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Interactive E-Comic Development Based on Problem-Based Learning for Transforming Science Education

Rizki Dwika Septiarini¹; Annurul Zahwa²; Atika Anggraini³; Agus Miftakus Surur⁴; Sabrina Nadjib Mohamad⁵; Nur Jahan Ahmad⁶

¹²³⁴⁵⁶Universitas Islam Negeri (UIN) Syekh Wasil Kediri, Indonesia

Correspondence e-mail: atikaanggraini@uinkediri.ac.id

Abstract:

The topic of light and optics is abstract in nature and therefore requires learning media that can visualize concepts concretely and match the dominant visual learning style of students, particularly among Grade VIII B students at MTsN 6 Kediri. This condition calls for science learning media that are interactive, contextual, and oriented toward problem solving. This study aims to develop an interactive e-comic based on Problem-Based Learning (PBL) for the topic of light and optics, and to examine its feasibility and practicality as a learning medium. The study employed the ADDIE model (Analyze, Design, Develop, Implement, Evaluate). The results show that the interactive e-comic was rated highly feasible based on validation by a material expert (87.5%) and a media expert (93.5%), and practical based on user responses in the small-scale trial (72%) and the large-scale trial (78%). The study concludes that the PBL-based interactive e-comic is feasible and practical as an alternative learning medium for transforming science learning on light and optics into a more interactive and contextual experience.

Keywords: E-comic; PBL; Light and Optic

Introduction

Educational transformation in the digital era demands learning innovations that go beyond replacing printed media with digital ones and genuinely change how students interact with knowledge. The digitalization of science education is an important agenda in this effort, given that natural science (IPA) learning still relies heavily on text and verbal explanation, which are poorly suited to bridging abstract concepts and students' concrete experiences. This need is especially urgent for science topics that are difficult to observe directly, such as light and optics, which require strong visualization and imagination skills to be well understood.

Based on a needs analysis at MTsN 6 Kediri, most Grade VIII B students were found to have a tendency toward a visual learning style, approximately 63.6% of all students. Students with a visual learning style tend to understand information more easily when it is presented as pictures, diagrams, and other illustrations. However, the learning resources available at the school are still dominated by textbooks with few colored illustrations and by instructional videos that tend to position students as passive viewers. This gap between students' learning style characteristics and the available learning media shows that learning technology innovation is no longer merely an option but a fundamental necessity for achieving high-quality science learning.

One form of learning technology innovation that is relevant to this need is the e-comic, a digital medium that integrates images and text in an interactive story narrative. Compared with printed comics, e-comics offer added value in the form of digital accessibility, interactive features such as audio and navigation, and ease of distribution without reliance on physical media, in line with the agenda of digitalization and digital literacy development in education. The use of e-comics is supported by the Multimedia Learning Theory, which holds that learning is more effective when information is presented through a combination of visual and verbal elements. To make learning more meaningful and contextual, the e-comic in this study is combined with the Problem-Based Learning (PBL) model, a learning model that places real-world problems as the starting point of the learning process so that students are actively engaged in identifying and solving problems, and which serves as an innovative teaching and learning approach to promote active student involvement.

Several previous studies have developed PBL-based e-comic media for various subjects and educational levels. Muhlisin et al. developed a PBL-integrated science e-comic on the respiratory system for Grade VIII students, which was rated highly valid by a media expert (88.6%) and a material expert (84.6%), and achieved a practicality level of 83.54% based on student responses. A'fifah, Latifah, and Sodikin developed an interactive PBL-based physics e-comic on fluids, which obtained very high feasibility percentages from a material expert (89.40%), a media expert (78%), and a learning instrument expert (91.67%), with "very interesting" responses from educators (95%) and students (91.49%). Wahyuni et al. developed a PBL-based e-comic for mathematical problem-solving skills, which was declared valid (score 3.57) and highly practical (86%) using the Plomp development model. Meanwhile, Lestari and Projosantoso developed a PBL-model science comic on environmental pollution that was rated highly feasible by a material expert, a media expert, teachers, and peers, with an average score above 4.2 on a 5-point scale.

