



The Usage of Comics in Physics Learning: A Systematic Review of the Indonesian Research Literature

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ABSTRAK

Di era digital saat ini, komponen visual, termasuk pendidikan, memengaruhi semua aspek kehidupan. Komik berupa interaksi informasi tertulis dan visual mungkin memiliki dua tujuan: mengajarkan konsep ilmiah secara efektif dan meningkatkan minat siswa. Penelitian ini bertujuan untuk menganalisis pengembangan komik dalam pembelajaran fisika berdasarkan kebutuhan proses dan hasil pembelajaran. Penelitian ini mengulas komik dalam pembelajaran fisika dan memberikan rekomendasi untuk penelitian dan praktik di masa mendatang. Penelitian ini menggunakan metode penelitian systematic literature review. Penelitian ini menyajikan tinjauan pustaka berdasarkan 23 penelitian. Prosedur yang digunakan dalam penelitian ini dari pengembangan pertanyaan penelitian, penyusunan kriteria pemilihan, pengembangan strategi pencarian, pemilihan studi dengan menggunakan kriteria pemilihan, penilaian kualitas studi, dan sintesis hasil pertanyaan penelitian. Pengumpulan data penelitian dilakukan dengan menggunakan pencarian daring dari pengindeks jurnal berbasis data seperti Google Scholar, IOP Science, DOAJ, dan Scopus. Tinjauan tersebut mengidentifikasi status dan tren penggunaan komik, sehingga berdampak terhadap proses pembelajaran, dan peluang bagi pengembang dan praktisi. Tren pengembangan penelitian menunjukkan bahwa penggunaan komik dalam pembelajaran fisika di Indonesia berfluktuasi. Hasil analisis data menunjukkan bahwa pembelajaran fisika dengan komik dapat menstimulasi kemampuan belajar siswa dengan baik. Sehingga dengan demikian, peneliti mengundang penelitian masa depan untuk fokus pada apa yang dipelajari siswa melalui komik melalui penerapan intervensi instruksional.

ABSTRACT

In today's digital age, visual components, including education, influence all aspects of life. Comics in the form of interaction of written and visual information may serve two purposes: teaching scientific concepts effectively and increasing students' interest. This study aims to analyze the development of comics in physics learning based on the needs of the learning process and outcomes. This study reviews comics in physics learning and provides recommendations for future research and practice. This research uses a systematic literature review research method. This research presents a literature review based on 23 studies. The procedure used in this study from the development of research questions, preparation of selection criteria, development of search strategies, selection of studies using selection criteria, assessment of study quality, and synthesizing the results of research questions. Research data collection was conducted using online searches from data-driven journal indexers such as Google Scholar, IOP Science, DOAJ, and Scopus. The review identified the status and trends in the use of comics, their impact on the learning process, and opportunities for developers and practitioners. Research development trends show that the use of comics in physics learning in Indonesia fluctuates. The results of data analysis show that learning physics with comics can stimulate students' learning ability well. Thus, the researcher invites future research to focus on what students learn through comics through the implementation of instructional interventions.

