and approaches that are in line with the research results of (A. C. Lestari & Annizar, 2020; Nasiba, 2022; Nuraini et al.,

2023; Pratidhina et al., 2022; Syahputra & Sinaga, 2024). Thus, it can be seen that the one that gave the highest average score was experimental class 1, where the class was a class that used a thermodynamic physics e-book containing local wisdom on the brick making process based on STEAM-PjBL. So that the results show that it has met the criteria for minimum learning completion.

Improvement Pretest-Posttest Score of Computational Thinking Skills in Each Group

Table 9 below shows the effect of the thermodynamic physics e-book with local wisdom on the STEAM-PjBL-based brick making process in improving computational thinking skills. This finding shows that at a significance level of 0.05 the pretest-posttest value has a significant increase in experimental class 1, experimental class 2, and control class.

Table 9. Results of Pairwise Comparisons

Measure	Treatment	I (time)	J (time)	Mean Difference (I-J)	Std. Error	Sig. ^b
Computational Thinking	Experiment 1	Pretest	Posttest	-37.971	0,999	0,000
	Experiment 2	Pretest	Posttest	-33.083	0,985	0,000
	Control	Pretest	Posttest	-29.639	0,985	0,000

Referring to the information presented in Table 9, if the significance value is <0.05 , it indicates a significant increase in students' computational thinking ability scores on the pre-test-post-test scores in each class. The difference of the mean MD (Mean Difference) score of the computational thinking test was -37.971 in experimental class 1, -33.083 in experimental class 2, and -29.639 in the control class. Because the MD values in all groups are negative, it can be concluded that the average post-test score is higher than the average pre-test score. Therefore, there was a significant increase in computational thinking ability in the pre-test-post-test in each class (Ho, 2014). Based on these results, it can be concluded that; H_0 is rejected and H_a is accepted, namely 'there is an increase in pre-test-post-test scores on students' computational thinking skills in each class.'

Furthermore, the Post Hoc test was conducted to determine classes that are not similar (different from each other), which is shown in Table 10 below.

Table 10. Results of Post Hoc Test Bonferroni Type in Computational Thinking Skill

Measure	I (Class)	J (Class)	Mean Difference (I-J)	Std Error	Sig.
Computational Thinking	Experiment 1	Experiment 2	3,25	1,647	0,152
		Control	5,53*	1,647	0,003
	Experiment 2	Experiment 1	-3,25	1,647	0,152
		Control	2,27	1,635	0,500
	Control	Experiment 1	-5,53*	1,647	0,003
		Experiment 2	-2,27	1,635	0,500

Referring to Table 8, it was found that in students' computational thinking ability, experimental class 1 was not significantly different from experimental class 2 as indicated by (MD = 3.25; $p > 0.05$), while for experimental class 1 with the control class had a significant difference where (MD = 5.53; $p < 0.05$). Thus, it shows that experimental class 1 using thermodynamic physics e-book with local wisdom of STEAM-PjBL-based brick making process has a higher effect on computational thinking ability compared to experimental class 2

and control class.

The use of thermodynamic physics e-books in the STEAM-PjBL-based brick making process is one form of technology utilisation in education (TPACK), which means that in learning there are elements of material as a source of knowledge, pedagogy and the use of technology in achieving learning objectives. In addition, the results of this study are in line with Papadakis (2022), that with the physical thermodynamics e-book that raises the STEAM-PjBL-based brick making process in an effort to improve computational thinking skills, it can train students in generating great and creative ideas for designing bricks and knowing the function of the design. In addition, they can also express themselves through Art (design) in the learning project of making bricks, as well as understanding the rapidly growing surrounding environment related to the brick making & burning system, so that students can think more critically and structured. Research results, Maharani (2020) & Pratidhina (2022) convey, through the STEAM approach can develop computational thinking skills. So that through this approach can encourage innovation in effective brick making techniques.