These four studies consistently show that PBL-based e-comics can be developed with high levels of feasibility and practicality across various topics, from the respiratory system, fluids, and mathematical relations and functions to environmental pollution. However, development research on PBL-based e-comics specifically for light and optics

remains very limited. The closest study, a PBL-based digital comic on vibrations, waves, and light, was limited to expert validation using a simplified 4D model (Erfani & Yanto, 2024), so a complete development process through the ADDIE stages, accompanied by a practicality test with users, has not yet been reported for this topic. This topic is among the most abstract in science and among those most in need of visualization support. The novelty of this study lies in the development of an interactive PBL-based e-comic designed specifically for light and optics, integrating the PBL syntax into the storyline and adapting the media's appearance to the dominant visual learning style of the students, as a concrete contribution to efforts to transform science learning through innovation and the digitalization of educational media.

Based on the above, this study aims to develop an interactive e-comic based on Problem-Based Learning for light and optics for Grade VIII B students at MTsN 6 Kediri, and to examine its feasibility and practicality as a learning medium. Specifically, the study focuses on three main aspects: (1) examining the characteristics of the developed PBL-based interactive e-comic, (2) examining its development process through the stages of the ADDIE model, and (3) assessing the level of feasibility and practicality of the media based on expert validation and user trials. Through this examination, a comprehensive picture of the quality of the developed media product is expected, as a form of innovation and digitalization in support of higher-quality science learning.

Methods

This study is Research and Development aimed at producing a learning media product in the form of an interactive e-comic based on Problem-Based Learning (PBL) for light and optics, and at examining its characteristics, feasibility, and practicality as a learning medium. The development procedure followed the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation (Branch, 2010). The ADDIE model was chosen because of its systematic yet flexible nature, which allows evaluation and improvement at every stage before the product proceeds to the next one.

The analysis stage was carried out through interviews with the science teacher and questionnaires distributed to Grade VIII B students at MTsN 6 Kediri to identify learning needs, student characteristics (including the tendency toward a visual learning style), and the difficulties encountered in learning light and optics. A curriculum analysis was also conducted to ensure that the content aligned with the Learning Outcomes (CP), Learning Objectives (TP), and Learning Objective Flow (ATP) of the Merdeka Curriculum.

In the design stage, a storyboard and initial e-comic design were prepared using Canva and Heyzine Flipbook. The storyboard was designed to explicitly integrate all five PBL syntax phases into the storyline: problem orientation, student organization, investigation, development and presentation of results, and evaluation and reflection. The design also took a multimodal approach by including audio elements, simple practical activities, and written exercises to accommodate the diversity of students' learning styles. At this stage, supporting instruments were also prepared, namely expert validation sheets and a user practicality response questionnaire.

The development stage involved producing the complete e-comic, which was then validated by a material expert and a media expert to assess content feasibility, presentation, graphics, alignment with the PBL syntax, and language use. The validation results, in the form of quantitative scores and qualitative feedback from the validators, served as the basis for product revision before user trials. After revision, a small-scale trial involving 8 students was conducted to assess the initial practicality of the media,

followed by a large-scale trial involving 33 Grade VIII B students as the main subjects to assess practicality under real learning conditions. In the implementation stage, students used the e-comic in groups over several meetings according to the story sections that had been designed, while in the evaluation stage the product was refined based on the trial results and user feedback. The product can be accessed at: <https://heylink.me/cahayadanoptik/>.

Data on media characteristics were collected descriptively from documentation of the product design and development process, covering the storyline structure, PBL syntax integration, interactive features, and the multimodal elements included. The feasibility and practicality data collection instruments consisted of validation sheets for the material expert and media expert, and a user response questionnaire using a Likert scale. Quantitative data in the form of validation scores and practicality response scores were analyzed by calculating the average score percentage, both overall and per aspect.

Qualitative data in the form of comments and suggestions from validators and users were analyzed descriptively to formulate revisions and refinements of the product at each stage of development. With this procedure, the study is directed toward producing a comprehensive picture of the characteristics, feasibility, and practicality of the PBL-based interactive e-comic on light and optics.

Results and Discussion

Findings

Characteristics of the Developed E-Comic

This development study produced an interactive e-comic based on Problem-Based Learning (PBL) on the topic of light and optics for Grade VIII students of SMP/MTs. The medium is packaged as a digital flipbook that can be accessed through a link and is equipped with audio features, page navigation, simple practical activities, and interactive exercises. Structurally, the e-comic consists of a cover page, learning outcomes and objectives, usage instructions, character introductions, three main story sections, a glossary, references, and a developer profile.

