JPPIPA 12(6) (2026)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of an Ethno-STEM Integrated Problem Based Learning Physics E-Module to Improve High School Students' Creative Thinking Skills

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Received: March 09, 2026
Revised: May 12, 2026
Accepted: June 25, 2026
Published: June 30, 2026

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DOI: 10.29303/jppipa.v12i6.15237

Abstract: Twenty-first century education demands the cultivation of creative thinking, yet preliminary studies in three high schools in Solok Regency revealed that students' creative thinking skills in physics averaged only 35.5%. This study aims to develop an interactive E-Module of physics on Work and Energy that integrates Problem Based Learning (PBL) with the Etno-STEM approach using the local wisdom of the Minangkabau Rumah Gadang to improve the creative thinking skills of senior high school students. The research employed a Research and Development design using the Plomp model, which consists of three phases: preliminary research, prototyping, and assessment. The product was validated by three experts using Aiken's V; practicality was assessed by teachers (n=2) and students (n=40); and effectiveness was tested through a pretest-posttest control group design at SMA Negeri 1 Pantai Cermin (experimental n=40; control n=41). Results show that the E-Module is highly valid (V = 0.98), highly practical (89.27%), and effective in improving creative thinking skills (N-Gain = 0.66, medium-high category) with significant differences between groups ($t = 6.351$; $p < 0.05$) and classical mastery of 87.5%. The integration of PBL and Etno -STEM in a digital, mobile-friendly module proves effective in cultivating fluency, flexibility, originality, and elaboration.

Keywords: Creative thinking skills; E-Module; Ethno-STEM; Physics education; Problem based learning

Introduction

21st century education demands participant educate No only speak in a way academic, but also capable think creative, critical, collaborative and communicative (Trilling & Fadel, 2009). Among four core competencies, creativity or think creative occupy position central Because become foundation innovation and problem solving non-routine problems (Alabbasi et al., 2022; Thornhill-Miller et al., 2023). Global recognition of importance think creative strengthened with made into Creative Thinking as innovative domain in Programme for International Student Assessment (PISA) 2022 cycle published 2024 (Simamora et al., 2024). In the era of industry 4.0, when artificial intelligence and automation has replace Lots routine work, ability produce original idea becomes differentiator main Power competition difficult human replicated machine (Getenet, 2024).

Think creative as construct scientific first formulated by Guilford (1967) through draft divergent thinking and developed by Torrance into four indicator operational that is fluency, flexibility, originality and elaboration detailing (Almeida et al., 2008; Torrance, 2018). On learning physics, thinking creative is very relevant Because physics demand ability imagine phenomenon abstract, designing experiments, as well as connect principle theoretical with application practical (Mahardika et al., 2024; Pamungkas et al., 2019). However, learning physics that emphasizes

How to Cite:
Sari, G., Usmeldi, Desnita, & Akmam. (2026). Development of an Ethno-STEM Integrated Problem Based Learning Physics E-Module to Improve High School Students' Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *12*(6), 384–394. https://doi.org/10.29303/jppipa.v12i6.15237

memorization formulas and exercises question closed precisely dull creativity participant education (Mweene & Muzaza, 2020; Meilasari, 2022).

One of factor reason low skills think creative is use linear teaching materials that only load description concept, example questions and exercises, without room exploration divergent (Magdalena et al., 2020; Hasanah et al., 2024). Electronic modules or E-Module appears as alternative relevant: independent teaching materials based electronics equipped animation, audio and video so allows participant educate interact active with material (Lastri, 2023; Parapat & Sagala, 2022). The developed e-module using digital platforms allows access through smartphone in a way flexible in accordance characteristics participant educate digital native (Mithasari et al., 2024; Nisa et al., 2020). Meta-analysis Fadillah et al. (2024) on 15 studies show that the Physics E-Module more effective compared to conventional teaching materials in increase think creative, thinking critical, results learning and literacy science, especially If combined with STEM, PBL, or CTL approaches (Paudi & Ngaito, 2026).