Computational thinking encourages the use of multiple disciplines to problem solving. The focus is on physics and thermodynamics being applied to understand the brick making process, which is part of the local culture. This shows how a scientific approach can provide a deeper understanding of traditional practices. In short, using decomposition techniques, the brick-making process can be broken down into smaller steps and analyzed using thermodynamic principles. Abstraction allows us to focus on the essential elements of the process, such as firing temperature and material composition, to improve efficiency and the quality of the final product.

This study has limitations that can be used as a basis for consideration for subsequent researchers, namely; Experimental activities require tools and materials that are not available in the Physics laboratory. In addition, the manufacturing stage needs to be carried out in a wider location, which is carried out at the brick craftsman's place, so that researchers collaborate with many brick craftsmen. Because if it is done in the Physics laboratory it is very limited. For this reason, researchers need to hold discussions and appeal first to 3 to 4 brick craftsmen. In addition, there needs to be permission and coordination with the principal and guardians regarding the learning process carried out in the field. So if you want to do similar research, it is very necessary to consider the method, time allocation and place.

Conclusion

The results of data analysis show that the thermodynamic physics e-book with local wisdom of brick making process based on STEAM-PjBL is proven to be feasible to use in learning high school physics based on the assessment of material experts, media experts, teachers and students. This is based on the 'very good' category from the assessment of all parties. The Anova test results showed a significant difference in the use of thermodynamic physics e-books with local wisdom on students' computational thinking skills. This is evidenced by an increase in the pre-test-post-test scores of students' computational thinking skills by 0,66 (medium). So it can be said that the e-book of thermodynamic physics with local wisdom can have a positive impact in learning physics that is innovative, creative, algorithmic and critical thinking in supporting the development of abilities in the 21st century. Therefore, it is

recommended that teachers can develop physics e-books with local wisdom that are more varied and understand the aspects of computational thinking in supporting the times. One of the implications of the research findings that have been conducted, namely: (1) the use of thermodynamic physics e-books containing local wisdom based on STEAM-PjBL can be an alternative solution in developing learning tools that not only emphasize cognitive aspects, but also shape character, art skills in students and have computational thinking skills that are relevant to the needs of the 21st century. This shows that a contextual learning approach based on local wisdom projects around can improve the quality of physics learning which has so far been considered abstract and difficult to understand, namely learning thermodynamic physics through the brick making process, (2) the development of physics e-books that contain diverse local/ethnoscience potentials will play an important role in helping students love and appreciate the local wisdom in their own areas. By presenting various local wisdoms and linking them to Indonesian history, it will be a good additional point to support the government's program, namely the Merdeka Curriculum in IPAS learning and the Pancasila student profile. So that it can increase their understanding of cultural heritage, produce a sense of pride in Indonesian identity, and motivate students to maintain and preserve it.

Credit Authorship Contribution Statement

Novita Eka Putri: Conceptualization, Methodology, Software, Visualization, Formal analysis, Writing – original draft, Writing – review & editing. **Dadan Rosana:** Conceptualization and Supervision. **Harto Nuroso:** Conceptualization and Supervision.