The main characteristic of the medium is the explicit integration of all five PBL syntax phases into the storyline. Rather than being stated only as a label, each phase is represented through a concrete event in the story that students can follow and, in several parts, actively carry out. The correspondence between each PBL phase and its representation in the e-comic is summarized in Table 1.

Table 1. Integration of PBL Syntax Phases into the Storyline of the E-Comic

No.	PBL phase	Representation in the e-comic
1.	Problem orientation	A contextual problem is introduced at the beginning of the story.
2.	Student organization	Story characters form discussion groups.
3.	Investigation	Practical activities and concept exploration guided by story characters.
4.	Presentation of results	Group presentation activities depicted in the story.
5.	Evaluation and reflection	Concept summaries and evaluation questions.

Source: Research data

In addition, the medium was designed with a multimodal approach. Audio features were provided to accommodate auditory learners, practical activities were included for kinesthetic learners, and structured narrative text was prepared for read/write learners. Through this combination, the e-comic is intended to reach not only students with a dominant visual learning style, which is the natural strength of a comic, but also students with other learning preferences.

Feasibility of the Media

The validation results show that the e-comic was rated highly feasible for use. The material expert gave a feasibility percentage of 87.5%, with the aspects of content suitability, alignment with the PBL syntax, and language each in the highly feasible category. The media expert gave a percentage of 93.5%, with the graphics and interactivity aspects contributing the highest scores. The supporting instruments, namely the learning interest questionnaire and the pretest-posttest items, were also rated highly feasible at 92.5% and 96.8%, respectively. The complete validation results are presented in Table 2.

Table 2. Results of Expert Validation of the E-Comic and Supporting Instruments

No.	Validated component	Feasibility (%)	Category
1.	E-comic (material expert)	87.5	Highly feasible
2.	E-comic (media expert)	93.5	Highly feasible
3.	Learning interest questionnaire	92.5	Highly feasible
4.	Pretest-posttest items	96.8	Highly feasible

Source: Research data

Several suggestions were given by the validators, among them adding a glossary to each section of the comic and stating the PBL syntax more explicitly in the narrative. These suggestions were addressed through product revision before the trials were carried out.

Practicality of the Media

Based on user responses, the practicality of the media reached 72% in the small-scale trial and 78% in the large-scale trial, both of which fall within the practical category. The practicality assessment covered content feasibility, presentation feasibility, graphics, interactivity, and the language used in the media. The results are shown in Table 3.

Table 3. Practicality of the E-Comic in the Small-Scale and Large-Scale Trials

No.	Trial	Practicality (%)	Category
1.	Small-scale trial	72	Practical
2.	Large-scale trial	78	Practical

Source: Research data

An increase of six percentage points was recorded from the small-scale to the large-scale trial. To give an overall picture, all of the percentages obtained in this study are visualized in Figure 1.

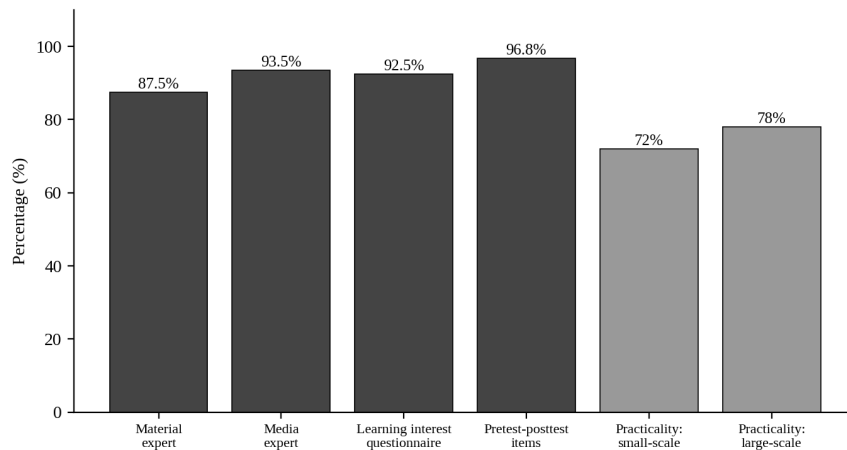


Figure 1. Feasibility and practicality percentages of the e-comic and its supporting instruments. Dark bars show expert validation results; light bars show practicality results from the small-scale and large-scale trials.

