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Development of a Physics Educational Comic as a Learning Medium for Pressure Materials

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ABSTRACT

This study addresses the challenge of low scientific literacy and conceptual understanding in physics among Indonesian students, a problem exacerbated by limited access to technology in schools like SMPN 3 Dumai. To counter the reliance on conventional teaching methods, this research developed an educational comic integrated with the Problem-Based Learning (PBL) model for the topic of Pressure. The objectives were to create a valid and practical learning medium and to test its effectiveness in enhancing junior high school students' conceptual understanding. Using the Research and Development (R&D) method with the 4D model, the comic was designed and validated by experts. A one-group pretest-posttest design was implemented with 32 ninth-grade students to measure learning outcomes. The results demonstrated a significant improvement in conceptual understanding, with the mean score increasing from 13.75 to 68.05. The N-Gain analysis indicated high improvement for most test items. Furthermore, the media received high feasibility and practicality ratings from both expert validation and user responses. The study concludes that PBL-based physics comics are a highly effective and practical learning medium that can significantly improve students' conceptual mastery, providing a valuable alternative for classrooms with limited technological resources..

Keywords : Educational Comics, Problem-Based Learning, Physics Learning.

I. INTRODUCTION

Education is a conscious effort to realize a cultural heritage from one generation to another. Education makes this generation a role model for the teaching of previous generations [1]. Education in Indonesia is expected to develop students as individuals through debriefing in various fields of study. With the provision of appropriate materials, students can develop logic and think reasonably. According to Permendikbud Number 103 of 2014, the scientific approach is operationalized in the form of learning activities that include observing, questioning, gathering information (trying), reasoning (associating), and communicating.

In line with the general purpose of education, science learning, especially science/physics, has a strategic role in improving science literacy, critical thinking skills, and readiness to face the challenges of the 21st century[2]. Science/Physics education not only emphasizes mastery of concepts and facts, but also the development of high-level thinking skills such as reasoning, creativity, open problem-solving, and collaboration and communication skills [3] . Therefore, the learning process needs to be actively and fun designed at every level of education. Thus, quality science education will produce individuals who have good scientific knowledge, understanding, and attitudes [4].

Furthermore, the special purpose of science subjects is to develop the potential of students to be able to understand various aspects of science, including facts, concepts, principles, laws, and theories. However, in practice, the achievement of Competency Standards and Basic Competency is still carried out based on their respective fields of study so that the integration between science materials has not been fully realized [5]. At the junior high school (SMP) level, students begin to be introduced to basic concepts of physics that require the ability to think logically and scientifically. Physics is a subject that is closely related to natural phenomena in daily life and includes facts, concepts, principles, laws, and theories. Problems in physics can be solved if students are able to understand the basic concepts of physics well [6].

One of the essential concepts in junior high school physics is the concept of pressure. Understanding this concept not only means knowing the theory, but also being able to apply it to solve real problems [7] . Without a

deep conceptual understanding, students run the risk of relying solely on mathematical calculations without being able to relate to contextual situations in everyday life.

Based on the results of the 2022 Programme for International Student Assessment (PISA) conducted by the OECD, the average score of Indonesian students in science competency is 383 points, down from 396 points in 2018. This decline is largely attributed to learning loss due to the COVID-19 pandemic [8]. PISA uses a 0–1000-point scoring scale, with the international average being in the range of 489–490 points. If Indonesia's score (383 points) is compared to the international standard of 500 points, the relative achievement of Indonesian students is about 77% of the OECD standard for science competence. This fact reflects the resilience of the Indonesian education system in facing the impact of the pandemic, in line with various recovery efforts, such as the implementation of the Independent Curriculum and the National Assessment [9]

The main problems faced by Indonesian students in understanding physics include low understanding of concepts, high levels of misconception, and weak problem-solving skills and science literacy. Research shows that only about 30% of students actually understand the concepts of physics being taught, while 36% have misconceptions and 34% do not understand concepts at all [10]. The causative factors include a lack of learning that emphasizes the identification of misconceptions, a lack of experimental and discussion activities, weak instilling problem-solving skills, and low student motivation [11]. Many students also experience boredom in learning science, especially physics, because the delivery is considered too theoretical and lacking contextual. Data shows that junior high school students face the highest difficulty in understanding physical symbols (85.5%), followed by difficulties in counting (83.3%), analyzing graphs and drawings (64%), and understanding concepts (38.8%) [12].