References

- Al Saadi, K., Lane-Kelso, M., Al Hafeedh, A., Zainab, A. S., & Al Wishahi, M. (2017). Are we ready for E-books? Omani university students' uses and perceptions of E-books. *Turkish Online Journal of Educational Technology*, 16(2), 11–25. <http://www.tojet.net/articles/v16i2/1622.pdf>
- Anisa, A. (2017). Meningkatkan Keterampilan Berpikir Kritis Peserta Didik Melalui Pembelajaran IPA Berbasis Potensi Lokal Jepara. *Jurnal Inovasi Pendidikan IPA*, 3(1), 1–11. <https://doi.org/http://dx.doi.org/10.21831/jipi.v3i1.8607>
- Archiyesa, C. A. (2019). Education Strategy towards Digital Competences in Welcoming Society 5.0. *J Basic Education*, 4(3), 33–45.
- Ardianti, S. D., Wanabuliandari, S., & Kanzunudin, M. (2019). Implementasi Pembelajaran Berbasis Ethno-Edutainment Untuk Meningkatkan Karakter Cinta Tanah Air Siswa Sekolah Dasar. *Refleksi Edukatika: Jurnal Ilmiah Kependidikan*, 9(2), 204–209. <https://doi.org/10.24176/re.v9i2.3503>
- Branch, R. M. (2009). Instructional Design: The ADDIE Approach. In *Department of Educational Psychology and Instructional Technology University of Georgia* (Vol. 53, Issue 9). Springer. <https://doi.org/10.1007/978-0-387-09506-6>
- Cansu, S. K., & Cansu, F. K. (2019). An Overview of Computational Thinking. *International Journal of Computer Science Education in Schools*, 3(1), 17–30. <https://doi.org/10.21585/ijcses.v3i1.53>
- Chawla, D., & Sodhi, N. (2018). *Research methodology: Concepts and Cases (2nd ed.* Vikas Publishing House Pvt Ltd.
- Cross, J., Hamner, E., Zito, L., & Nourbakhsh, I. (2016). Engineering and Computational

- Thinking Talent in Middle School Students: A Framework For Defining and Recognizing Student Affinities. *Proceedings - Frontiers in Education Conference, FIE, 2016-Novem*, 1–9. <https://doi.org/10.1109/FIE.2016.7757720>
- Fukuyuma, M. (2018). Society 5.0: Aiming for a New Human-Centered Society. *Japan SPOTLIGHT*, August, 47–50. <http://www8.cao.go.jp/cstp/>
- Hake, R. R. (1999). Analyzing Change/Gain Scores. *Unpublished.[Online] URL: Http://Www.Physics.Indiana.Edu/~Sdi/AnalyzingChange-Gain.Pdf*, 1–4. <https://web.physics.indiana.edu/sdi/AnalyzingChange-Gain.pdf>
- Hakim, M. L. (2023). Kebijakan Pembelajaran Jarak Jauh Berakibat Learning Loss dan Penurunan Kualitas Pendidikan. *Journal of Islamic Education Management*, 4(2), 117–126. <https://doi.org/https://doi.org/10.30762/joiem.v4i2.1934>
- Herianto. (2020). *Pengembangan E-Book Multimedia Interaktif Berbasis Flip Builder Tema IPA Pada Proses Pembuatan Gamela Untuk Meningkatkan Keterampilan Generik Sains Dan Curiosity Peserta Didik SMP*. Universitas Negeri Yogyakarta.
- Ho, R. (2014). *Handbook of Univariate and Multivariate Data Analysis With IBM SPSS* (second edi). CRC Press Taylor & Francis Group.
- Huda, C., Siswoningsih, D., & Nuvitalia, D. (2020). Efektivitas Pembelajaran Fisika Menggunakan Modul Sains Berbasis Local Wisdom Pada Pembahasan Suhu dan Kalor. *Jurnal Penelitian Pembelajaran Fisika*, 11(1), 89–94. <https://doi.org/10.26877/jp2f.v11i1.5827>
- Ifriliya, L., Hayat, M. S., Roshayanti, F., & Siswanto, J. (2022). Potensi Implementasi Computational Thinking pada Pembelajaran Fisika. *Unnes Physics Education Journal*, 1–14. <http://journal.unnes.ac.id/sju/index.php/upej%0APotensihttp://journal.unnes.ac.id/sju/index.php/upej%0APotensi>
- Kemdikbud. (2022). *Keputusan Menteri Pendidikan, Kebudayaan, Riset dan Teknologi Republik Indonesia Nomor 56/M/2022 tentang Pedoman Penerapan Kurikulum dalam Rangka Pemulihan Pembelajaran*.
- Lestari, A. C., & Annizar, A. M. (2020). Proses Berpikir Kritis Siswa dalam Menyelesaikan Masalah PISA Ditinjau dari Kemampuan Berpikir Komputasi. *Jurnal Kiprah*, 8(1), 46–55. <https://doi.org/https://doi.org/10.31629/kiprah.v8i1.2063>
- Lestari, S. (2021). Pengembangan Orientasi Keterampilan Abad 21 pada Pembelajaran Fisika melalui Pembelajaran PjBL-STEAM Berbantuan Spectra-Plus. *Ideguru: Jurnal Karya Ilmiah Guru*, 6(3), 272–279. <https://doi.org/https://doi.org/10.51169/ideguru.v6i3.243> Artikel
- Litia, N., Sinaga, B., & Mulyono, M. (2023). Profil Berpikir Komputasi Siswa dengan Menggunakan Model Pembelajaran Problem Based Learning (PBL) Ditinjau dari Gaya Belajar di SMA N 1 Langsa. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, 7(2), 1508–1518. <https://doi.org/https://doi.org/10.31004/cendekia.v7i2.2270>
- Madhakomala, M., Dewi, M. A., Azizah, S., Syachputri, Z. A., & Nuhaq, S. (2023). Kurikulum Darurat Sebagai Solusi Ketertinggalan Pembelajaran Peserta Didik Di Masa Pandemi. *SPEKTRUM: Jurnal Pendidikan Luar Sekolah (PLS)*, 11(1), 145–151. <https://doi.org/10.24036/spektrumpls.v11i1.117086>
- Maharani, S., Nusantara, T., As'ari, A. R., & Qohar, A. (2020). *Computational Thinking (Pemecahan Masalah di Abad Ke-21)* (A. Septyawan, I. Susilowati, E. F. Subeqi, & E. Melasevix (eds.); 1st ed., Issue September). Wade Group.
- Mardapi, D. (2018). *Teknik Penyusunan Instrumen Tes dan Non Tes* (A. Setiawan (ed.); Januari 20). Parama Publisihing.
- Matloob, T. (2015). “How would I Like to Read a Mawlawna Ebook?”: Children’s Interests