1. INTRODUCTION

In an increasingly dynamic educational environment, it is necessary to modify learning approaches to meet the needs of the Merdeka Curriculum and 21st-century skills (Heryanti et al., 2023; Tesalonika et al., 2022; Yuhastina et al., 2020). Scientific knowledge is full of abstract concepts that are mostly communicated through language. When students are faced with abstract topics to learn, teachers face a challenge in providing relevant instruction (Dinda Sartika et al., 2023; Setiyaningsih & Wiryanto, 2022). Students, on the other hand, frequently view science as a collection of abstract concepts to be remembered, rather than as concepts and processes that are applicable in everyday life (Gormally, 2020). Real-world problems in meaningful circumstances drive today's pupils. These criteria are addressed by using cartoons/comics that contain visuals of certain scenarios (Gordon et al., 2023; Noperi et al., 2018; Sari et al., 2019). Comics can help pupils develop a strong conceptual understanding by providing captivating visuals (Siregar et al., 2019; Toh et al., 2017; Yonanda et al., 2019). This aligns with the Merdeka Curriculum's objectives of developing critical thinking and problem-solving abilities. Comics have recently emerged as a medium for mass communication and the dissemination of knowledge. Comics have become a popular method of communication because they can capture the interest of readers of all ages and cultural backgrounds (Artha et al., 2020; Farinella, 2018; Siregar et al., 2019). Because of their content and images, comic books are widely used as instructional materials (Akcanca, 2020; Artha et al., 2020; Farinella, 2018; Siregar et al., 2019; Yonanda et al., 2019). Presenting abstract science through comics allows readers to understand concepts through both visual and textual channels, promoting the construction of mental models (Jian, 2023). Comics are a collection of images placed in a sequence to transmit information and/or generate an aesthetic response in the reader (Laksmi & Suniasih, 2021; Rochmah & Fahyuni, 2021; Siregar et al., 2019). Although comics vary greatly in structure, they often consist of a succession of images with dialogue and character ideas expressed in the form of speech bubbles. The concepts they convey are complicated, but by distilling them down to their fundamental message and using simple visual comparisons, these comics educate and engage audiences that other media cannot always reach (McDermott et al., 2018) (Rochmah & Fahyuni, 2021; Spiegel et al., 2013).

According to bibliometric analysis of the usage of comic books as didactic sources in science education from 2011 to 2020, there was a considerable increase between 2018 and 2019. However, production fell in 2020 due to the COVID-19 pandemic, which slowed the expansion of this field of study. Indonesia, along with Brazil, is the second most productive country in terms of scientific production on this topic, having contributed to 12 of the 60 documents analyzed. This puts it ahead of other Southeast Asian countries, like Malaysia, which only produced 5 scientific output documents. Other research developed specific comic learning media for the field of physics in Indonesia from 2012 to 2022; however, the trend of research on the production of physics comics fluctuates from year to year (Septiawan et al., 2023) (Gemelli et al., 2024). However, there was the greatest increase from 2019 to 2021, with the most publications of study on the development of physics comic media in 2021. Furthermore, research articles came from Indonesia, America, and France. According to its density, Indonesia has contributed the most research publications on the development of comic-based physics learning media.

Science comics are commonly utilized for educational and scientific communication goals, with an emphasis on outreach and awareness-raising (Damopolii & Rahman, 2019; Friesen et al., 2018). Comics are utilized to address significant and complex issues engagingly and excitingly, introducing scientific ideas to new audiences. Comics can be utilized to spark students' interest in learning and inspire them to reflect, think critically, and participate actively in the learning process (Laksmi & Suniasih, 2021; Rochmah & Fahyuni, 2021; Saputri & Estiastuti, 2018; Siregar et al., 2019). Educational comics can help youngsters learn about natural disasters, particularly earthquakes, which can have a significant influence (Saputri & Estiastuti, 2018; Uğureli et al., 2023). This is intended to raise awareness and prepare them for the future. As a result, instructional comics will reduce the psychological effects that may occur before, during, and following an earthquake and effectively educate people about natural disasters. Other research report that Indonesian researchers have researched the development and use of comics in education, particularly in science and physics, but only a few comic studies have focused on the variables that influence comics' effectiveness in physics learning (Gemelli et al., 2024; Septiawan et al., 2023). Other research studied the Effectiveness of Comics to Train Students' Critical Thinking Skills in Physics Learning, investigating the effectiveness of comic media that only focuses on students' critical thinking skills in physics learning (Khoiriyah & Suprpto, 2021). In several additional studies in Indonesia, the usage of comics in education has expanded at the elementary level. This is corroborated by research suggest that the trend of using comic media can improve students' understanding, which impacts learning outcomes and instills students' character values (Maulidah & Wulandari, 2021; Nevilia et al., 2020; Puspitasari & Rodiyana, 2022). In this case, these studies only apply to elementary schools, but physics is taught in high schools, hence little attention has been paid to the use of comics in physics education. Although some prior studies have investigated the use of comics in classroom