The Problem Based Learning (PBL) model developed by Barrows (1986) places problem authentic as point reject learning. Through investigation to problem, participant educate trained formulate questions, collect information, submit hypothesis and compile solution a process that is in line with four indicator think creative Torrance (Arends, 2012; Hmelo-Silver, 2004). Hamimah et al. (2020) report that more of the 70 schools that implemented PBL experienced improvement skills 21st century including think creative. Mulyani (2020) and Desnita et al. (2024) also showed that PBL has an impact positive to results learning and thinking critical participant educate. However, the problems presented in learning physics in Indonesia in general Still decontextualized and detached from riches culture local (Puspasari et al., 2019).

For bridge problem said, the approach Ethno - STEM is here as integration between ethnoscience and Science, Technology, Engineering, and Mathematics (Idrus, 2022; Priyani & Nawawi, 2020). Integration wisdom local to in learning science create environment learning that is contextual, meaningful and encouraging participant educate linking draft scientific with experience cultural they (Lidi et al., 2020). Rohmantika et al. (2021) study on the material fluid dynamic and Sumarni et al. (2020) show that based teaching materials Ethno-STEM in significant increase creativity participant educate compared to learning conventional. Findings similar reported by Siregar et al. (2025) and Maryanti et al. (2023) that the E-Module Ethno-STEM is based on wisdom local increase ability think creative. Rohman et al. (2024) emphasized integration Ethno -STEM with PjBL model and PBL produces improvement creativity, motivation and engagement participant educate in a way consistent.

Review to study previously show achievements at a time gaps that still exist open. Seruni et al. (2019) and Nisa et al. (2020) succeeded develop E-Modules that improve ability think critical, but products produced not yet can accessible through smartphone. Sari et al. (2021) developed an E-Module based on wisdom local that can used in a way offline and online via smartphone, but the content not enough push exploration divergent. Yulkifli et al. (2022) developed a physics E-Module based project-based learning integrated Valid and practical Ethno-STEM, while Nazifah et al. (2022) and Asrizal et al. (2022) developed a physics E-Module effective STEM integrated learning. Fauzi et al. (2020) demonstrated an integrated E-Module culture local effective increase competence knowledge, but not yet measure in a way specific skills think creative. Most of them study Existing Ethno-STEM new emphasize aspect validity and practicality teaching materials and not yet combine it in a way systematic with learning models based demanding problems exploration, analysis depth and production original solution. This is it gap research answered by the study this.

Analysis needs that are carried out researchers on three schools in Solok Regency —State Senior High School 1 Pantai Cermin, State Senior High School 1 Lembah Gumanti, and MAS TI Surian— showed that skills think creative participant educate on the material physics only reach average 35.5% (very low category), competence average knowledge 55%, motivation study 57%, and interest study 55%. Interview with a physics teacher confirm that the E-Modules are available Still serve material linearly, less integrate wisdom local, minimal aspects interactive and not yet mobile friendly (Syahfitri & Muntahanah, 2024). Based on findings empirical this research This aim to: (1) produce physics E-Modules based problem integrated Ethno -STEM, (2) testing validity, (3) testing practicality, and (4) testing effectiveness of E-Modules in increase skills think creative participant educate Grade X SMA on the topic of Work and Energy. Context Selected Ethno -STEM is Minangkabau Gadang House architecture, which is rich in principle physics like effort, energy potential, energy kinetic, law eternity energy and power.

Novelty study this located on three aspects that have not been answered in a way simultaneously by research previously. First, integration three component learning-interactive digital format based flipbooks, consistent PBL syntax, and context Developed Ethno - STEM in a way deep — deep One the whole product, not just alignment standing components itself. Second, the context wisdom selected local (Rumah Gadang architecture) is treated as organizing principle that becomes vehicle epistemic draft physics, so that every

element culture linked direct with one indicator think Torrance 's creative explicit (Sumarni & Kadarwati, 2020; Yulkifli et al., 2022). Third, evaluation effectiveness done use design pretest-posttest control group with analysis layered prerequisite tests, independent samples t-tests, N-Gain and completeness classical—so that conclusion No only lean on one indicator statistics. Convergence three aspect this expected give contribution for practice learning physics based wisdom local Minangkabau and for literature educational design research in Indonesia (Plomp & Nieveen, 2013).