Taken together, the findings answer the three focal points of the development study. First, the e-comic has a clear and distinctive character, namely the full embedding of the PBL syntax in the story and a multimodal design. Second, the product was judged highly feasible by two experts and by the validation of its supporting instruments. Third, the product was judged practical by users in two successive trials. These three results form the basis for the analysis presented in the following section.

Analysis

Media Characteristics as a Form of Learning Innovation

The main characteristic of the developed e-comic lies in the explicit integration of all five PBL syntax phases into the storyline, rather than merely attaching the learning model as a label to existing media. This approach is consistent with the findings of Lestari and Projosantoso (2016), who emphasized that the storyline of a comic needs to be designed to follow the PBL syntax systematically so that it can train students' thinking skills rather than merely entertain. The integration of PBL into a digital comic on light-related content was also reported by Erfani and Yanto (2024), who regarded comics as a means of stimulating students' interest in topics perceived as difficult. However, that study stopped at expert validation, whereas the present study extends the process to student trials.

The difference between this study and the earlier studies is that it adds a multimodal layer, namely audio, practical activities, and structured text, which was not an explicit focus in the four previous studies. This approach is relevant to Dale's Cone of Experience (Dale, 1969), which states that engaging more senses in learning supports better information retention, and to the VARK theory (Fleming & Mills, 1992), which stresses the importance of providing multiple modes of representation for the diversity of students' learning preferences. In the developed e-comic, the two theories are translated into concrete design decisions: audio for auditory learners, practical activities for kinesthetic learners, and structured narrative text for read/write learners, while the comic format itself serves visual learners.

The developed e-comic also does not merely move a print format onto a screen. It changes how students interact with the material through digital navigation, audio elements, and an interactive story structure that demands active engagement rather than passive reading. Thus, this product represents a shift from digitalization as media conversion toward digitalization as a transformation of how learning takes place. This

distinction matters because a comic that is only scanned or reformatted keeps the same passive reading experience as its printed version, whereas the flipbook in this study gives students tasks to perform at specific points in the story, which is the kind of engagement that PBL requires.

Feasibility as an Indicator of Product Quality

The high feasibility percentages from the material expert (87.5%) and the media expert (93.5%) are consistent with the pattern in earlier development studies of PBL-based e-comics. Muhlisin et al. (2023) obtained feasibility of 84.6–88.6%, A'fifah et al. (2026) obtained 78–91.67% across various aspects, and Wahyuni et al. (2023) obtained a validity score of 3.57 on a 4-point scale. Comparable levels were reported for a PBL-based digital comic on vibrations, waves, and light, with an average validation of 90% (Erfani & Yanto, 2024), and for a flipbook-based digital comic for junior secondary school, with expert validation between 98.33% and 100%. These comparisons are summarized in Table 4.

Table 4. Comparison of Expert Validation Results with Earlier Studies

No.	Study	Validation result
1.	This study (material expert)	87.5%
2.	This study (media expert)	93.5%
3.	Muhlisin et al. (2023)	84.6–88.6%
4.	A'fifah et al. (2026)	78–91.67%
5.	Wahyuni et al. (2023)	3.57 (4-point scale)
6.	Erfani and Yanto (2024)	90% (average)
7.	Flipbook-based digital comic, junior secondary school	98.33–100%

Source: Research data and cited studies

This similarity of pattern suggests that systematic development models that include formative evaluation at each phase, such as ADDIE, can produce media products with high feasibility across topics and educational levels. The result of the present study therefore does not appear to be an isolated case, but rather reflects the consistency of a development procedure that treats evaluation as part of every stage.

The media expert's score (93.5%) in this study is among the highest compared with the earlier PBL-based e-comic studies discussed above. Interestingly, it is also higher than the material expert's score (87.5%), a pattern opposite to the findings of Muhlisin et al. (2023) and A'fifah et al. (2026), where the material expert's scores were higher. The higher score from the media expert indicates that the product's strength lies in its graphics and interactivity, while the substantive aspect of the material, although still highly feasible, leaves room for further refinement, for example in the depth of explanation of more complex concepts such as image formation by lenses. This reading is in line with the nature of the medium: a comic must condense content into short dialogues and panels, so the balance between narrative appeal and conceptual depth is a recurring design challenge.