Students often experience misconceptions about hydrostatic pressure, especially regarding the effect of container shape, area, and pressure direction [13]. This indicates that conceptual understanding in fluid mechanics remains a significant challenge at the junior high school level. In line with this, interest in physics and mathematical comprehension were found to have a positive correlation with problem-solving ability among students in Ambon, Indonesia [14].Furthermore, teaching approach plays a crucial role in shaping students' conceptual learning outcomes, as demonstrated by research that revealed significant effects of different instructional methods on physics understanding [15]. However, inconsistencies in how fundamental principles such as Pascal's law are presented in textbooks may also contribute to students' confusion [16].

This condition is also reflected in the results of observations at SMPN 3 Dumai. This school experiences limited internet signals and unstable electricity supply, making it difficult to use e-learning. Teachers rely more on package books and Student Worksheets (LKS) as the main sources. This situation is exacerbated by the dominance of lecture methods, the lack of practicum, and the lack of interesting learning media. As a result, students tend to simply memorize formulas without really understanding the concepts and their application in everyday life.

Learning media plays an important role in the physics learning process because it serves to help visualize abstract concepts, increase motivation, and encourage active student involvement. According to Prahani et al. [17], interactive learning media in physics significantly improve students' outcomes, deepen conceptual understanding, and make learning more engaging. Their bibliometric and literature review of the top 100 most-cited studies over the last thirty years highlights the crucial role of interactivity in digital learning environments.

Similarly, Stănciulescu et al. [18], [19] found that visualization media substantially increase students' self-efficacy and task engagement, showing a medium to large effect size that indicates improved motivation and participation in active learning contexts. Furthermore, Halim et al. [19] demonstrated that e-learning media such as narrative feedback, modular instruction, and realistic video effectively reduce misconceptions in physics learning. Among these, narrative feedback was shown to have the most significant impact, based on a quasi-experimental study involving 281 students using a three-tier diagnostic test. In general, learning media can be understood as everything that is able to channel messages and stimulate students' thoughts, feelings, attention, and abilities so as to create an effective learning process [20]. Thus, media is not only an intermediary of information, but also a means to clarify concepts, provide visual support, simplify complex material, and increase motivation to learn [21]

Theoretically, the use of technology-based media such as multimedia, augmented reality, and virtual labs is supported by multimedia cognitive theory, multiple representation theory, and constructivist learning theory. These three theories emphasize the importance of presenting information through various channels (visual, audio, interactive) to strengthen students' understanding and retention [22]. In the context of physics learning, the proper use of media is very important because it can help students understand concepts that are abstract and

difficult to imagine. Without the support of learning media, students often experience learning difficulties which ultimately have an impact on low learning outcomes[23].

One of the alternative learning media that is in accordance with school conditions with technological limitations is educational comics. Comics have the advantage of presenting material visually and narratively, so abstract concepts are easier to understand. Through a combination of images and text, comics can present material in a concrete, contextual, and interesting way for students [24]. Furthermore, comics have great potential as an effective learning medium in various fields, such as language, economics, and basic education. A number of studies have shown that the use of comics has been proven to increase reading interest, learning motivation, concept understanding, and create a fun and interactive learning atmosphere [25].

The advantages of comics as a learning medium include: visually appealing material presentation, light and easy-to-understand language, portability because it can be carried and used anywhere, and flexibility to integrate with certain values or contexts [26]. Comics are also considered very feasible and practical to use by both teachers and students, with expert validation and positive user responses. In addition, comics can help foster a positive attitude towards learning, encourage creativity, and make the learning process more meaningful [27]. Another advantage of comic media is its ability to make students read without feeling forced. Story narratives combined with pictures are able to attract students' attention and facilitate understanding. Not surprisingly, many developed countries have used comics as a strategy to increase students' interest in reading textbooks[28].