Method

Study this is Research and Development (R&D) using the Plomp et al. (2013) model. Plomp and Nieveen's model chosen because nature systematic, flexible, iterative and guarantees fulfillment three criteria quality product development, namely validity, practicality and effectiveness. Procedure development consists of on three phase main, namely (1) preliminary research (analysis) needs and context), (2) development or prototyping phase, and (3) assessment phase. In this phase prototyping, developed four evaluated prototype in a way layered through self evaluation, expert review, one to one evaluation, small group evaluation, and field test as recommended Tessmer (1993).

Subject study is participant educate class X of SMA Negeri 1 Pantai Cermin, Solok Regency, West Sumatra. At the stage one-to-one evaluation involved three participant educate from selected XE 3 class in a way purposive based on category ability high, medium and low. At stage small group evaluation involved nine participant educate from class XE 2 and XE 5. At stage field test and assessment phase, class XE 1 (n = 40) was determined as class experiments using the Physics E-Module Based Problem Integrated Ethno -STEM, and class XE 4 (n = 41) as class control that uses module print conventional. Validation product involving three lecturer expert from the Master of Physics Education Study Program, Padang State University, while the practicality test was at the stage field test involving two physics teachers from SMA Negeri 1 Pantai Cermin.

E-Module developed use application Canva and run as digital flipbook via Heyzine so that can accessible through smartphone and web browser. Selected material is Effort and Energy in Phase E of the Independent Curriculum. Context Integrated Ethno - STEM is Minangkabau Gadang House architecture, which includes appointment beam wood pillars, foundation stone removal through gutter bamboo, gonjong roof from palm fiber, system pulley wood traditional, as well as Batagak Penghulu tradition of mutual cooperation. Every elements of the Rumah Gadang made into as vehicle epistemic for draft physics (Sumarni & Kadarwati, 2020; Yulkifli et al., 2022). Five PBL syntaxes are integrated in a way consistent to in every activity learning (Arends, 2012).

Instrument data collection consists of above (1) questionnaire analysis needs and characteristics participant educate, (2) sheets validation experts who cover five aspects (substance material, design learning, display visual communication, integration Ethno -STEM and PBL, as well as development skills think creative), (3) questionnaire practicality for teachers and participants education that includes aspect convenience, practicality, power attraction, implementation and effectiveness time, and (4) tests essay skills think creatively arranged based on four Torrance indicators — fluency, flexibility, originality and elaboration —on the Work and Energy material (Alabbasi et al., 2022; Almeida et al., 2008).

The validity of the E-Module is analyzed using Aiken's V formula (Aiken, 1985) as follows shown in Equation (1).

$$V = \Sigma s / [\, n(c - 1)] \quad (1)$$

with $s = r - l_0$, l_0 is number evaluation validity lowest, c is number evaluation validity highest, r is the number given by the validator and n is number of validators. Product declared valid if $V \geq 0.6$ (Azwar, 2015). Practicality analyzed with formula in Equation (2):

$$NP = (\text{score obtained} / \text{score maximum}) \times 100\% \quad (2)$$

with category 81–100% very practical, 61–80% practical, 40–60% sufficient practically, 20–40% do not practical, and 0–20% very impractical. practical. Effectiveness analyzed through (1) prerequisite tests Kolmogorov–Smirnov normality and Levene's homogeneity, (2) independent samples t-test for compare posttest means class experiments and classes control, (3) analysis N-Gain formulated by Hake (1999) as in Equation (3), and (4) completeness classical as in Equation (4).

$$\langle g \rangle = (S\_post - S\_pre) / (100 - S\_pre) \quad (3)$$

$$KK = (JT / JS) \times 100\% \quad (4)$$

where $\langle g \rangle$ is N-Gain, S_post is the average value posttest, S_pre is the average value pretest, KK is completeness classical, JT is amount participant educate complete and JS is amount all over participant educate. Category N-Gain following Hake (1999): high ($\langle g \rangle > 0.7$), medium ($0.3 < \langle g \rangle \leq 0.7$), and low ($\langle g \rangle \leq 0.3$). Product stated effective if N-Gain class minimal moderate and more experiments tall compared to class control, as well as

there is difference significant posttest mean ($p < 0.05$) which is beneficial class experiment.