The validators' specific feedback, such as adding a glossary and making the PBL syntax explicit in the narrative, shows that expert validation serves not only as a measurement but also as a quality control mechanism that shapes the final product. The

two suggestions point in the same direction as the other findings: the glossary strengthens the conceptual side of the material, which was the aspect with the lower score, and the explicit PBL syntax strengthens the instructional alignment of the story. This underscores the importance of repeated formative evaluation in media development, as emphasized in the basic principles of the ADDIE model.

The supporting instruments, namely the learning interest questionnaire (92.5%) and the pretest-posttest items (96.8%), also reached the highly feasible category. This is important for the continuation of the research, because the validity of an instrument determines whether data collected in later effectiveness testing can be trusted. In other words, the study has prepared not only the medium but also the measurement tools required for the next stage.

Practicality of the Media and Its Relevance to Independent Learning

The increase in practicality from the small-scale trial (72%) to the large-scale trial (78%) shows that the refinements made based on feedback from the early stage contributed to the ease of use of the media more broadly. This level of practicality is lower than the findings of Wahyuni et al. (2023), who reported practicality of 85.1–87.87% for a PBL-based e-comic on mathematical problem solving, although it remains within the practical category. Both values are also lower than the expert feasibility percentages, which ranged from 87.5% to 96.8%. A direct comparison should be made carefully, since experts and students assess the medium from different viewpoints and with different instruments. Nevertheless, the gap suggests that what is judged ideal by experts is not automatically as easy to use for students, and that the user experience, for instance the clarity of navigation and the length of the story, remains an area for improvement.

A fairly good level of practicality is important, particularly in the context of independent learning outside the classroom, because media that are easy to access and navigate without intensive teacher guidance have the potential to support students' learning independence and widen the range of conditions in which the media can be used, including online. Since the e-comic is accessed through a link, students can open it on their own devices, repeat sections they have not understood, and use the audio and glossary features without waiting for the teacher.

From the perspective of educational digitalization, the practicality of this digital flipbook is also relevant to the characteristics of students as digital natives who are accustomed to interacting with technological devices. Compared with printed comics, the digital format removes physical distribution barriers and opens opportunities for more flexible content updates. This is an added value in line with the sustainable development agenda in education, since digital media do not require reprinting for every revision or academic year.

For teachers, these findings carry several practical implications. The e-comic can be used as a ready-made learning resource whose structure already follows the PBL phases, so teachers do not have to design the sequence of problem orientation, group work, investigation, presentation, and reflection from scratch. It can also be assigned for independent study before or after a lesson, while class time is used for the group discussion and presentation activities that the story models. For media developers, the results indicate that a development process combining expert validation, a small-scale trial, and a large-scale trial gives repeated opportunities to detect weaknesses early, and that the feedback gathered at each step should be reported explicitly because it explains why the final product differs from the initial draft.

Limitations of the Study

This study focused on the development process, characteristics, feasibility, and practicality of the media, and therefore did not empirically measure its impact on learning outcome variables such as interest and students' cognitive achievement. Testing the effectiveness of the media on these variables is a relevant next step for future research, to complete the overall picture of this e-comic's contribution to learning light and optics. Future studies may also examine whether the multimodal features, particularly audio and practical activities, contribute differently for students with different learning preferences.

Conclusion

This development study successfully produced an interactive e-comic based on Problem-Based Learning (PBL) for light and optics for Grade VIII SMP/MTs students, developed systematically and continuously through the ADDIE model. The main characteristic of the medium lies in the explicit integration of all five PBL syntax phases into the storyline, combined with a multimodal approach consisting of audio features, practical activities, and structured narrative text, so that the medium accommodates not only the dominant visual learning style among students but also other learning preferences.

Based on the validation results, the medium was rated highly feasible, with a feasibility percentage of 87.5% from the material expert and 93.5% from the media expert. The supporting instruments, namely the learning interest questionnaire and the pretest-posttest items, were also rated highly feasible at 92.5% and 96.8%, respectively. In terms of practicality, user responses in the small-scale and large-scale trials reached 72% and 78%, respectively, which fall within the practical category and indicate that the medium is easy for students to use and understand.

These findings confirm that the PBL-based interactive e-comic is feasible and practical to develop as an alternative learning medium for light and optics. More than just a media product, this development represents a concrete embodiment of the transformation of science learning through innovation and digitalization, in line with efforts to deliver science learning that is more interactive, contextual, and oriented toward problem solving. Future research is recommended to test the effectiveness of this medium on learning outcome variables such as students' interest and cognitive achievement, to complete the overall picture of its contribution to learning light and optics.

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