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E-comic as a media to build an understanding of newtons concepts

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Abstract: This research aims to create effective physics e-comic learning media to help students understand Newton's concepts. The Research and Development method was used in conjunction with a 4-D development model that consists of four stages: definition, design, development, and dissemination. At the definition stage, a series of needs analysis was carried out, collecting and analyzing information. After a series of definitions had been formulated, the next step was to design. This stage involved designing the product that would be created in accordance with the previously completed definition formula. After the design stage was completed, the designing stage consisted of two steps, namely expert appraisal (expert assessment), accompanied by revisions and developmental testing (development trials) up to the deployment stage. A limited trial on 27 students of class VIII from SMP Negeri 15 Semarang resulted in an increase of 80% in student learning outcomes in final physics learning with the criteria "very feasible." Based on limited trials, the e-comic media developed was effective and could be used as a physics learning medium to build understanding of Newtonian material physics concepts. This research could serve as a foundation for several other studies that employed diverse and innovative learning media, such as e-comics, which could have ramifications for readers' understanding of several concepts related to their cognitive abilities.
Keywords: physics e-comic; learning media; learning outcomes

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Introduction

Education is a deliberate effort to prepare students for their future roles through guidance, teaching, or training activities (Lee et al., 2011; Muali, Islam, Bali, & Baharun, 2018; Tsai, Chuang, Liang, & Tsai, 2011). Physics is the science that studies the structure of matter and the interactions of the basic components of the universe. Physics is a meaningful subject to master because each topic must be properly comprehended before moving on to application activities. Student understanding of a concept becomes important during the teaching and learning process because one of the success factors of learning activities can be judged how well students understand the topic. This is because students' conceptual understanding affects their ability to understand the problems and occurrences around them. Understanding the core problems of such phenomena will allow them to propose effective solutions (Kalyuga, 2010). Students can become good problem solvers if they understand the topics properly (Kladchuen & Srisomphan, 2021).

Students will not be able to understand the concept of new facts when the foundation of basic knowledge is not built properly and firmly. Maintaining a longer and stronger basic understanding can be ensured from the foundation of new knowledge being built. Newtonian studies become an important concept for building a solid foundation. Newtonian mechanics is the central topic in introductory physics, and force is one of major concepts of all physics (Hairan, Husin, & Abdullah, 2019).

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Newton's concept serves as the fundamental foundation for comprehending natural concepts and phenomena that occur around us. Several mechanical ideas, including dynamics and kinematics, serve as the foundation for many aspects of industrial and economic development (Haritos, 2019). This is an important reason why students must grasp Newtonian physics for industrial progress, which leads to long-term advances in the economy and other elements of life (Evenhouse, Kandakatla, Berger, Rhoads, & DeBoer, 2020; Hairan et al., 2019).

Many educational researchers developed quantitative assessment instruments to evaluate ways in increasing students' conceptual understanding of physics and minimize misconceptions in physics learning (Hairan et al., 2019). Newtonian mechanics had approximately 50 Research-Based Assessment Instruments (RBAIs) developed because Newtonian mechanics is the main topic in most physics sequences and is required for other sequences (Hairan et al., 2019).

Several instruments, such as the Inventory of Basic Concept Mechanics (IBCM) relating to the concepts of force and kinematics, have been developed based on research results to measure understanding of mechanical concepts. FMCE stands for Force and Motion Conceptual Evaluation, and it is used to assess mechanics content understanding (Kinematics, force, energy, and graphing). The Force Concept Inventory (FCI) is used to assess mechanics content knowledge (force, kinematics), whereas the Half Leg Force Concept Inventory (HFCI) is used to assess mechanics content knowledge (force, kinematics) (Chen, Ren, Li, Wang, & Zhang, 2019; Hidayati & Permana, 2019; Jufriadi & Andinisari, 2020; Nguyen, 2017). Mechanics Diagnostic Test (MDT) is used to identify students' misconceptions in mechanics. This tool has the objective of evaluating teaching objectively until it is enhanced to identify common misconceptions before the tool is finally revised (Hairan et al., 2019). Eventually, the tool is used to assess students' comprehension of fundamental Newtonian mechanics concepts. The large number of instruments used to assess students' understanding of Newtonian mechanics demonstrates that this subject has gotten significant attention from various studies. Since the concept of this material is highly broad and has a wide range of application sectors, it requires special consideration (Sundaygara et al., 2021). This is a key reason why this research was conducted, mainly to raise material regarding the concept of Newton's law.