Result and Discussion

Characteristics and Structure of the Resulting E-Modules

Physics E-Module Based Problem Integrated Ethno -STEM is interactive digital teaching materials developed use Canva application and run it become flipbook through Heyzine, so can accessible through smartphone When anywhere and anytime. This E-Module intended for participant educate grade X SMA/MA odd semester on the topic of Business and Energy, with integrate wisdom local Minangkabau Gadang House architecture as context Ethno -STEM. The E-Module structure consists of above preface, table of contents, map concept, introduction, two activities learning that is each organized following the five syntaxes of PBL, evaluation end, conclusion, glossary, and bibliography. Completeness component this fulfil principle self-instructional as put forward by Kosasih (2021) and Lastri (2023), namely module must capable guide participant educate finish One cycle Study in a way independent.

Integrated PBL model through five consistent syntaxes: (1) orientation participant educate on problems, (2) organizing participant educate for learning, (3) guidance individual and group investigations group, (4) development and presentation results work, as well as (5) analysis and evaluation of the problem-solving process problems (Arends, 2012; Hmelo -Silver, 2004). Components introduction load Achievements Learning in accordance Independent Curriculum Phase E (BSKAP No. 32 of 2024) and objectives learning six grains from level C2 to C6. Approach Ethno -STEM integrated through the context of the Rumah Gadang that was developed in a way in-depth, including documentary videos about Rumah Gadang architecture with review wonder science traditional like gonjong roof system, connections peg without nails, stone foundations and principles physics in every element buildings. Table 1 summarizes integration Ethno -STEM Rumah Gadang with draft physics and indicators think Torrance creative.

Table 1. Ethno -STEM Integration Based on Rumah Gadang in E-Module

Elements of the Rumah Gadang	Draft Physics	Indicator Torrance Creative
Appointment beam wood pole in a way vertical	Work ($W = F \cdot d \cdot \cos\theta$; $\theta = 0°$)	Fluency — identifying various method appointment
Moving foundation stones through gutter bamboo (inclined plane)	Business with angle ($W = F \cdot d \cdot \cos\theta$)	Flexibility — comparing two methods transfer
Gable roof from palm fiber at a height of 8–10 m	Potential Energy ($E_p = mgh$)	Elaboration — calculating and analyzing material energy
System pulley wood traditional for raise material	Law of Conservation of Mechanical Energy	Originality — designing system pulley alternative
Gotong royong batagak penghulu / batagak kudo-kudo	Power and Efficiency ($P = W/t$)	Flexibility and Elaboration — reflection mark culture and physics

E-Module Validity

The validity of the E-Module is assessed by three lecturer experts (V1, V2, V3) from the Physics Education Masters Study Program, Padang State University using sheet validation that covers five aspects and is analyzed with Aiken's V formula (Aiken, 1985). Validation results presented in Table 2.

Table 2. Results of E-Module Validation by Expert Validators

Aspect Validation	V1	V2	V3	Average	Aiken's V	Category
Substance of Material	4	4	4	4	1	Valid
Learning Design	3.67	4	4	3.89	0.96	Valid
Appearance Visual Communication	3.67	4	4	3.89	0.96	Valid
Integration of Ethno -STEM and PBL	4	4	4	4	1	Valid
Development Skills Think Creative	4	4	3.8	3.93	0.98	Valid
Overall Average	3.87	4	3.96	3.94	0.98	Valid

Based on Table 2, the Aiken's V value for fifth aspect is in the range of 0.96–1.00 with an average of 0.98. All mark exceeds the minimum limit of $V \geq 0.6$ so that the E-Module is declared very valid and feasible tested. The height mark validity aspect substance material reflected from compilation material in a way logical and structured, including draft effort, energy potential, energy kinetic, law eternity energy and power, as recommended Asrizal et al. (2022), Asri et al. (2022), and Fadillah et al. (2024) through meta- analysis confirm that accuracy substance is determinant main the effectiveness of the physics E-Module at the high school

level, because error conceptual as small as anything on independent teaching materials will embedded without correct direct from the teacher.