learning and their impact on specific areas, there is still a lack of awareness of the various factors influencing the use of comics in physics education in Indonesia. In contrast to previous studies that focused on the individual impact of comic use factors in learning in Indonesia, this study integrates a systematic literature review approach to analyze the complex interactions of various factors in influencing the effectiveness of comic use in Indonesia. Based on the explanation above, this study adds to the body of knowledge by investigating the use of comics in physics education in Indonesia. This is because Indonesia is a huge country with many cultures, so it is vital to study (Nugraha et al., 2023). In recent years, the number of science-themed graphic novels accessible in bookstores, as well as the number of websites that popularize science through comics or cartoons, has increased dramatically (Artha et al., 2020; Khotimah et al., 2021; Siregar et al., 2019). The fact that popularizing science through comics has proven to be an economic phenomenon (with significant sales in bookstores or via web displays) suggests that this topic will continue to acquire popularity (Spiegel et al., 2013). The expanding use of comics and cartoons to explain and disseminate science argues that academic institutions should conduct additional research in this area (Hobri et al., 2021; Indriasih et al., 2020; Udayani et al., 2021). These sources support the statement in the quote that the use of comics to popularize science is a new phenomenon that is still under-researched academically but has the potential to continue to grow in the future. Literature reviews on the use of comics in Information about the use of comics in physics learning will provide an overview for teachers or lecturers in Indonesia to plan and develop comic learning media. Therefore, the purpose of this study is to review research and publications on the development of physics comic learning media that have a high potential to be used as learning media. This study conducts a more specific analysis than previous studies, investigating the efficiency of comics in physics learning to acquire certain skills. Thus, the research questions in this context are comic trends in Indonesia in physics topics, aspects trained, and methods used. Thus, the popularity of physics comics and their various successes in educational contexts strengthen the potential, beliefs, and preferences in Indonesia

2. METHOD

This study uses a systematic literature review model research method. This type of review was chosen because it provides a clear and precise method for reviewing the literature on existing research that is focused on answering specific research questions (Gordon et al., 2023; Newman & Gough, 2020; Roslina et al., 2022). The procedures used in this study were adapted from (Newman & Gough, 2020; Nurmahasih & Jumadi, 2023). The procedure consists of (1) developing research questions, (2) constructing selection criteria, (3) developing search strategies, (4) selecting studies using selection criteria, (5) assessing the quality of studies, and (6) synthesizing results of research questions (Newman & Gough, 2020; Nurmahasih & Jumadi, 2023). These six steps are operationalized by researchers as explained below. First, *Develop a Research Question*. The selected research questions were created to better understand the research and use of comics in physics learning over the past seven years. The research questions in this study are listed showed in Table 1. The presentation of comic trends in physics learning (RQ1) considers the evolutionary aspect of the number of journal publications over time. This study shows the topics raised in the use of comics (RQ2). The benefits of using comics in learning physics (RQ3) refer to the positive outcomes and attitudes of students when using comics (e.g. increased academic levels, motivation, creativity, etc.). Innovation in comic research in Indonesia (RQ4) refers to some variations in the types of strategies used by researchers in comics. The research questions in this study are presented in Table 1.

Table 1. Research Questions in the Study

No	RQ	Question
1	RQ1	What is the trend of comics in Indonesia's physics learning?
2	RQ2	What are the most common physics topics applied in comics in Indonesia?
3	RQ3	What are the advantages of using comics in learning physics?
4	RQ4	What are the innovations in comic research in Indonesia?

