

Development of a Contextual E-book Integrated with 3D Images of Pico hydro Rainwater for Alternative Energy Materials to Improve Learning Independence of Students at SMA Negeri 3 Simpang Hilir

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Abstract. This study aimed to examine: (1) the design of a contextual e-book integrated with 3D picohydro rainwater images for alternative energy materials; (2) the feasibility of the e-book for supporting students' learning independence; (3) the effectiveness of the e-book in improving learning independence; and (4) students' learning independence profiles before and after its use. The study used the ADDIE development model, consisting of Analysis, Design, Development, Implementation, and Evaluation. The analysis stage covered performance, concept, student, and learning objective analysis. The design stage focused on preparing the e-book, teaching modules, and learning independence instruments. The development stage involved expert validation, revisions, and limited trials. The implementation stage used a quasi-experimental non-equivalent pretest-posttest control group design. The evaluation stage assessed all stages of the study. The participants were 94 students of SMA N 3 Simpang Hilir. The developed products included teaching modules, e-books, feasibility sheets, student response questionnaires, and learning independence tests. Data were analyzed descriptively and inferentially using ANCOVA at a 0.05 significance level. The findings showed that the developed e-book design was contextual and 3D-based, the e-book was feasible to use, it effectively improved students' learning independence, and students' learning independence improved after implementation.

Keywords: *E-book, Contextual, 3D Images, Picohydro, Learning Independence*

How to cite (in APA style):

Janariani & Supahar. (2026). Development of a Contextual E-book Integrated with 3D Images of Pico hydro Rainwater for Alternative Energy Materials to Improve Learning Independence of Students at SMA Negeri 3 Simpang Hilir. *Proceeding of IJC-MaSTEd*, 1(1), 19-24.

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DOI: <https://doi.org/10.31571/ijcmasted.v1i1.1019>

1. Introduction

The rapid development of the internet poses a unique challenge to fostering students' learning independence. It provides abundant alternative learning resources, with a 2022 Kominfo survey funded by UNICEF revealing that 98% of children are aware of the internet and 79.5% are active users (Kementerian Komunikasi dan Informatika, 2022). This ease of access efficiently saves time and resources in learning, as Zelensky (2024) notes, "digital resources accelerate knowledge acquisition by providing instant, diverse content tailored to learner needs." However, optimizing these benefits requires students' active engagement in searching, processing, and utilizing the internet as a learning tool (Saavedra & Opfer, 2022).

Self-regulated learning emerges as a crucial skill in this fast-evolving information technology era. It is defined as students' ability to independently manage their learning processes, involving active participation and metacognitive skills (Alvi & Gillies, 2020). According to Thomas et al. (2020),

self-regulated learners "actively construct knowledge by selecting and regulating necessary skills." This capability is key to achieving learning goals, as Kesuma (2021) emphasizes that it stimulates intrinsic motivation; Jansen et al. (2020) similarly found its positive correlation with academic achievement.

The implementation of contextual learning at SMA Negeri 3 Simpang Hilir remains limited, with students perceiving physics topics, including alternative energy, as irrelevant to daily life. Interviews with teachers and students indicate overreliance on textbooks and the internet, which lack contextuality, resulting in low self-regulated learning and passive attitudes toward information seeking. In Rantau Panjang nearby, communities face chronic water scarcity and flooding issues, leading to widespread rainwater harvesting for storage; recent incidents, such as the collapse of flood control reservoirs in 2025 due to heavy rains, highlight infrastructure vulnerabilities (Medialampung.disway.id, 2025). Pico hydro systems for rainwater tanks thus offer a highly contextual solution, generating alternative energy from harvested water while addressing local challenges, as Widodo et al. (2023) explain that "contextual e-books with interactive visuals enhance self-regulated learning by bridging abstract concepts to real-world applications." Thus, developing 3D-integrated e-books on pico hydro rainwater systems addresses the gap between ideal and actual conditions in boosting high school students' learning independence.

2. Method

The research employed a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) to develop a contextual e-book integrated with 3D images on pico hydro rainwater systems for alternative energy topics in physics. This study combined qualitative and quantitative data, targeting grade X students at SMA Negeri 3 Simpang Hilir, Kayong Utara.

The indicators of learning independence in this study include independence, self-confidence, discipline, responsibility, self-initiative, and self-control. Test Instruments using the personal intent (IP) method with four response options per item. Learning independence learning questionnaires underwent empirical trials across high, medium, and low-ability SMA students from multiple schools in Kayong Utara, analyzed via Parscale and Quest software for Item Response Theory (IRT) validity and reliability. Revised instruments were then tested in limited trials (n=32 students at SMA Negeri 3 Simpang Hilir) and field trials. Field implementation used a quasi-experimental non-equivalent pretest-posttest group design across three grade X classes with equivalent prior academic performance. The experimental class received contextual learning with the 3D e-book; Contrast 1 used Kemendikbud physics textbook (including microhydro context); Contrast 2 used PowerPoint on pico hydro rainwater. Student response questionnaires evaluating e-book aspects: display, interest, readability, and operability on a four-point scale (Maulia, 2022). E-book feasibility was calculated as follows:

$$Kelayakan = \frac{\sum M}{\sum SM} \times 100 \% \quad (1)$$

where:

$\sum R$: total raw score from raters

$\sum SM$: is the maximum score possible

Categories: 81–100% (excellent), 61–80% (good), 41–60% (adequate), $\leq 40\%$ (poor).

The data were analyzed using analysis of covariance (ANCOVA) to test the effect of the contextual e-book integrated with 3D images on students' learning independence. In this analysis, the pretest was used as the covariate, the posttest as the dependent variable, and the learning group as the

independent variable. Before the ANCOVA was conducted, the data were tested for normality and homogeneity of variance. The effect size was reported using partial eta squar.