Aspect integration Ethno -STEM and PBL as well substance material get mark highest (V = 1.00). Achievement This indicates that the context of Rumah Gadang No placed as patch cultural, but rather as vehicle epistemic place draft physics born. Yulkifli et al. (2022) confirms that the Physics E-Module based Ethno -STEM only will fulfil condition validity construct if context culture functioning as organizing principle that explains structure all over activity Study. Idrus (2022) through meta- analysis conclude that success integration ethnoscience -STEM is determined by the depth connectedness epistemic between context culture and concepts scientific. Aspect development skills think creative get V value = 0.98 because all over E-Module components are designed in a way explicit for practice four Torrance indicators—fluency, flexibility, originality, and elaboration. Alabbasi et al. (2022) emphasized that fourth indicator the No will develop in a way automatic through exposure content, but rather must trained through designed tasks specifically, and Mahardika et al. (2024) strengthens that training explicit indicator think creative through physics modeling increase ability creative participant educate in a way significant. This result in line with Kurniawan et al. (2021) for the Physics E-Module based inquiry integrated ethnoscience, as well as Sari et al. (2021) who developed the E-Module material temperature and heat based ethnophysics.

E-Module Practicality

Testing practicality done in a way layered through one to one evaluation, small group evaluation and field test as recommended by Tessmer (1993). In one to one evaluation, participants educate capable tall demand explicitness connection between Rumah Gadang context and concept physics, participants educate capable currently need glossary term wisdom more local complete, and participants educate capable low need example more filling and instructions operational. This pattern in harmony with theory zone of proximal development (Vygotsky, 1978) that every participant educate need type different scaffolding. After all over input followed up, E-Module enters stage small group evaluation (n = 9) and field test (class XE 1, n = 40 and two teachers). Recapitulation evaluation presented in Table 3.

Table 3. Summary of Assessment Results Practicality of E-Modules by Three Groups Assessor

Aspect Evaluation	Small Group (n=9)	Teachers (n=2)	Students (n=40)
Convenience	87.78%	87.50%	88.27%
Practicality	87.04%	84.38%	88.75%
Attractiveness	90.74%	–	91.77%
Implementation	–	90.63%	–
Time Effectiveness	–	81.25%	–
Overall Average	88.52%	86.76%	89.27%
Category	Very Practical	Very Practical	Very Practical

Table 3 shows that mark practicality highest obtained from group participant educated (89.27%), followed by small group (88.52%), and teachers (86.76%). Third group is in the very practical category. Plomp et al. (2013) formulated practicality as criteria quality second after validity, where the product considered practical when the users perceive product the can implemented with easy in condition real. Convergence very practical assessment from all group assessor indicates that the E-Module does not depending on certain ideal conditions for can functioning (Asrizal et al., 2022; Nazifah & Asrizal, 2022).

From the teacher's perspective, the aspect implementation PBL syntax acquisition appreciation highest (90.63%). Arends (2012) emphasized that implementation PBL syntax relies on clarity distribution role between teachers as facilitators and participants educate as an investigator. The developed E-Module provide guide detailed instructions for every PBL phase so that teachers do not need compile guide new. Hmelo -Silver (2004) added that PBL modules that provide embedded scaffolding reduce burden teacher cognitive in operationalizing complex learning models. From the perspective of participant education, aspects Power pull get appreciation highest (91.77%), consistent pattern with achievements small group (90.74%) and emphasized that the context of Rumah Gadang succeed build connectedness emotional between participant educate with material. Maryanti et al. (2023) showed that the E-Module is based on Ethno -STEM that digs wisdom local get response emotional strong positive, especially when context the culture referred to near with identity cultural participant educate. Rohmantika et al. (2021) concluded that based teaching materials Ethno -STEM gain response more positive Because build relevance between knowledge knowledge and identity culture participant didik, and Parapat et al. (2022) strengthen that the E-Module is interactive based

approach contextual push involvement cognitive Because existence convergence between digital media, context learning and approach learning.