- and Concerns When Reading Ebooks. *New Review of Children's Literature and Librarianship*, 21(1), 59–76.
<https://doi.org/https://doi.org/10.1080/13614541.2015.976094>
- Mufidah, I. Z., Salsabila, K. M., Muniroh, C., Risqi, F. D. M., Kurniawan, R., & Trisnowati, E. (2023). Analisis Hukum Termodinamika pada Pembuatan Batu Bata di Magelang, Jawa Tengah. *Jurnal Pendidikan MIPA*, 13(3), 784–789.
<https://doi.org/https://doi.org/10.37630/jpm.v13i3.1053> Analisis
- Naibaho, P. R. P., Hestukoro, S., Akhiruddin, & Sitorus, M. B. H. (2023). Teknologi Tepat Guna Pembuatan Batu Bata Di Desa Pematang Sijonam Kecamatan Perbaungan. *JUBDIMAS (Jurnal Pengabdian Masyarakat)*, 2(1), 24–29.
<https://doi.org/https://doi.org/10.59663/jubdimas.v2i1.222>
- Najib, K. (2018). Kajian Etnosains Proses Pembuatan Genteng sebagai Bahan Ajar Tambahan Pelajaran IPA Terpadu. *Jurnal Penelitian Pembelajaran Fisika*, 9(2), 98–103.
<https://doi.org/10.26877/jp2f.v9i2.3107>
- Nasiba, U. (2022). Brankas Rahasia: Media Pembelajaran Numerasi Berbasis Berpikir Komputasi untuk Meningkatkan Kemampuan Pemecahan Masalah. *Jurnal Didaktika Pendidikan Dasar*, 6(2), 521–538. <https://doi.org/10.26811/didaktika.v6i2.764>
- Nuraini, F., Agustiani, N., & Mulyanti, Y. (2023). Analisis Kemampuan Berpikir Komputasi Ditinjau dari Kemandirian Belajar Siswa Kelas X SMK. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 7(3), 3067–3082. <https://doi.org/10.31004/cendekia.v7i3.2672>
- Nuvitalia, D., Saptaningrum, E., Ristanto, S., & Putri, M. R. (2022). Profil Kemampuan Berpikir Komputasional (Computational Thinking) Siswa SMP Negeri Se-Kota Semarang Tahun 2022. *Jurnal Penelitian Pembelajaran Fisika*, 13(2), 211–218.
<https://doi.org/10.26877/jp2f.v13i2.12794>
- OECD. (2023). *PISA 2022 Assessment and Analytical Framework*. OECD. https://www.oecd-ilibrary.org/education/pisa-2022-assessment-and-analytical-framework_dfe0bf9c-en
- Papadakis, S. (2022). Apps to Promote Computational Thinking and Coding Skills to Young Age Children: A Pedagogical Challenge for the 21st Century Learners. *Educational Process: International Journal*, 11(1), 7–13.
<https://doi.org/https://dx.doi.org/10.22521/edupij.2022.111.1>
- Pratidhina, E., Kuswanto, H., & Rosana, D. (2022). *Pembelajaran Online Fisika Berbasis Pemodelan* (M. Dew (ed.); 1st ed.). Cipta Media Nusantara (CMN).
- Putri, N. E., & Rosana, D. (2024). Kebutuhan Guru dan Siswa terhadap Pengembangan E-book Bermuatan Kearifan Lokal “Proses Pembuatan Batu Bata” sebagai Perangkat Pembelajaran Fisika. *Unnes Physics Education Journal*, 13(3), 247–258.
<https://doi.org/https://doi.org/10.15294/upej.v13i3.15185>
- Schleicher, A. (2019). PISA 2018 Insights and Interpretations. In www.oecd.org/termsandconditions. www.oecd.org/pisa
- Setianingrum, D. A., & Jumadi, J. (2023). STEAM Study on Local Wisdom of Batik Tulis Yogyakarta to Develop Science Teaching Materials. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7390–7400. <https://doi.org/10.29303/jppipa.v9i9.5133>
- Setianingrum, D. A., Matahari, D. B., Jumadi, J., & Wilujeng, I. (2023). Development of Science e-Book Containing Gamelan's Local Wisdom Based on STEAM-POE to Facilitate Students' Love of Local Culture. *Jurnal Penelitian Pendidikan IPA*, 9(6), 4791–4800. <https://doi.org/https://doi.org/10.29303/jppipa.v9i6.3760>
- Setyani, U., Nugroho, I. R., Jumadi, J., Suyanta, S., & Wilujeng, I. (2024). Development of the PjBL Model Science E-Book to Improve Creative Thinking Skills of Middle School Students. *Jurnal Penelitian Pendidikan IPA*, 10(3), 1032–1038.
<https://doi.org/10.29303/jppipa.v10i3.6303>