Previous research on educational comics has generally focused on the aspect of visualizing concepts and increasing student learning motivation. Comics have proven to be able to attract students' interest, but their function is still limited to additional illustrations and has not been fully integrated into certain learning strategies. Thus, although comics are effective in helping students understand the material, their role is not optimal as a structured learning medium. The novelty of this research lies in the development of educational comics that are integrated with the Problem Based Learning (PBL) syntax. The storyline in comics is arranged based on PBL stages, namely problem orientation, student organization, investigation, development of works, and analysis and evaluation. In this way, comics not only function as a narrative-visual medium, but also as a means of applying a problem-based learning model.

The integration of Problem Based Learning (PBL) into comic media is increasingly relevant to current educational research trends. Several recent studies have shown that PBL-based comics, both in physics, mathematics, and science subjects, are able to make students more active, increase learning motivation, deepen concept understanding, and develop problem-solving skills [26]. This is because PBL comics adapt the stages of PBL into the storyline—starting from problem orientation, organization, guidance, solution development, to evaluation—so that students are directly involved in the process of scientific thinking and problem-solving [29]

In line with the formulation of the problem, the purpose of this research is to produce PBL-based physics comic media on pressure materials in junior high school. In addition, this study aims to test the effectiveness of comic media in improving students' understanding of concepts. Furthermore, this study is also aimed at determining the feasibility level of PBL-based physics comics as a learning medium through the results of expert validation, teacher response, and student response.

II. METHOD

This research uses **the Research and Development (R&D) method** which aims to produce products in the form of learning media and test their effectiveness. The R&D method emphasizes a systematic process, starting from the identification of potentials and problems, data collection, product design, validation, revision, to field trials to ensure the feasibility and effectiveness of the product [30]. Validation and repeated revisions are carried out so that the product is truly according to the needs of the user.

This study uses a mixed methods research approach that integrates quantitative and qualitative data to provide a more comprehensive understanding of the phenomenon being studied. This integration can be done through a variety of strategies, such as the use of convergence tables, joint displays, or triangulation, which allow researchers to compare, confirm, and enrich findings from both types of data [31]. The main advantage of this approach is its ability to generate the depth (of qualitative data) and breadth (of quantitative data) of information, so as to provide a more complete and valid picture[32]. This methodological approach also helps integrate qualitative and quantitative findings, clarifies theoretical propositions, and improves understanding of the relationship between theory and empirical results. It can challenge existing assumptions and help in developing new theories.[33]

The development model chosen was 4D (Define, Design, Develop, Disseminate) from Thiagarajan, Semmel, and Semmel (1974). This model is suitable for developing learning media because it provides systematic stages: (1) Define, analyze needs and formulate development goals; (2) Design, design initial product or prototype; (3) Develop, develop products through expert validation and trials; and (4) Disseminate, disseminate products through publication or limited distribution [34]. In the context of this study, the Disseminate stage is carried out in a limited manner.

To measure the effectiveness of the product, this study uses a quasi-experimental quantitative design with a one group pretest–posttest design model. The research scheme is shown as follows:

$$O_1 \rightarrow X \rightarrow O_2$$

Fig. 1. one group pretest–posttest design

Information:
O_1 = pretest,
X = treatment (physics comics),
O_2 = posttest.

Quantitative data in the form of pretest and posttest scores were analyzed through N-Gain calculations to determine the improvement of students' concept understanding. Meanwhile, qualitative data was obtained from the Likert scale questionnaire (student and teacher response) and the student reflective questionnaire. Qualitative data are analyzed descriptively and thematically to assess the eligibility, attractiveness, and ease of use of media.

The subject of this study is grade IX students of SMPN 3 Dumai with a sample of 32 people. The research instruments used consisted of a concept understanding test in the form of 10 description questions with interpreting, classifying, inferring, comparing, and exemplifying indicators; validation sheets involving subject matter experts and media experts; teacher and student response questionnaire; as well as a reflective student questionnaire. Through the use of these instruments, this research is expected to be able to ensure the validity, reliability, practicality, as well as effectiveness of Problem Based Learning (PBL)-based physics comic media in improving students' understanding of concepts on pressure materials.

