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Science Learning Transformation: Android Digital Comics (MiGiRo) as a Science Learning Resource on the Concept of Genetics

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Abstract
The learning resources used by teachers in science education, such as textbooks and student worksheets, are often less engaging and primarily limited to occasional presentations. Students grow disinterested and distracted as a result of this lack of variation. This study set out to assess the efficacy, usefulness, and reactions of junior high school students to the employment of Android-based digital comics (MiGiRo) as a teaching tool for the subject of genetics. The Research and Development (R&D) method with the Plomp model was employed. Validation was conducted by material experts, media experts, and linguists, while practicality was assessed by science teachers, and student responses were collected from ninth-grade students. The data were analyzed quantitatively. The validation results indicated that MiGiRo received scores of 86.3% from material experts, 75% from media experts, and 92.5% from linguists, all within the very good category, making it suitable for use. The practicality test showed a score of 96.7%, indicating that MiGiRo is very practical with no revisions needed. Student response testing during the field trial resulted in an overall score of 88.3%, also in the very good category. It can be concluded that MiGiRo is a useful and legitimate interactive learning tool for junior high school students.

Keywords: Android digital comic, science learning resources, genetics

INTRODUCTION

Science education can help students to master theories and concepts related to problems in everyday life (Oktaviyanti et al., 2023). Natural Sciences (IPA) is a combination of several disciplines, namely physics, biology, chemistry and earth science (Diniya, 2019) about natural objects and phenomena obtained from the results of scientists' thoughts and investigations using the scientific method (Hisbullah & Selvi, 2018). The object of science learning can be an abstract or concrete object (Ismiyanti, 2020). To learn science, we can utilize some various sources such as package books, companion books, the internet, or learning directly from nature (Qismawa & Jumini, 2020). Science learning can also be supported by media and learning resources to achieve learning objectives (Syarif, 2020).

In the fact, one of the most difficult disciplines in education to increase pupils' comprehension and interest in is science (Darling-Hammond et al., 2020). The tendency in science learning to explain abstract concepts can cause difficulties for students in understanding the material. When teachers convey abstract science concepts only through verbal explanations, students may not be able to understand them well. This problem may arise due to the limited ability of students to master science concepts, which in turn can have an impact on suboptimal learning outcomes (Ismiyanti, 2020). So, the development of science learning materials has a very important role in improving students' understanding and interest in science. Good science learning materials should be able to connect theoretical concepts with their application in everyday life, and encourage students to think critically and creatively (Sinurat et al., 2023).

The development of science and technology can help humans in various aspects of life. In the 21st century, technology brings significant changes to all aspects of life, including education (Amirah & Mahartika, 2023). Nowadays, every individual is required to understand the sophistication of existing technology, including teachers (Anesia, et al., 2018). In Indonesia, since the Covid pandemic, the existence oflearning loss in students has made teachers have to use their skills and abilities in integrating technology in learning. The characteristics of students who are already familiar with technology, as well as the ability of schools to provide technological equipment, encourage teachers and schools to immediately integrate ICT in the learning process (Rahayu, 2017). Teachers are expected to be able to develop digital literacy, especially in creating learning media (Lestari et al., 2022). The main aspect that affects the absorption of teaching materials is learning media (Nurniawan & Puspasari, 2014). Thus, technology is expected to help teachers in carrying out learning in the classroom.

Along with technological developments, science learning materials are now not only limited to textbooks or laboratory experiments, but also involve the use of interactive media such as simulations, videos, and digital applications that make it easier for students to understand complex concepts. In addition, the development of science teaching materials must also consider the diversity of student learning styles, so that these teaching materials can be tailored to the needs of each individual (Tzenios, 2020). Along with the rapid development of technology, the development of science learning materials is now increasingly influenced by advances in information and communication technology. The integration of ICT in education, especially in the development of learning media, can help create teaching materials that are more interactive and interesting for students (Dakhi et al., 2020; Kustyarini et al., 2020). In Indonesia, especially after the Covid-19 pandemic, learning challenges faced by

students, including learning loss, encourage the importance of technology utilization in the learning process. Teachers are expected to have skills in integrating technology to create learning media that suits students' needs and can increase their interest and understanding of science materials (Lestari & Supahar, 2020). Thus, technology becomes a very important tool in developing more relevant, innovative and effective science learning materials.