Not only in Indonesia, physics is known for its difficulties, a similar thing happened in Malaysia (Saleh, 2011) and Afghanistan (Hairan et al., 2019). Traditional teaching methods are frequently used in both schools and universities. In 2013, attempts were undertaken in Afghanistan to boost the number of university lecturers with master's and doctoral degrees; partnerships with a number of American, European, and Asian universities resulted in the publication of new textbooks for schools from grade 1 to grade 12 (Hairan et al., 2019). Several studies have been conducted in order to develop various learning models, books, teaching materials, modules, learning tools, tools, and learning media with consequences for students' conceptual abilities about Newton's laws. According to the findings of the research, using learning tools or media has a considerable impact on students' conceptual abilities (Ayu, Saputro, Sarwanto, & Mulyani, 2023; Dhina, Hadisoebroto, & Mubaroq, 2019).

Learning aids or media play an important role in teaching and learning. Innovative learning media catalyzes interaction between teachers and students (Chua, 2018; Yurina & Lopukhova, 2017). The use of media can help teachers clarify information to students. The use of media in learning as a learning aid is crucial. Learning media also allows teachers to use supporting facilities that attract students' interest and passion while studying, such as internet networks that can display photographs, movies, and other media. Students, undoubtedly, demand a new learning approach in order for the learning process to appear seamless (Lee et al., 2011; Muali et al., 2018; Tsai et al., 2011). Learning media will also increase students' interest in what they are studying, which will improve their learning outcomes. Due to practical aspects, a monotonous, and unappealing appearance, students' interest in reading comics in the form of (hard) books is also starting to fade (Oktarina & Muskhir, 2021; Rasiman & Agnita, 2014). Students must be invited to learn in an enjoyable style that does not feel like they are studying because learning tools that can help students understand ideas in an entertaining way and deliver learning experiences in creative ways are desperately needed (Boden & Kenway, n.d.; Prahani et al., 2022; Tsuei, Huang, & Cheng, 2020).

One thing that can be done to increase the quality of physics learning is to make instructional media more innovative and effective. Learning will be more effective since students will not become bored as readily while using physics learning media in the form of e-comics created to assist students understand physics by exhibiting material, graphics, stories, and sample questions. Unlike prior print media comics, they were perceived as weak in terms of developing students' intellectual understanding. Aside from the fact that these comics still require time and access to be published in print media, past comics are deemed inappropriate for the current digital era. The comics developed in this research employ an approach and are adapted to everyday life in accordance with Indonesian culture (Christie, Beames, & Higgins, 2016; Fang, Xu, Grant, & Stronge, 2016; Mueller, 2014). This is done to make students feel more connected to the subject being taught. They understand the subject better because they can feel the phenomena or concepts being taught based on cultural proximity and what they encounter every day (Dorfman, Javidan, & Hanges, 2012; Long & Hanh, 2020; Sun & Gao, 2019).

Scott McCloud (1994) defines the term comics as "juxtaposed pictorial and other images in deliberate sequence intended to convey information and/or to produce aesthetic response in the water". Harvey (2005) does not support this definition and claims that "McCloud's definition relies too heavily upon the pictorial character of comics and not enough upon the verbal ingredient. Comics uniquely blend the two. No other form of static visual narrative does this. McCloud includes verbal content (which he allows is a kind of imagery), but it is the succession of images that is at the operative core of his definition. However, that regardless of emphasis, neither sequence nor blending inherently excludes the other." (Cimermanová, 2015).

It has now progressed to electronic comics (e-comics). Comics are illustrated stories that have their own plot and appeal for their readers (Maharani et al., 2019). Changing printed comics into digital comics is one of the innovations that can overcome the quality of physics learning (Febriani, Ratu, & Rahman, 2020), where E-comics as a medium can develop creativity and imagination in thinking. Among other things, e-comic media can help teachers employ media to create better learning outcomes. Presenting comics in electronic form also makes it easier for students to access, study, or utilize them anywhere and whenever they choose, much as they do with gadgets or cellphones (Buchori & Setyawati, 2015; Damayanti & Kuswanto, 2020; Rasiman & Agnita, 2014). A teacher who uses online and offline e-comic media to activate the learning process in class can increase learning outcomes (Friedman & Friedman, 2013; Greene & Hale, 2017). In contrast to some who believe that games and education are at opposite ends of the spectrum, there has been a paradigm shift in which the border between games and education is becoming increasingly difficult to separate. The contemporary era is one in which learning while playing makes time more effective in learning. Based on the explanations provided above, the aim of this research is to develop excellent physics e-comic learning material to assist students in understanding Newton's concepts.