Before being tested, PBL-based physics comic media was validated by material experts and media experts. Data from validation results from material experts and media experts were analyzed by calculating the average score of each indicator using the formula:

$$\bar{X} = \frac{\sum X}{N} \quad (1)$$

Information:
$\bar{X}$ = average score
$\sum X$ = total score obtained
N = number of validators

Then the average result is converted into a percentage:

$$P = \frac{\bar{X}}{X_{maks}} \times 100\% \quad (2)$$

Information:
P = percentage of eligibility
$\bar{X}$ = average score of validation results
X_{maks}= maximum score

The interpretation categories of validation results are determined by percentage as shown in the following table.

Table 1. Categories of Expert Validation Results

Percentage (%)	Category
81 – 100	Highly

	Valid
61 – 80	Valid
41 – 60	Quite Valid
21 – 40	Less Valid
0 – 20	Invalid

After going through the validation stage by experts, the product was then tested on a research sample consisting of teachers and students. The data from the trial results were obtained through a questionnaire of teacher and student responses, which were then analyzed using percentage calculation with a certain formula. The formula used is**:**

$$P = \frac{\text{Acquisition Score}}{\text{Maximum Score}} \times 100\ \% \qquad (3)$$

Information:

P = percentage of eligibility
Acquisition Score = the total score obtained
Maximum Score = the ideal number of scores

The interpretation of the questionnaire results uses the categories as shown in the following table :

Table 2. Response Questionnaire Results Category

Percentage (%)	Category
81 – 100	Highly Worth It
61 – 80	Proper
41 – 60	Quite Decent
21 – 40	Less Worthy
0 – 20	Not Eligible

Meanwhile, to determine the improvement of students' understanding of concepts in each question, the N-Gain test was used with the following formula:

$$N - Gain = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}} \qquad (4)$$

Information:

Spost = total score of the post
Spre = Scoring total pretest
Smax = maximum score

The interpretation of the N-Gain value can be seen in the following table :

Table 3. N-Gain Interpretation Categories

N-Gain Value	Category
$g > 0.70$	High
$0.30 \leq g \leq 0.70$	Mideum
$g < 0.30$	Low

III. RESULTS AND DISCUSSION

A. Results

Expert validation was conducted to assess the feasibility of the physics comic based on Problem-Based Learning (PBL) before it was implemented in the classroom. The validation involved two categories of experts, namely media experts and material experts. Media experts focused on evaluating aspects of appearance and utilization, such as text clarity, image variation, design, and the effectiveness of the comic as a learning medium.

Meanwhile, material experts assessed content feasibility, presentation feasibility, and language feasibility to ensure that the concepts presented were accurate, systematic, and appropriate for junior high school students.

The results of expert validation serve as an important benchmark to determine the quality of the product. High validation scores indicate that the comic is not only visually attractive but also effective in supporting learning objectives, presenting accurate content, and using language that is clear and understandable. Therefore, expert validation provides a strong basis for the conclusion that the developed physics comic is suitable for use as a learning medium.

Table 4. Media Expert Validation Results

Aspect	Indicators Assessed	Average Score	Percentage (%)	Category
Appearance	Text (title, font size, dialogue clarity, flow), Images (variation, color composition, text placement, background consistency, character consistency), Packaging (cover design, content relevance, attractiveness)	4.47	89.33%	Very Valid
Utilization	Media function, student activeness, contribution to learning objectives, function as a learning resource, effectiveness of illustrations, balance between entertainment and knowledge	4.78	95.56%	Very Valid
Average		4.63	92.44%	Very Valid

The validation by media experts shows that the comic-based physics media integrated with PBL is categorized as *very valid* in both appearance and utilization. The high score in utilization (95.56%) demonstrates that the comic is not only visually appealing but also effective in supporting active learning and achieving instructional goals. This indicates that the design successfully balances the dual role of comics as both an engaging medium and a reliable learning resource.