Second, *Construct Selection Criteria*. Selection criteria are carried out by considering the limitations of the review. To do this systematically and transparently, rules are developed regarding which studies can be selected for review. All data used in this study are considered eligible if they meet the following criteria: 1. empirically oriented; 2. the field of physics education; 3. the research was conducted at the secondary education level; 4. the focus of the research is the comic intervention for physics learning; 5. the research subjects are students; and 6. references come from journals and international proceedings publications

published online. The authors collected studies by conducting a manual search of articles currently published in the period 2018 to 2023. Third, *Develop Search Strategy*. In this paper, the existing educational literature related to comic interventions for physics learning in the classroom is reviewed. A systematic search collected research articles from international and local databases. The research data collection was conducted using online searches from data-based journal indexers such as Google Scholar, IOP Science, DOAJ, and Scopus published between 2018-2023. The international databases used are Google Scholar, ResearchGate, ERIC, Taylor and Francis, and Springer. Local databases were used to obtain more research in the Indonesian context.

The Indonesian Ministry of Education and Culture has provided a website portal (<https://sinta.kemdikbud.go.id>) called Sinta (science and technology index) to access accredited Indonesian journals. The search was conducted in the period March-April 2023 by selecting journals related to comics in physics learning, applying a special education filter, and using the keywords "comics and physics learning", "comics and physics education", and "comics in science education". The search parameters were set as follows: Document type: "Article." Language: "English". As a result, hundreds of documents were found related to comics in physics learning. The abstracts of all identified articles were analyzed to ensure that the subject matter was closely related to utilizing comics in physics learning. Fourth, *Select Studies Using Selection Criteria*. In the research selection process, the title and abstract of the article are checked first to determine whether the research is relevant or not (Newman & Gough, 2020; Nugraha et al., 2023). As a result, only 23 studies were used to collect data. Fifth, *Assess The Quality of Studies*. This phase takes place after the review planning phase is completed. We have designed a data extraction form (spreadsheet) with the following elements: Study name, year of publication, journal, sample size, target group, field of education, reported benefits, time dimension, and main results. Sixth, *Synthesis Results of Research Question*. The final stage is to perform data synthesis. This stage was carried out to obtain and integrate information from selected research to respond to research questions.

3. RESULT AND DISCUSSION

Result

In this section, we delivered an analysis, synthesis, and visualization of the selected documents to address each research question. **First, Trends of Comics in Physics Learning in Indonesia (Evolution over time)**. The study technique imposed a year restriction, requesting only publications since 2018, to discover the most recent research on educational comics programs in physics learning. 71 scholars contributed to the 23 selected articles, with 22 investigations carried out cooperatively. The research participants were from the fields of physics and science. Participants included experts and lecturers from physics, physics education, scientific education, electrical engineering, electrical engineering, and informatics education, and primary school teacher education. At least 12 universities, 2 schools, and 1 corporation engaged in education in 8 provinces of Indonesia, in conjunction with Brunei Darussalam, have arranged instruction utilizing comics in physics study. **Figure 1** shows the growth trajectory of publications over time.

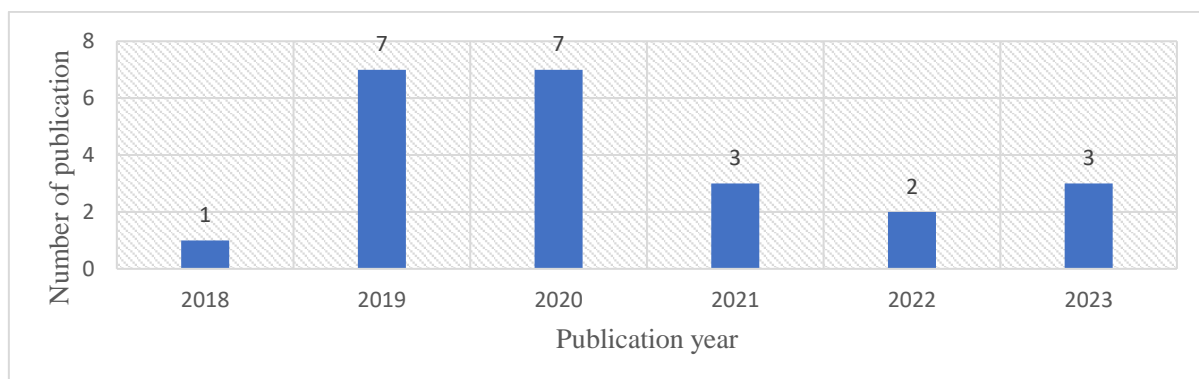


Figure 1. Annual Publication of the Usage of Comics in Physics in Indonesia (Source: Authors' Elaboration)