Method

The Research and Development (R&D) method used in this study is the 4-D development model. This development model was chosen for its accuracy as a foundation for constructing learning tools rather than as a learning system. The 4-D development model consisted of four steps: Define, Design, Development, and Disseminate. Figure 1 depicted the development model. This study used data collection techniques by observation, interviews, and questionnaires. The subjects of this research were class VIII students from SMPN 15 Semarang, a group of 27 individuals. SMPN 15 Semarang was chosen as the research topic because it had a diverse student population, including ethnic diversity, student ability diversity, and a wide range of student character traits and interests (Creswell, 2014; Simonds & Christopher, 2013). As a result, the findings of this research would be able to represent the situations of different schools with diverse student personalities and profiles (Corazza & Glăveanu, 2020; Khazanchi & Masterson, 2011; Literat, 2017). Observation sheets, questionnaires, and interview guide sheets would be used in this research to conduct in-depth interviews, even though the interviews would be unstructured.

As users of the product, namely e-comics, students and several teachers were subjected to observations, interviews, and surveys. A product quality assessment sheet was employed as the questionnaire technique. Users could also submit textual replies regarding quality and feedback on the product being developed, notably e-comics, via the questionnaire.

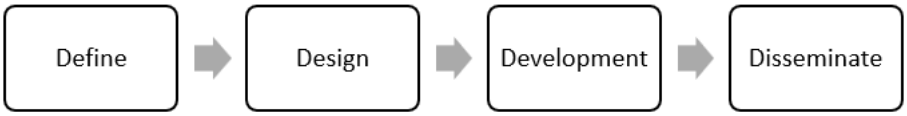

Figure 1. 4-D R&D Development Model

Figure 1 showed the 4-D R&D Development Model. In the define stage, the researcher analyzed and gathered data on e-comics learning medium, physics materials, and the amount to which development was required. In the design stage, it was done by designing and compiling criterion tests, selecting learning media, selecting learning media formats, and pre-designing learning media. During the development stage, a product in the form of an e-comic was created. This product was then evaluated and tested on users by expert validators (Febriani et al., 2020). At this stage, expert validation (validator and reviewer) and development tests were performed. The final stage was the disseminate stage, which involved gathering comments and feedback on learning media generated as a result of the effects of dissemination. This e-comic was distributed over the website.

After the data was collected, the next step was to process the data to assess the feasibility of electronic comics as learning media. Observation and interview data were processed in descriptive form, while questionnaire data were processed using the Likert scale and Guttman scale (Cohen, Manion, & Morrison, 316AD). Observation data from student learning activities such as 1) Visual activities, 2) Listening activities, 3) Oral activities, 4) Writing activities, 5) Emotional activities, 6) Mental activities, and 7) Motor activities were utilized to determine the process of student learning activities (Creswell, 2014). Data analysis techniques in this study included data collection, selection and editing, as well as coding and data presentation.

Results and Discussion

This research resulted in an e-comic for junior high school students that discussed Newton's laws. Newton's laws were discussed in relation to common occurrences in Indonesian society. The image design and language used were intended for people who were familiar with Indonesian culture to accept and understand (Agostinho, 2011; Hupkes, Veldhoen, & Zuidema, 2018; Palmiero, Cardi, & Belardinelli, 2011; Şimşek, Altun, & Ateş, 2010). Presenting material and concepts that were contextual and suited to phenomena that were close to students' culture and everyday life had been shown to have more implications for students than non-contextual presentation. Many studies had shown that giving such content might help students understand concepts more quickly and create a longer lasting effect on the student's brain and memory (Cao, Li, Wang, & Huang, 2017; Coelho, Augusto, & Lages, 2011; Sung, Hwang, & Chang, 2015).

At the time of data collection, the material in e-comic physics was determined. Newtonian mechanics was the fundamental topic in beginning physics, and force was one of the most important concepts in all of physics (Hairan et al., 2019). The requirements analysis results suggested that this material was critical since it is the foundation of various materials and concepts in physics. The findings of research on students' grades and achievements in relation to Newton's laws were also relatively poor. According to needs analysis, students and teachers were happier when they learned through media, and they required media that was entertaining, fun, and useful while also presenting right and suitable concepts (Dewi, Magfiroh, & Nurkhalisa, 2019; Kerstetter, 2012; Zhou, Wang, Song, & Wu,

2017). This was what motivated academics to create e-comic-based learning material on Newton's laws with the goal of showing applicable Newtonian phenomena in everyday life, as illustrated in Figure 2.