- Simajuntak, B. A., Panjaitan, A. P., Darmawan, A., Maharani, Purba, I. R., Rachmad, Y., & Simanjuntak, R. (2014). *Korelasi Kebudayaan dan Pendidikan: Membangun Pendidikan Berbasis Budaya Lokal*. Yayasan Pustaka Obor Indonesia.
- Smith, J. M., Ness, H. C. Van, Abbott, M. M., & M.T.Swihart. (2022). *Introduction to Chemical Engineering Thermodynamics* (Ninth Edit). McGraw Hill LLC.
- Syahputra, W. I., & Sinaga, B. (2024). Peningkatan Kemampuan Berpikir Komputasional Siswa Melalui Penerapan Model Pembelajaran Berbasis Proyek. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, 4(1), 1–26.
<https://doi.org/https://doi.org/10.51574/kognitif.v4i1.1157>
- Taylor, P. C. (2016). Why is a STEAM Curriculum Perspective Crucial to the 21st Century? *Research Conference 2016, August*, 89–93.
https://www.researchgate.net/publication/307396291_Why_is_a_STEAM_Curriculum_Perspective_Crucial_to_the_21st_Century
- UNESCO. (2018). A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2. *Information Paper*, 51(51), 1–146.
<http://uis.unesco.org/sites/default/files/documents/ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf>. Consultado em 05fev2023, 17:45