As can be observed, the distribution varies each year: 1 article (4.35%) was published in 2018, 7 articles (30.43%) in 2019, 7 articles (30.43%) in 2020, 3 pieces (13.04%) in 2021, 2 articles (8.70%) in 2022, and 3 articles (13.04%) in 2023. During the period 2018 to 2023, the number of articles fluctuated. A rapid increase occurred in 2019. The most reviewed publications were published in 2019 and 2020, while

the fewest reviewed articles were released in 2018. However, there was a sharp fall from 2021 to 2022. The use of comics in physics education has not been researched uniformly across Indonesia. The majority of studies were conducted on Java Island, with 18 publications (from the provinces of Jakarta, West Java, Central Java, East Java, and Yogyakarta), followed by Sumatra Island (from the provinces of Jambi and Aceh) with 3 publications, Kalimantan Island (from the province of South Kalimantan) with 1 publication, and Sulawesi Island (from the province of Gorontalo). The use of comics in physics education has not been reported from Indonesia's largest island (Papua). In the international database, 3 articles were published in Scopus (Q2), namely in the Journal of Technology and Science Education, 1 article in Q3 (Revista Mexicana de Física E), and 1 article in Scopus (Elsevier) (Global Journal of Business and Social Science Review). In addition, 7 selected articles were published as conference proceedings articles, namely in the Journal of Physics: Conference Series. A total of 16 articles in the Indonesian database consisted of 11 articles published in ten Sinta journals. A total of 6 articles were published in Sinta 2 journals, consisting of two in the Journal of Research in Science Education, one in the International Journal of Social Learning, one in the Jurnal Penelitian dan Pembelajaran IPA, one in Thabiea: Journal of Natural Science Teaching, and one in the Unnes Science Education Journal. In total, the publications were published in 14 different journals, with the majority of the research published in the Journal of Physics: Conference Series articles.

Second, Topics in Physics. The several research investigated multiple distinct subjects within the same or separate physics content. **Table 2** shows that comics can be used in 13 topics where most physics comics used in Indonesia in the articles that have been analyzed mostly raise abstract material. The most visualized topics in comics are Newton's Law (12.50%), Momentum and Impulse (12.50%), Optics (12.50%), and Heat and Temperature (12.50%). The accumulation of topics discussed in this study is presented in **Table 2**. The research was distributed to elementary, junior high, high school, and college students. High school students were the most commonly employed research subjects, accounting for 14 publications. Meanwhile, only one study focused on college students. The study focused on undergraduate students majoring in physics education who aspired to teach physics.

Table 2. Distribution of Physics Topics in Studies

No	Field	Number of Articles	Percentages (%)
1	Newton's Law	3	12.50
2	Momentum and Impulse	3	12.50
3	Optics	3	12.50
4	Heat and Temperature	3	12.50
5	Work and Energy	2	8.33
6	Newton's Gravity	2	8.33
7	Global Warming	2	8.33
8	Vibration and Wave	1	4.17
9	Ideal Gases	1	4.17
10	Magnetism	1	4.17
11	Thermodynamics	1	4.17
12	Static Electricity	1	4.17
13	Sound	1	4.17

Third, Advantages of Using Comics in Physics Learning in Indonesia. Of the 23 articles that have been studied, it shows that each article has its advantages. The following table summarizes the benefits of applying comics in physics learning. Similarly, most studies report multiple benefits. The table 3 shows that the highest percentage is in using comics for critical thinking ability with percentages (22.58%), followed by learning outcomes (12.90%). The effect of using comics in physics learning shows positive results. The evidence demonstrates that the use of comics in physics education has an impact on students' learning outcomes. Awareness of the benefits of using comics in physics education is critical. Distribution of Advantages of Using Comics in Physics Learning in Studies showed in **Table 3**.