The product design stage began with developing a plot or storyline that was used as a framework for making electronic comics as shown in Figure 3. The first step in making this e-comic was selecting the media used, namely the Clip Studio Paint and Photoshop applications. The second step was the preparation of the storyline, this step included the selection of e-comic themes and titles, as well as characters and storyline concepts. The theme of this e-comic was learning physics entitled Newton's Law I. The characters chosen for this e-comic were students and teachers, whose personalities were tailored to the objectives of the project. The plot concept was developed using the story topic "A Visit to the City Museum" and dialogue scenarios adapted to Newton's Laws material. The characters and plot were adapted to Indonesian culture, with kids wearing headscarves and junior high school uniforms in Indonesia, and teachers wearing typical Indonesian teacher uniforms. The purpose of the visit is the city museum, as was common in Indonesian schools. In Indonesia, the use of cat characters was also prevalent. Cats were a supporting character that contributed to the concept of Newton's law. The selection of scenarios used in Newton's Law I subject in this e-comic was the scene when students and teachers got on the bus and the bus driver abruptly hit the brake lever to avoid the cat in front of the vehicle, as depicted in Figure 4.

Figure 2. Scene Example Application of Newton's Laws

Figure 3. Framework E-comic

After the product was designed and developed, two material experts and two media experts assessed the electronic comic. This assessment was used as an outline for the development of e-comics by examining the characteristics of material, form, graphics, and language. When developers received suggestions from validators, they might rewrite the e-comic one more time until it was ready. Suggestions from the validator included choosing a font for e-comics because the font chosen had to be more precise in terms of shape and size. The usage of the appropriate typeface design and size had been shown to affect reader comfort, ensuring that they were satisfied and comfortable with what they read. As a result, the developer updated the product by adjusting the shape and size of the typeface to match the pictures and illustrations. Another suggestion was to improve the character's expression because it did not accurately depict the situation. For example, the character might be in an exciting position, but his or her countenance was puzzled. Students could understand the scenario and problems that arose by depicting expressions in a picture without having to read the text carefully. The usage of interesting images could help pique students' interest in reading and make them intrigued about what the images they were looking at were telling them (Ahmed & Chao, 2018; Caldwell, Whewell, & Heaton, 2020; Şimşek et al., 2010). Developers changed character expressions to suit the plot or dialogue. Another validator suggested adding sample questions because the product did not exist. Thus, the developer added examples of questions so that students would be more likely to learn practice questions (Hajhosseiny, 2012; Thomas & Goering, 2018). Presenting questions aided in the development of students' mathematical and literacy skills, particularly when they were relevant to the problems and topics being taught (Lai & Li, 2011; Yu & Frenkel, 2013). This allowed students to get more acquainted with and trained in the kind of questions and problems associated with the content and concepts being taught.

Figure 4. The selection of scenarios used in the subject of Newton's Law I in this e-comic

Validation at the development stage was carried out by two material experts and two media experts, namely the PTI study laboratory, the Head of the Digital Business Department, and a science teacher at SMP Negeri 15 Semarang, as well as a lecturer in the physics education department. The average proportion of results achieved through validation by material expert 1 was 98%, with the criteria "very feasible", while material expert 2 gave an average percentage of 90% with the criteria "very feasible". The average percentage of material expert validation scores with the criteria "very appropriate" was 94%. Similarly, the average percentage of validation results from media expert 1 was 88%, which was included in the "very feasible" criteria, and media expert 2 was 94%, which was also included in the "very feasible" criteria. For all media expert validations on the "very appropriate" criteria, the average percentage obtained was 91%.

The information was distributed to 27 students of class VIII from SMP Negeri 15 Semarang. In the "very feasible" criteria, the average score was 99%. The following average results were achieved based on the feasibility evaluation completed by material experts, media experts, and students, as shown in Table 1.