The Effectiveness of E-Modules in Increase Skills Think Creative

The effectiveness of the E-Module was tested use design pretest-posttest control group in class XE 1 (experimental, n = 40) and class XE 4 (control, n = 41). Plomp et al. (2013) placed effectiveness as criteria quality highest in educational design research, where the product it is said effective if its use produce impact appropriate learning with objective development. Average value results pretest and posttest per indicator think creative presented in Table 4.

Table 4. Average Pretest and Posttest Scores Per Indicator Think Creative

Indicator Think Creative	Pretest		Posttest	
	Experiment	Control	Experiment	Control
Fluency	34.8	34.2	80.2	63.1
Flexibility	35.4	34.9	77.8	60.5
Originality	37.6	37	77.1	60
Elaboration	38.5	37.6	79.4	63.7
Average Total	36.6	35.9	78.6	61.8

Table 4 shows that in the condition pretest, ability beginning second class relatively equal and low on all four indicator think creative (average 36.6 and 35.9). After treatment, class experiment show improvement Far more tall compared to class control, with difference posttest ranges from 15.7–17.3 points and the difference the largest on the indicator Flexibility. Before conducting a t-test, conducting a prerequisite test normality (Kolmogorov–Smirnov) and homogeneity (Levene) the results of which presented in Table 5.

Table 5. Results of the Normality and Homogeneity Test of Pretest and Posttest Data

Test	Data	Class	Statistics	Sig.	Conclusion
Kolmogorov Smirnov	Pretest	XE 1 (Experiment)	0.11	0.2	Normal
Kolmogorov Smirnov	Pretest	XE 4 (Control)	0.107	0.2	Normal
Kolmogorov–Smirnov	Posttest	XE 1 (Experiment)	0.094	0.2	Normal
Kolmogorov–Smirnov	Posttest	XE 4 (Control)	0.101	0.2	Normal
Levene	Pretest	–	0.415	0.522	Homogeneous
Levene	Posttest	–	1.187	0.28	Homogeneous

Table 6. Results of the Independent Samples t-Test (Posttest)

Data	t- count	t- table (df =79; α=0.05)	Sig. (2-tailed)	Conclusion
Posttest XE 1 vs XE 4	6.351	2	0	H_0 Rejected

All pretest and posttest data normally distributed (Sig. > 0.05) and variance second group homogeneous, so that assumptions prerequisites for independent samples t-test fulfilled. The t-test results are presented in Table 6.

The t-value (6.351) is greater big from t- table (2,000) with significance 0.000 < 0.05 so H_0 is rejected. Rejection of H_0 indicates that there is difference in average value significant posttest between class experiment (78.6) and class control (61.8), with direction difference profitable class experiment. For measure size improvement, done analysis N-Gain as presented in Table 7.

Table 7 shows that mark N-Gain class experiment more tall compared to class control on all four indicators. Based on Hake's criteria (1999), indicators Fluency in class experiment reach category high (⟨g⟩ = 0.70) whereas three indicator other is in the category currently with an average of ⟨g⟩ = 0.66. Meanwhile that, the whole indicators in class control is in the category currently with an average of ⟨g⟩ = 0.40. Completeness classical in both class presented in Table 8.