Much literature shows that technology has great potential in the science learning process. Ryan & Cowie (2009) mention that technology can encourage independent or collaborative learning. Technology has various capabilities, such as providing interactive content, providing quick learning feedback, diagnosing learners' needs, providing effective methods to overcome learning difficulties, assessing learners' learning processes and outcomes, and storing examples of learners' work to improve learning outcomes (Watson & Watson, 2011). Learners' reflections can be facilitated by computers, which help them become more aware and able to direct their own thinking, making learners more responsible for their learning decisions (Lai, 2008). The role of technology in learning is expected to make learners more interested in learning science concepts, especially abstract concepts.

Science learning resources in Indonesia are still very limited. It is proven by the difficulty of finding reading books about science material, especially those in Indonesian. In fact, most teachers use foreign-language reading books as additional references in learning. Likewise, reading books about science for children are still very rare (Qismawa & Jumini, 2020). Comics are one of the innovations that can be developed for science learning resources and foster students' interest in learning science concepts. Empirically, students are more interested in reading picture books than textbooks (Daryanto, 2013). In addition, comics provide simple stories, easy to capture and understand others, so they are very popular with both children and adults.

Specifically, research on comic development in science learning is still very limited. Based on a search using the help of Publish or Perish software on the Google Scholar database between 2015-2024 with the keywords 'android-based comics' and 'inheritance of properties', 58 related articles were found. However, of the 58 articles, there are only 4 articles related to comics. Research conducted by Qismawa & Jumini, (2020). focused on developing comics on the topic of disaster mitigation with the research subject of grade 8 junior high school students. Research conducted by and Imrotin, et al. (2022) focuses on developing comic strips sourced from anecdotes as a combination of literature and animation vocational theory with the research subjects of vocational high school students. Research conducted by Zuhlina (2023) focuses on developing android-based games on digestive system material with the subject of class XI high school students. Research conducted by Sonia, et.al. (2024) is a systematic literature review research related to the use of android-based learning media at the junior high school level. The results showed that the use of Android-based learning media in class VII was focused on solar system material with a portion of 10%. In grade VIII, this media is mostly applied to the material of the excretory system, covering 7.50%. In contrast, 7.50% of the cell material in class IX focused on using these media. Overall, class VIII accounts for 46% of all Android-based learning media applications.

Coupled with the results of interviews with science teachers, it was found that the learning resources used in the science learning process on the material of genetics were still rare. During the learning process, teachers only use textbooks and student worksheets as well as presentations using power points displayed through the projector

screen in the classroom. This causes most students to pay less attention to the ongoing learning. Furthermore, the teacher also explained that there was no pictorial learning resource equipped with a story, let alone an android-based one. Thus, it can be mentioned that Research on the development of comics as a learning resource for science education, especially Android-based comics, is still very limited, creating a clear gap in the literature. While there are various studies on the use of digital media in education, most of them focus on other topics such as disaster mitigation, vocational training, or anatomy, with very few exploring the specific use of Android-based comics for teaching science, particularly on topics like genetics.

The existing resources in Indonesian schools, especially those for science education, are often limited to textbooks and worksheets, which fail to engage students effectively. This issue is compounded by the lack of visually rich, story-driven learning materials, such as comics, that could capture students' interest. Interviews with science teachers further revealed that the use of Android-based learning media is minimal, and there is a notable absence of interactive, narrative-based resources. This presents an opportunity for research to fill the gap by developing Android-based comics specifically designed for science education, which could enhance students' engagement, understanding, and interest in complex scientific concepts like genetics. Therefore, this study seeks to occupy this niche by creating Android-based digital comics as an innovative and effective learning resource for science in junior high schools. This research focuses on developing Android-based comics as learning media to overcome the problems that have been identified, namely the limited learning resources that are interesting and effective, especially in the topic of genetics.

The research questions include:

RQ1: how is the need analysis in learning resource development on android-based comics on the topic of genetics?

RQ2: How is the validation of material, media and language experts on android-based comics on the topic of genetics?

RQ3: How is the practicality of android-based comics on the topic of genetics?

RQ4: How do students respond to android-based comics on the topic of genetics?

METHOD

This study used a research and development (R&D) approach. Research and development is a process used to develop and validate educational products. The steps of this process are commonly referred to as the R&D cycle, which consists of studying research findings pertinent to the product to be developed, developing the product based on these findings, field testing it in the setting in which it will be ultimately used, and revising it to correct any deficiencies found in the filed testing stage (Borg & Gall, 1984). Development research is based on two objectives, namely the development of product prototypes and the formulation of methodological suggestions for the design and evaluation of these product prototypes.