Table 5. Material Expert Validation Results

Aspect	Indicators Assessed	Average Score	Percentage (%)	Category
Content Feasibility	Relevance to core competencies, concept accuracy, meaningfulness, connection to real-life contexts	4.25	85.00%	Very Valid
Presentation Feasibility	Systematic structure, integration of text and visuals, completeness of explanation, clarity of presentation	4.30	86.00%	Very Valid
Language Feasibility	Clarity of language, appropriateness for students' level, readability	4.67	93.33%	Very Valid
Average		4.41	88.11%	Very Valid

The material validation confirms that the comic content is highly feasible for use in junior high school learning. The strongest aspect is language feasibility (93.33%), which indicates that the text is clear, readable, and suitable for students' comprehension level. Meanwhile, the content and presentation aspects are also rated *very valid*, reflecting accurate physics concepts and systematic delivery. Overall, the integration of problem-based learning (PBL) into the comic ensures that students can connect physics concepts such as pressure with real-life situations, thus enhancing meaningful learning.

The level of feasibility of the subject matter experts is in the very feasible category, with some improvement notes. The validator suggested that the explanation of the concept be accompanied by additional sample questions to strengthen students' understanding. In addition, input was also given regarding media aspects, namely so that the comic cover design was made simpler and more informative, the identity of the characters was clarified, and the use of dialogue language was adjusted to the language style of junior high school students so that it was more communicative and easy to understand.

Overall, the results of expert validation show that PBL-based physics comics are suitable for use in learning with minor revisions. Based on these suggestions, several improvements were made, including:

1. **Cover** : The comic cover was simplified and supplemented with class identity, subject material, and illustrations that depict pressure phenomena. This adjustment was intended to make the cover not only attractive but also informative, ensuring that students immediately understand the context and learning focus of the comic.

(a) Before revision, (b) After revision.
Fig. 2. Revised cover of physics comic teaching materials.

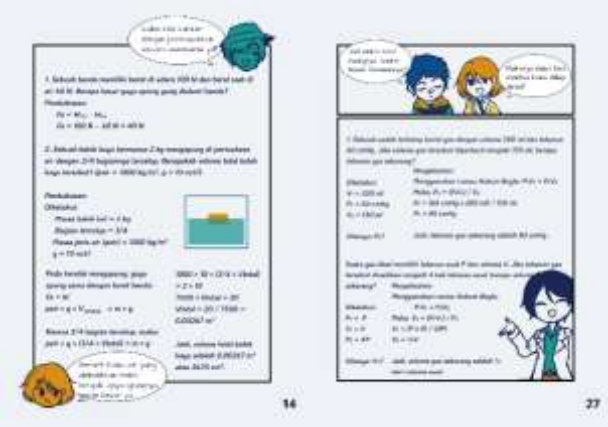
2. **Character Identity** : A brief explanation of the role of the main character was included in the storyline. This addition helps students to follow the plot more easily and identify the connection between the characters and the physics concepts being discussed. Strong character identity also supports narrative engagement, making learning feel more personalized and relatable.

(a) Before revision, (b) After revision.
Fig. 3. Addition of character identity in comic storyline.

3. **Dialogue Language** : The dialogues were revised by adapting the sentences to the everyday language used by junior high school students. This makes the communication in the comic more natural, conversational, and easier to comprehend. As a result, students are less likely to feel distanced by formal or technical language and more motivated to engage with the material.

(a) Before revision, (b) After revision.
Fig. 4. Adjustment of dialogue language to students' daily communication.

4. **Example Problem** : At the end of the comic story, example problems were added to strengthen the link between the concepts and their application in calculations. This integration allows students not only to understand the concept theoretically but also to practice applying it in problem-solving contexts, in line with the objectives of problem-based learning.



(a) Before revision, (b) After revision.
Fig. 5. Integration of example problem at the end of the story**.**

The results of the response analysis from both students and teachers are summarized to evaluate the feasibility of the developed comic media. The assessment was carried out across four main aspects, namely appearance, content, experience, and language. Each aspect was rated in percentage form to reflect the level of feasibility based on student and teacher perceptions.