Table 3. Distribution of Advantages of Using Comics in Physics Learning in Studies

No	Advantages	Number of Articles	Percentages (%)
<i>Cognitive</i>			
1	Critical Thinking	7	22.58
2	Learning Outcomes	4	12.90
3	Mathematical Representation	3	9.68
4	Scientific Literacy	2	6.45

No	Advantages	Number of Articles	Percentages (%)
5	Conceptual Understanding	2	6.45
6	Creative Thinking	2	6.45
7	High Order Thinking	1	3.23
8	Problem-Solving	1	3.23
9	Verbal Representation	1	3.23
10	Communication	1	3.23
<i>Affective</i>			
8	Scientific Attitude	2	6.45
9	Cooperate Attitude	1	3.23
<i>Metacognitive</i>			
10	Motivation	3	9.68
11	Self Reliance	1	3.23

Based on Table 3, it can be seen that almost all reviewed studies examined comics itself as a result of the cognitive-only framework used in those studies. Affective, metacognitive, and other domains started to emerge in the literature. Pre- and post-tests nearly generated the data. Some studies used pre- and post-questionnaire. In terms of affective, metacognitive, and other domains, they were examined through refutation texts, related questionnaires, or interviews. The questionnaire was mostly used to bring about effective and or metacognitive aspects, such as motivation, self-reliance, and scientific attitude. **Fourth, Comics Innovation.** The reviewed researchers conducted several instructional interventions for comics to improve students' understanding of physics concepts. Researchers in the comics field integrated each intervention, so finding some interventions in one study was possible. The complete comics types are presented in Table 4.

Table 4. Distribution of Comics Innovation in Indonesia

No.	Types	Number of Studies	Percentages (%)
1	Android-based comics	11	30.56
2	Comic based on local wisdom	4	11.11
3	Comic based on critical thinking aspects	4	11.11
4	Comic based on problem-based learning	3	8.33
5	Comic based on mathematical representation aspects	3	8.33
6	Comic-integrated student worksheet	2	5.56
7	Inquiry-based comics	1	2.78
8	Guided inquiry-based comics	1	2.78
9	Problem-solving based comics	1	2.78
10	Modules webcomic	1	2.78
11	Character-based comics	1	2.78
12	Comic based on discovery learning	1	2.78
13	Comic-based physics module	1	2.78
14	Comic based on creative thinking aspects	1	2.78
15	Comic based on verbal representation aspects	1	2.78

The data in Table 4 shows that the comics development innovation is based on a literature study. The type of strategy that is most often applied to comics is developing comics operated using an Android (30.56%) as digital comics. Four articles (11.11%) see comics as a development of learning media that involves the context of local wisdom stories. For example, the game of hopscotch (Engklek), phenomenon at Gajah Mungkur Dam, marbles games, and Carom games. Meanwhile, four other articles show the integration of aspects of critical thinking skills in comics to train critical thinking skills.

Discussion

First, Trends of Comics in Physics Learning in Indonesia (Evolution over time). The research field of comic application in physics learning in Indonesia with 23 articles fluctuated in the period 2018-2023 with the majority of publications coming from Java Island. The research methodology imposed a year restriction, requesting only publication since 2018, intending to know the most current research on physics comics programs. This research is still relatively new. The fluctuating growth in publications since 2018 reported in this and other studies indicates that the use of comics in physics learning needs further investigation, especially with the growing use of mobile devices, particularly in developing nations.