Table 1. Overall Feasibility

No	Validators	Feasibility	Criteria
1	Material expert	94%	Highly feasible
2	Media Expert	91%	Highly feasible
3	Respondent (students)	99%	Highly feasible
	Average percentage	95%	Highly feasible

Based on the final feasibility test results, an average percentage of 95% was attained, indicating that the e-comic was included in the "very feasible" criteria for use. The students' minimum mastery score before utilizing the e-comic was 47%. However, after implementing the e-comic, 80% of students scored above the minimum mastery criteria. The validation results suggested that employing e-comic

to improve physics learning outcomes was both valid and feasible. Thus, e-comic could be utilized as an alternate learning media to promote and improve physics learning. Aside from offering it to schools, the e-comic was extensively published on the webtoon website, allowing the general public to use it as well. Thanks to the changes made in response to validator suggestions, this e-comic was shared. E-comic had been validated and revised as an innovative way of improving students' physics learning outcomes, resulting in e-comic products that were very suitable for use as learning media.

We believed that the generated e-comic could help students learn physics curriculum based on Newton's Law I. Similarly to Weber's research, 2021 restricted basic Newtonian dynamics relationships with the two new approaches, namely comparative investigation of computing models and video motion analysis (Weber & Wilhelm, 2021). Additionally, Salmiza Saleh discovered a slight difference in the level of conceptual comprehension based on the developed Test of Conceptual Understanding of Newtonian Physics (Saleh, 2011b).

Due to the significance of variations in Newton's law learning media, as well as the fact that this research was still homework and/or a parable for researchers who want to preserve the understanding of Newton's concept, it appeared sufficient to be an advantage of innovation in e-comic learning media for other physics materials. Keep in mind that creating e-comics required technological competence in order to use the comic's scene-by-scene development tool.

In addition, the selection of material on understanding other concepts in physics would also encourage students to explore more about natural phenomena around them. Designing storyline scenarios and choosing natural phenomena topics would indirectly train students in understanding the concept of the phenomenon itself.

The incorporation of E-comics into media development was seen as an excellent medium for developing and strengthening conceptual understanding, critical thinking, and student character values. According to Rasiman, and Agnita S. P: 2014 research, Flip book maker-based e-comic learning media could also improve students' learning abilities, critical thinking, and foster character values such as: discipline, cooperation, honesty, confidence, and tenacity.

According to (Baifeto, Samsudin, Efendi, & Athiyyah, 2022) research on the development of physics comics entitled Developing PHYCOM (Physics Comics) on Newton's Law Material for 10th Grade High School Students with research results that PHYCOM teaching materials could be used by students as independent study materials. The study, entitled Development of Sir Isaac Newton's Biographical Comic as a Physics Learning Media Using the SAI Paint Tool Application, was the only one. This research included methods for creating the comic character Sir Isaac Newton with the SAI Paint Tool application. Sir Isaac Newton, the comic character, was intended to be used as a physics learning medium. Finally, the research results indicated that the product was quite highly feasible. According to (Hadi & Dwijananti, 2015) research, entitled Developing an Android-Based Physics Comic as a Supplement to the Subject of Radioactivity for High Schools, he was able to overcome the abstract concept of Radioactivity with images generated in comic form. Similarly, the research entitled "Development of Physics Comic Learning Media on Basic Measurement Material for Compreng 1 State High School Students" had succeeded in generating physics comics on physics material that were of high quality and appropriate for usage.

In this way, the development of e-comics could undoubtedly become a medium that was used to lay the groundwork for understanding students' concepts and views of physics, where students still believed physics was a difficult subject and experience cognitive load before understanding. The e-comic developed as part of this research had several advantages, including the fact that it contained material concerning Newton's Laws, which was so close to everyday life that we were unaware of its existence (Walton & Kemmelmeier, 2012). This e-comic highlighted the phenomenon of Newton's laws in numerous people's experiences, including the students themselves. Aside from that, this e-comic had questions regarding Newton's laws that students could use to improve their cognitive abilities. Since the example questions were packed in comic form, it was intended that the cognitive load on students would be reduced.

Conclusion

E-comics had succeeded in building an understanding of the physics concepts of Newton's Law I among students. This was demonstrated by the learning outcomes of students who held positions higher than the minimum completion criteria. E-comics could make learning more enjoyable, understandable, and in line with the present period of learning while playing, particularly in physics learning, which was still regarded as a cognitive strain on students. Flip book maker-based e-comic learning media could also help kids improve their learning abilities and critical thinking, as well as built character traits including discipline, cooperation, honesty, confidence, and perseverance (Rasiman. & Pramasdyahsari, 2014). With the development of this e-comic, students would be assisted to understand the concept of Newton's Law I, which would lower students' cognitive burden while also laying the groundwork for understanding other physics materials.

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