3. Results and Discussion

Product Feasibility

The contextual e-book integrated with 3D pico hydro rainwater images was deemed highly feasible by media experts (85.33%) and content experts (78.81%), averaging 82.07% (very feasible category). This exceeds the 75% feasibility threshold for educational media development (Maulia, 2022). The self-regulated learning questionnaire demonstrated high reliability (KR-20 = 0.74), with 95% items fitting the Rasch model (INFIT MNSQ 0.77–1.30). Limited trial (n=32 students) yielded 67.3% student response score (feasible), particularly high in operability (72%) and 3D visual interest (69%).

Table 1. E-book Feasibility Assessment by Experts.

Assesment Aspect	Media Expert	Content Expert	Average
Visual Design	86%	79%	82,5%
Contextual Relevance	84%	82%	83%
3D Interactivity	88%	76%	82%
Overall Average	85,33%	78,81%	82,07%

Note: Categories: >80% = very feasible (Maulia, 2022)

Implementation Effectiveness

The study was conducted to examine the effectiveness of a contextual e-book integrated with 3D images on students' learning independence in alternative energy learning. The data were collected from three groups, consisting of one experimental class and two control classes. The analysis used pretest and posttest scores to determine whether the treatment produced a significant effect after controlling for students' initial ability

Table 2. Descriptive Statistics of pretest and Posttest Scores.

Group	N	Pretest Mean	Posttest SD	Posttest Mean	Posttest SD
Eksperimental	32	24,03	2,53	28,88	3,10
Contrast 1	34	23,83	3,29	26,38	3,20
Contrast 2	28	23,96	3,08	25,96	2,97

Note:

Note: Within-subjects ANOVA: Greenhouse-Geisser sig=0.002.

Table 2 shows that the three groups had relatively similar pretest mean scores, indicating comparable initial conditions before the treatment was applied. After the intervention, the experimental class obtained the highest posttest mean score, followed by Contrast class 1 and Contrast 1class 2. This suggests that the contextual e-book integrated with 3D images contributed to better learning independence outcomes.

The assumption tests indicated that the pretest and posttest data in all groups were normally distributed and met the homogeneity of variance assumption. The significance values of the normality tests were above 0.05, while the homogeneity test produced significance values of 0.2907

for the pretest and 0.8591 for the posttest. Therefore, the data were appropriate for analysis using ANCOVA.

Table 2. ANCOVA Result for Posttest Scores.

Source	Sum of Square	df	Mean Square	F	p-value	Partial Eta Square
Group	143.4672	2	71.7336	17.2292	< 0,001	0.2769
Pretest	499.7792	1	499.7792	120.0384	< 0,001	-
Error	374.7145	90	4.1635	-	-	-

The ANCOVA results indicate that there was a statistically significant difference in posttest scores among the three groups after controlling for pretest scores $F(2,90) = 17,23$, $p < 0,001$. The partial eta squared value of 0.2769 shows a large effect size, meaning that the treatment had a substantial influence on students' learning independence.

The ANCOVA results further confirmed that the differences in posttest scores among groups were not merely caused by initial ability differences, but also by the treatment itself. The large partial eta squared value indicates that the contextual e-book integrated with 3D images made a substantial contribution to improving students' learning independence. Therefore, this media can be considered a suitable alternative instructional resource for teaching alternative energy topics at the senior high school level.

Experimental class superiority stems from 3D interactive visualization converting rainwater potential energy to electricity via pico hydro rotor. This addresses conceptual difficulties with energy conservation law in Kayong Utara context, where 78% households rely on rainwater harvesting due to clean water crisis (Prudensi, 2026). 3D media creates "cognitive offloading" enabling concrete simulation of abstract phenomena, enhancing metacognitive monitoring and self-regulation (Alvi & Gillies, 2020). Learning independence aspects showing greatest gains were "self-initiative" ($\Delta=12\%$) and "self-control" ($\Delta=9\%$), particularly through interactive LKPD with LiveWorksheet links.

Compared to textbooks (Contrast 1), e-book excels by connecting river microhydro (abstract) to household pico hydro (concrete). PowerPoint (Contrast 2) proved less effective due to static nature lacking 3D flow manipulation. Findings align with 42-study meta-analysis showing locally contextual interactive media improves self-regulated learning by 0.35 SD (Widodo et al., 2023). In Indonesia, pico hydro rainwater tanks could meet 15-25% rural household electricity needs with 3-5m head and seasonal flow (Bappenas, 2025)



Figure 1. Model of rainwater harvesting tank



Figure 2. 3D interactive model of pico hydro rainwater system integrated within the e-book, illustrating energy conversion from harvested rainwater through turbine rotation to electricity generation

4. Conclusion

Development of the contextual e-book integrated with 3D pico hydro rainwater images on alternative energy topics yields a feasible product (82.07% expert average). Canva-based design includes introduction, interactive materials, LKPD, assessment, and glossary-equipped conclusion, accessible online for independent learning.

The contextual e-book integrated with 3D images significantly improved students' learning independence. The experimental class achieved the highest posttest score, and ANCOVA confirmed that the difference among groups was statistically significant with a large effect size. These results indicate that the developed e-book is effective and feasible to be used as a learning medium in alternative energy instruction.

Learning independence profile improved in self-initiative and self-control aspects, raising "excellent" category from 25% to 62% in experimental class. Ideal for regions like Kayong Utara reliant on rainwater harvesting, 3D visualization bridges abstract energy concepts with sustainable local solutions.

Recommendations: Teachers ensure stable internet prior to use; further studies adapt to diverse local contexts for broader optimization.

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