Although research on the use of comics in physics learning has not been published in all provinces in Indonesia, participation and collaboration among Indonesian universities show a promising rise in its use for physics learning. One study discovered a multi-country collaboration to publish scientific results on the application of these comics, between Indonesia and Brunei Darussalam (Fananta et al., 2019). This shows that the articles reviewed are up to date, so the results of this study can be used by stakeholders related to physics education or further research. Given that a period of 10 years was considered, this is a relatively small number of documents. These data suggest that it is difficult to identify reputable international publications at local and international levels that publish research on comics in physics learning in Indonesia. The impact of these information sources is lower regarding citations than works published as full articles in scientific journals. All of this indicates that the topic of study is yet to gain recognition in the area and still lacks relevance within the area of educational research. However, it is promising that the topic at least has a place in the scientific community and boasts defined lines of research. These findings may persuade the research community to consider scholarly publication on the subject in prestigious journals as a potential future challenge for improving the quality of implementation and development of physics comics in Indonesia. These findings may encourage the research community to pursue scientific publication on the issue in a respected journal as a future project.

Second, Topics in Physics. Newton's Law, Momentum and Impulse, Optics, and Heat and Temperature are commonly addressed topics in comics. This topic was examined in every educational stage. Researchers are interested in investigating these principles for their potential application in comics for a variety of reasons. Students from high school to college regard these topics as abstract, difficult concepts to grasp (Badeo & Koc, 2021; Khotimah et al., 2021). Heat is a static concept that may be appropriate for comics as a medium consisting of static images, can be learned easily through the experiments provided in the comics (Özdemir & Eryilmaz, 2019; M. A. Putri & Prodjosantoso, 2020). There are many applications in everyday life (Fananta et al., 2019; M. A. Putri & Prodjosantoso, 2020; Safitri et al., 2022). Physics is taught by identifying physical phenomena that exist around students using a region's customs/traditions on momentum and impulse (Damayanti & Kuswanto, 2021; Rahayu & Kuswanto, 2021; Sari et al., 2020).

According to the findings of the study, Senior High School was the most frequently studied level of education among the selected studies. According to Piaget's cognitive theory, kids aged 11 and above are in the formal operational stage. High school children have a higher level of abstraction and can think better as compared to the concrete operational stage (students aged 7-11 years) (Baptista et al., 2019; Ghazi & Ullah, 2015; Senan, 2013). Comics might help student's cognitive growth at this stage since they provide abstract physics concepts in an understandable visual format. Students begin to develop abstract and logical thinking abilities (Akcanca, 2020; Artha et al., 2020; Farinella, 2018; Siregar et al., 2019; Yonanda et al., 2019). Educational comics can assist bridge the comprehension of abstract physics concepts with visual representations, allowing students to better construct their understanding (Artha et al., 2020; Farinella, 2018; Siregar et al., 2019). In addition, comics can also stimulate hypothetical-deductive thinking which is a characteristic of the formal operational stage, by presenting physics scenarios or problems in an interesting and contextual format (Saputri & Estiastuti, 2018; Uğureli et al., 2023). This encourages students to analyze situations, make hypotheses, and draw conclusions based on the information presented in the comics, following the characteristics of thinking at the formal operational stage. So it's understandable that there aren't many study topics for junior high and primary school students. Furthermore, as physics begins to be taught at the high school level, the majority of the targets of physics comic media are high school students. Moreover, implementation of teacher participation remains quite limited at all university levels. In reality, prospective physics instructors are potential agents of future change in physics education.

Third, Advantages of Using Comics in Physics Learning in Indonesia. According to the study, incorporating comics in physics learning has several advantages. These benefits were classified into three categories: cognitive benefits, affective advantages, and metacognitive advantages. Almost all studies are based on cognitive frameworks. Research related to the use of comics in physics learning is quite promising, as seen from its influence on various aspects of abilities and skills, such as critical thinking (Azmy et al., 2020; Handayani et al., 2019; M. A. Putri & Prodjosantoso, 2020). This is because students are presented with mathematical principles and story scenarios, allowing them to draw conclusions from the subject matter acquired and train their learning drive and reading comprehension skills. Comics can help promote scientific attitudes by providing affective benefits (Mutia et al., 2020; M. A. Putri & Prodjosantoso, 2020). The narrative in comic stories engages readers on both cognitive and affective levels (Farinella, 2018). Narratives can be utilized to supplement the sorts of reasoning employed by students when discussing socioscientific topics, promoting the development of positive attitudes toward science (Ritchie et al., 2011; Weber et al., 2013). The most widely studied variable in the metacognitive aspect is motivation (Nikmah et al., 2019; Praptiwi et al., 2018; Safarati & Zuhra, 2023). Humor in comics allows pupils to progress from easier to more challenging subjects, which can motivate students (Cher & Toh, 2022; Chu & Toh, 2020).