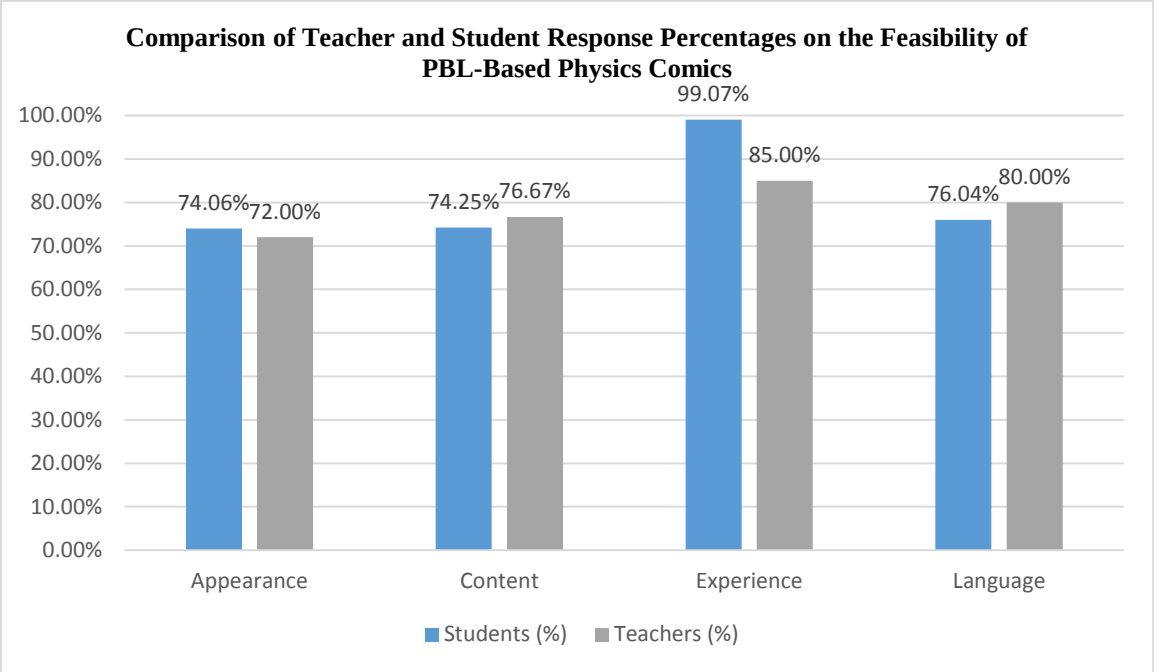


Fig. 6. Comparison of Teacher and Student Response Percentages toward the Feasibility of PBL-Based Physics Comic

The results of the response analysis from students and teachers are presented in Table X. In terms of appearance, students gave a score of 74.06%, while teachers rated it slightly lower at 72.00%. For the content aspect, students provided an assessment of 74.25%, which was comparable to the teachers' rating of 76.67%. The experience aspect showed the highest percentage, with students giving 99.07%, indicating very strong engagement, while teachers rated it at 85.00%. Finally, for the language aspect, students rated it at 76.04%, whereas teachers gave a slightly higher score of 80.00%. Overall, the data indicate that both students and teachers responded positively to the developed comic media, with the experience aspect receiving the highest appreciation, particularly from students.

Based on the results of a reflective questionnaire of 32 students, several main themes were obtained that described their learning experience through the use of physics comics on pressure materials.

No	Aspect / Theme	Description and Student Statements
1	Difficulties in Calculation Aspect	Some students still experience difficulties when dealing with mathematical calculations, especially in the use of pressure formulas which are considered long and confusing. *"The formula is long, so confusing" (I); "It's a bit dizzy when you look at the numbers" (R).*
2	Clarification of Concepts through Comic Stories	Comics help correct students' misconceptions. One student stated: *"At first I thought that ships could float due to gravity, after reading the comics I found out because of the buoyancy force" (D).*
3	Self-Identification with Comic Characters	Students can relate to the characters Mika and Dino who initially misunderstood concepts. *"I'm like Mika who misunderstood at the beginning" (Safira); "I'm just like Dino, I misunderstood it first" (F).*
4	Understanding the Definition of Pressure	Most students can define pressure as a force per unit area. *"Pressure is a force per unit area" (Z); "Push on a surface" (A).*
5	The Most Helpful Parts of the Story	Concrete panels such as nail incidents, Archimedes' law, and solid pressure are considered most helpful. *"The part of the nail incident is because it is easy to understand" (N); "Archimedes' Law, so understand the buoyancy force" (A).*