Table 7. Results of N-Gain Analysis of Creative Thinking Skills

Indicator	Experiment	Category	Control	Category
Fluency	0.7	Tall	0.44	Currently
Flexibility	0.65	Currently	0.39	Currently
Originality	0.63	Currently	0.37	Currently
Elaboration	0.67	Currently	0.42	Currently
Average	0.66	Currently	0.4	Currently

Table 8 shows difference completeness very striking classical between class experiments (87.5%) and class control (53.7%). Class experiment has beyond criteria completeness classical minimum 80%, while class control is at far below criteria the difference. This No can explained by factors ability beginning due to prerequisite tests show second class equivalent before

treatment. Fadillah et al. (2024) through meta- analysis conclude that the Physics E-Module in a way general more effective compared to conventional teaching materials, especially when integrated with learning models active such as PBL and approaches contextual like Ethno -STEM. Asrizal et al. (2022) also reported the advantages of STEM- based E-Modules over module conventional in increase results Study physics.

Table 8. Completion Competence Classical Learners

Class	N	Completed (≥70)	Not Completed	Completeness Classical	Category
XE 1 — Experiment (Ethno -STEM E-Module)	40	35	5	87.50%	Completed
XE 4 — Control (Print Module) Conventional)	41	22	19	53.70%	Not Completed

Effectiveness of the developed E-Module can explained through three mutually reinforcing mechanisms strengthen. First, training explicit four Torrance indicator through PBL syntax. Alabbasi et al. (2022) emphasized that every indicator need designed tasks special for activate it, while Guilford (1967) formulated divergent production as component main underlying creativity fourth indicator Hamimah et al. (2020), Mulyani (2020), and Desnita et al. (2024) through study experiment strengthen that PBL gives impact positive to ability think level tall participant educate.

Second, the use of Rumah Gadang as vehicle Developed Ethno -STEM in a way In-depth. The Context of Rumah Gadang No treated as illustration outskirts, but rather as system real place draft effort, energy potential, energy kinetic, law eternity energy and power linked in a way organic. Sumarni et al. (2020) stated that contextualization kind of this convert Study physics from memorize formula become understand phenomenon, so that room for think creative open in a way natural. Rohman et al. (2024) strengthens through study experiment that learning Ethno -STEM based wisdom ecological in a way significant increase creativity participant educate compared to learning conventional. Findings similar reported by Siregar et al. (2025) who developed a physics E-Module Ethno -STEM in manufacturing galamai and find its effectiveness in increase ability think creative participant educate. Maryanti et al. (2023) in general consistent show that the E-Module Ethno -STEM is based wisdom Yogyakarta local improve skills think creative participant educate.

Third, the digital format of the E-Module can be accessible through smartphone allows participant educate continue exploration outside of class hours. Mweene et al. (2020) and Seruni et al. (2019) emphasized that digital interactive media expands chance participant educate train skills complex without limitation space and time. Mithasari et al. (2024) strengthens that the E-Module is based on a digital flipbook platform and provides experience ergonomic learning on appropriate digital devices characteristics participant educate digital generation. Synergy third mechanisms—explicit PBL, contextualization Immersive ethno -STEM and flexible digital formats — explained Why class experiment reach superiority significant Good in completeness classical and in magnitude N-Gain fourth Torrance indicator compared class control.

In a way overall, Physics E-Module Based Problem Integrated Ethno -STEM in the context of Rumah Gadang has fulfil fourth objective research: produce product complete qualified, valid according to evaluation expert, practical according to teachers and participants educate and effective increase ability think creative. Third criteria quality Plomp et al. (2013)— validity, practicality and effectiveness — were met. in a way simultaneous through connectedness organic between the PBL model, the approach Rumah Gadang based Ethno -STEM, and interactive digital format.

Research Limitations and Implications

A number of limitations need examined in interpret findings this. First, test the effectiveness done on one school with size sample class 40 participant experiment students and classes control of 41 participants educate, so that generalization findings to population participant high school education national Still need replication cross schools and across regions. Second, the context Ethno -STEM used limited to the architecture of the Minangkabau Gadang House and the material on Business and Energy; the influence context other cultures on the material physics different need tested for ensure transferability approach. Third, measurement think creative use test essay based on four Torrance indicators and not yet integrate dimensions addition like abstractness of titles and resistance to premature closure which is also a Figural version of TTCT components (Almeida et al., 2008; Torrance, 2018). Fourth, duration treatment limited to one learning unit so that impact retention term length and transfer of skills to other materials not yet can evaluated.