More than half of reviewed studies examined the application of physics comics itself as a result of the cognitive-only framework used in those studies. Affective, metacognitive, and other domains started to emerge in the literature. Studies in establishing the factors influencing the use of comics have explored some affective and metacognitive variables. Yet, those variables have not been considered in empirical studies. However, Indonesian researchers agree that physics comics interventions positively impact research participants in classroom settings.

Fourth, Comics Innovation. The concept of comics integration is understood variably. Indonesian researchers view the integration of physics comics as: First, Innovation in the use of digital technology in learning; used Android and websites to develop comics to improve problem-solving ability (Annisa et al., 2020). Second, Comic-assisted learning syntax; employed comics as a learning medium in the Guided Inquiry Model as a series of directors in learning activities and linking comics with PBL model strategies to find solutions to real-world problems easily (M. A. Putri & Prodjosantoso, 2020; Safitri et al., 2022). Third, Learning strategy; integrating local wisdom into physics content in comics and developed a character-based comic science learning media to increase self-reliance learning. Fourth, Assessment; adapted comic strips into Student Worksheets that were developed and integrated deep questions into them (Damayanti & Kuswanto, 2021; Ramadhan et al., 2019; Sulistya & Projosantoso, 2019).

Comics are most commonly utilized in knowledge construction. There have only been two journal papers on the use of comics in assessment scenarios, both in the form of worksheets. Some studies integrate multiple interventions into one study. For example, examined the effectiveness of using the android-based Carom games comic integrated into discovery learning to improve critical thinking and mathematical representation abilities. The comic research can also focus solely on the development of the comic, without connecting it with other learning interventions (Dewantara, 2020; Mutia et al., 2020; Rahayu & Kuswanto, 2021). Most researchers used the comics approach with android-based comics. The selection of digital comics can be used as a solution for increasing interest and learning results of the science of the students because the image-side comics that can visualize the situation between the figures it is expected to help students understand and give reasoning to the learning materials. Due to the popularity of computers, the home has become a new learning environment, highlighting the important role of digital technology in expanding the scope of learning spaces. This recommendation aligns with the global aim of educational scholars in the twenty-first century to investigate how teachers incorporate technology into their instruction (Putri et al., 2022) (Wang et al., 2024). The limitation of this study is that this study only examines the use of comics in physics learning. It is hoped that other studies will examine comics in other subjects. The implication of the study is that this study provides information on the use of comics in physics learning that has a positive impact on students.

4. CONCLUSION

Research findings show that comics can be used at various levels of education, including elementary, middle, high school, and undergraduate. Comics are most widely used at the high school level. Since 2018, the number of studies published on the application of comics in physics learning in Indonesia has been unstable, and the years with the most studies on comics were 2019 and 2020. This Research is still relatively new. Research on publication trends Research on the development of physics comic learning media needs to be known to find out the year of publication trends, topics that are often raised in comic media, countries that publish the most, authors who publish the most, and articles that other authors most often cite. The research trend is to find out the type of good development, authors with good development experience, and correlated keywords so that better development research can be carried out. In Indonesia, comics teach several physics concepts, the most popular of which are Newton's Laws, Momentum and Impulse, Optics, and Heat and Temperature. The advantages of using comics in physics learning include increasing student learning success, performance, attitudes, and interests.

5. REFERENCES

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