6	**Need for Additional Explanation**	Some students still show confusion regarding the application of concepts and formulas. *"Why does buoyancy only occur in water?" (D); "What is the formula for the pressure of a liquid?" (S); "I cannot understand without practicing directly" (M, SC).*
7	**Emotional Response to Comics**	Students' affective responses are positive — comics are considered fun and funny. *"Funny and laughable, sometimes" (J); "None, because they're all fun" (F).*
8	**Perception of Comic Complexity**	Some students think comics contain too many formulas, making them confusing. *"The formula is long and dizzying" (R, J).*
9	**Interest in the Context of Everyday Life**	Real-life contexts such as tires, nails, boats, and hydraulics make comics more engaging. *"About tires, because the material is interesting" (At).*
10	**Development of Understanding While Reading**	Some students were confused at first but understood better as they continued reading. *"Confused at first, but when you start reading a little so you start to understand" (Mo, Sa).*

To identify the students' level of conceptual understanding, the pretest and posttest results are broken down as follows.

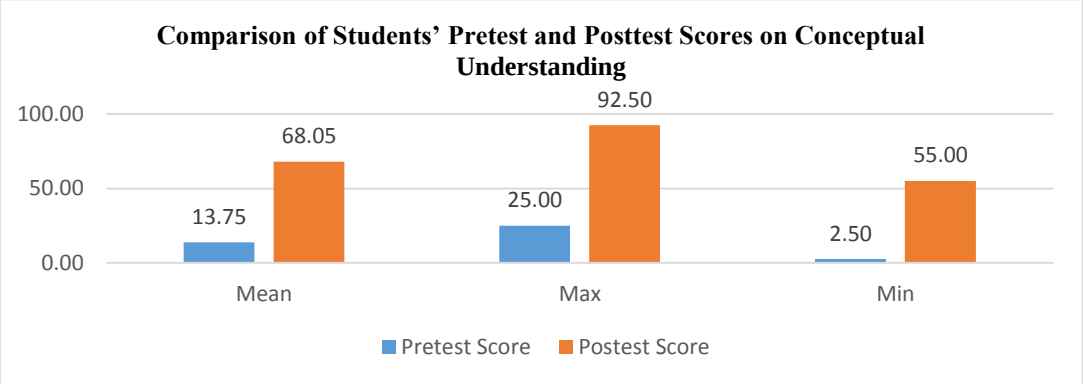


Fig.7.. Comparison of students' pretest and posttest scores showing a significant improvement in conceptual understanding after the implementation of PBL-based physics comics.

The comparative analysis of pre-test and post-test scores reveals a dramatic and conclusive improvement in student performance. The average score (mean) experienced a substantial increase, rising from 13.75 to 68.05, indicating a significant enhancement in the overall conceptual understanding across the entire group. Furthermore, the maximum score improved from 25.00 to 92.50, demonstrating that even the top learners were able to considerably advance their knowledge. Most notably, the minimum score surged from a very low 2.50 to a respectable 55.00. This remarkable leap confirms that the instructional intervention was exceptionally effective for all participants, successfully bridging critical knowledge gaps and ensuring that every student achieved a solid and uniform level of mastery by the end of the program.

The N-Gain distribution is used to find out the extent of the improvement of students' understanding after participating in learning using physics comic media.