Although there is limitations said, the findings study This give relevant implications Good in a way theoretical and practically. In theoretical, research This strengthen thesis of Sumarni et al. (2020) and Rohman et al. (2024) that integration Ethno -STEM with learning models active like PBL produces greater impact strong compared to application of each approach in a way

separate, and give proof empirical that context wisdom local Minangkabau can functioning as valid organizing principle for draft physics effort and energy. In practical, the resulting E-Module can become references for high school physics teachers in West Sumatra to develop similar teaching materials on the material physics others and can become part from collection digital school teaching materials that support implementation Independent Curriculum Phase E. Research advanced recommended to (1) expand test subjects to a number of school with characteristics different, (2) developing Ethno -STEM E-Modules on the material other physics such as movement harmonics, vibrations, or wave with context culture different, (3) measure impact to other dimensions such as think critical, motivation learning, attitude scientific and digital literacy of participants educate, and (4) do longitudinal study for evaluate retention and transfer of skills think creative (Maryanti et al., 2023; Siregar et al., 2025).

Conclusion

Study development This succeed produce physics E-Modules based problem integrated Ethno -STEM on the material of Business and Energy for participant educate Class X SMA. E-Module developed use Canva application and run it as flipbook through Heyzine load component complete which combines five syntaxes Problem Based Learning with wisdom local Minangkabau (Gadang House) as context Ethno -STEM. Four findings main reported in study this. First, the results validation by three expert shows that the E-Module is very valid with an average Aiken's V = 0.98 in five aspects assessment. Second, testing practicality by two teachers, nine participant educate (small group) and four tens participant the field test produced an average practicality of 86.76% –89.27%, all of which is in the very practical category. Third, testing effectiveness through design pretest-posttest control group prove that the E-Module is effective increase skills think creative participant education, shown by the difference significant average posttest (t = 6.351; Sig. = 0.000), value N-Gain class more 0.66 experiments tall compared to class control (0.40), and completeness classical 87.5% which exceeds minimum criteria 80%. Fourth, fourth Torrance's indicators— fluency, flexibility, originality and elaboration — developed in a way consistent in class experiments, with fluency reach category high (⟨g⟩ = 0.70). Contribution main study This lies in the proof that connectedness organic between interactive digital formats, PBL models and approaches Ethno -STEM in the context of Rumah Gadang can fulfil third criteria quality educational design research in a way simultaneous and functional effective as means training explicit four indicator think Torrance creative research this also enriches literature Ethno -STEM Indonesia with add context wisdom Minangkabau local on the material of Business and Energy, as well as provide a development model that can adapted for context culture and materials physics others. For physics teachers, E-Modules can utilized as alternative contextual teaching materials that support implementation Independent Curriculum Phase E, whereas for participant educate, E-Modules facilitate learning independent and meaningful through smartphones outside of class hours. Study advanced recommended for expand context wisdom local to the material physics other, expanding test subjects to more Lots school with characteristics different, and measure impact use of E-Modules for dimensions other learning such as ability think critical, motivation learning, attitude scientific and digital literacy of participants education. Longitudinal study for evaluate retention skills think creativity and transferability to other materials are also required for strengthen generalization findings.

Acknowledgments

Writer says accept love to Prof. Dr. Usmeldi, M.Pd. as lecturer mentors, to expert validators, to Principal of State Senior High School 1 Pantai Cermin along with the physics teacher, and to participant educate class X which has participate in stage one to one evaluation, small group evaluation and field test.

Author Contributions

Conceptualization, G.S. and U.; methodology, G.S. and U.; software, G.S.; validation, U.; formal analysis, GS; investigations, G.S.; resources, GS; data curation, GS; writing—original draft preparation, GS; writing—review and editing, G.S. and U.; visualization, G.S.; supervision, U. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

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