Table 6. Total Pretest-Postest Score and N-Gain Results

Question No	Total Pretest Score	Total Posttest Score	N-Gain	Category
1	51	78	0,55	Mid
2	26	99	0,99	High
3	56	83	0,61	Mid

4	31	84	0,77	High
5	0	93	0,93	High
6	7	81	0,80	High
7	0	82	0,82	High
8	0	95	0,95	High
9	4	79	0,78	High
10	1	97	0,97	High

The data show a significant improvement across all test items. For example, in Question 1, the score increased from 51 (pretest) to 78 (posttest). Similarly, Question 2 improved from 26 to 99, and Question 3 rose from 56 to 83. Even questions with very low pretest scores, such as Question 5 (0), Question 7 (0), and Question 8 (0), demonstrated remarkable progress in the posttest with scores of 93, 82, and 95, respectively. Based on the results of the N-Gain calculation, the distribution of improved student learning outcomes shows variations in the medium and high categories. Of the ten questions analyzed, there were two questions in *the medium* category (N-Gain = 0.55 and 0.61) and eight questions in *the high* category (N-Gain between 0.77–0.99).

This shows that most students experience a significant improvement in comprehension after using learning media, especially since the majority of questions are in the *high* category. Meanwhile, questions in the *medium* category still showed an improvement, although not as big as other questions.

Thus, it can be concluded that the use of this media is effective in improving student understanding, with the distribution of learning outcomes being dominant in the *high category*. All hypertext links and section bookmarks will be removed from papers during the processing of papers for publication. If you need to refer to an Internet email address or URL in your paper, you must type out the address or URL fully in Regular font.

B. Discussion

The analysis results showed a significant improvement in students' conceptual understanding after using Problem-Based Learning (PBL)-based physics comics. The average pretest score was categorized as low, while the posttest score increased to a good level. This finding indicates that students were able to connect abstract physics concepts—such as pressure and force—with concrete and relatable contexts illustrated in the comics. The narrative structure helped students visualize phenomena like compressive force, hydrostatic pressure, and Pascal's law through daily life situations, suggesting that learning went beyond memorization to meaningful conceptual interpretation.

This result is consistent with Badeo and Ong Kian Koc [1], who reported that the use of a comic-based learning module significantly improved both students' conceptual understanding and motivation in physics. Their mixed-method quasi-experimental study involving 68 Grade 8 students demonstrated that comic integration supports both cognitive and affective learning outcomes. Similarly, Zarvianti and Sahida [35] found a notable increase in students' creative thinking and understanding after implementing PBL-based physics comics. Their study, conducted using the 4D development model, showed high validity (0.85) and practicality (94.67%), confirming the effectiveness of PBL comic media in fostering engagement and comprehension.

Further analysis of students' N-Gain scores shows improvement in the medium to high category, which reflects that most students experienced meaningful learning progress. The Wilcoxon test results confirm a significant difference between pretest and posttest, emphasizing that the comic effectively facilitated concept reinforcement through step-by-step problem-solving activities. Students' responses during learning also showed increased engagement—they were more active in asking questions, explaining their reasoning, and drawing conclusions. Teachers reported that students appeared more confident and enthusiastic when using the comic media, especially during the discussion phase of the PBL process.

Scientifically, these improvements can be interpreted as an outcome of combining narrative and visualization, which makes abstract ideas easier to process and remember. According to Paivio's Dual Coding theory, learning is strengthened when verbal and visual information are presented together, and this was evident in students' increased test results and verbal explanations. Yet, unlike previous studies, this research used comics as the main medium, which allowed students to both visualize and solve problems within a narrative. The positive responses from students and teachers further strengthen the conclusion that PBL-based physics comics can serve as an effective learning tool that enhances motivation, comprehension, and conceptual connection to everyday experiences.

IV. CONCLUSION

The findings of this study show that PBL-based physics comic media is able to significantly improve students' understanding of concepts. The integration of PBL syntax in comics not only makes students understand the material, but also encourages them to think critically and be actively involved in problem solving, so that learning is not limited to memorizing formulas alone. In addition, comics have proven to be an alternative solution for learning media in schools that still face technological limitations, because they can be used independently without dependence on the internet network. Thus, the research hypothesis is proven, that PBL-based physics comic media is effective and feasible to be used to improve the understanding of junior high school students' concepts on pressure materials.

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