The development model used is the Plomp model. This model was proposed by Plomp in 1997. Plomp stated that in development research, a research design is needed. Plomp briefly characterises design in education as a method by which people work systematically towards solving problems. Plomp's model consists of a preliminary investigation phase, a design phase, a realisation/construction phase and a test, evaluation and revision phase, as well as implementation. In this study, the development was only carried out up to the test, evaluation, and revision phases because the

implementation phase requires a long process and time. In general, Plomp's model is described as follows in Figure 1.

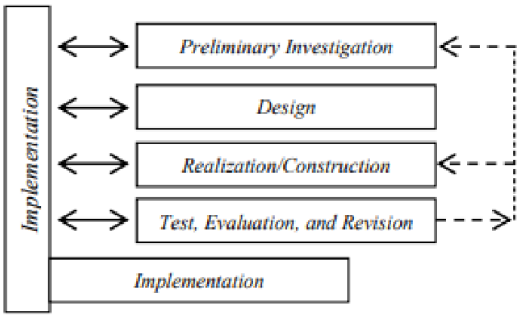

Figure 1. The Development Design

The stage of preliminary investigation is carried out by analyzing the needs or conducting a problem analysis within the scope of the material to be developed for the comic. During this phase, a curriculum analysis is performed, along with an assessment of the needs of both students and teachers. Next is the design phase, where the focus is on designing an android-based comic media for teaching inheritance material. The initial product planning involves identifying the basic competencies related to the topic of genetics. Researchers then gather material related to genetics through online resources such as journals, digital books, learning materials, or presentations. The subsequent phase is the realization or construction phase, which follows from the design phase. During this phase, the learning products and necessary instruments are created and the outcome is an android-based comic as a learning product. Finally, the test, evaluation, and revision phase takes place. This phase consists of three main activities: first, validating the material, media, and language used in the android-based comics by experts; second, evaluating the practicality of the comic media; and third, assessing how students respond to the android-based comics.Validation scoring by validators using a Likert scale of 1-4 for assessment points. The answer to each instrument that uses a Likert scale has a very good to bad gradation (Sugiyono, 2019). The results of the percentage level of validity are then interpreted in qualitative statements (Riduwan, 2020) based on the Table 1.

Table 1. Assessment Criteria for Construct Validity

No	Percentage (%)	Assessment Criteria
1	0% - 25%	Not good
2	26% - 50%	Fair
3	51% - 75%	Good
4	76% - 100%	Very Good

FINDINGS AND DISCUSSION

Preliminary Research Stage

This stage involves conducting a needs analysis or problem analysis within the scope of the material to be developed for the comic. To gather insights, students respond to questions provided via Google Forms. This method helps identify the areas where students face challenges or have gaps in understanding, allowing for a targeted approach in designing the comic to address these specific needs effectively. The data can be seen in Figure 2.

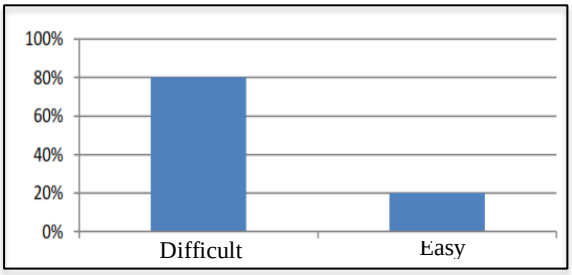

Figure 2. Questionnaire of students' responses about science learning

Based on data gathered from a questionnaire distributed to students, it was revealed that 80% of the respondents, equivalent to 16 students, found learning science to be difficult, while 20% or 4 students believed that learning science was not challenging. This indicates a significant disparity in students' perceptions of the subject, with the majority expressing difficulty in grasping the concepts. The findings suggest that many students may be struggling with the complexities of science, which could be attributed to factors such as the teaching methods, the nature of the subject matter, or a lack of engaging learning materials. The results highlight the need for educational approaches that make science more accessible and engaging for students.

Next, a total of 60% or 12 students reported using the package book as an independent learning resource during science lessons, while 20% or 4 students mentioned utilizing student worksheets for the same purpose. Additionally, 15% or 3 students indicated that they used modules as independent learning resources, and 5% or 1 student relied on animated videos. Interestingly, none of the students had ever used comics as an independent learning resource. This suggests that while traditional resources like books, worksheets, and modules are commonly used, there is a lack of familiarity with comics as a tool for independent learning in the context of science education. The data can be seen in Figure 3.

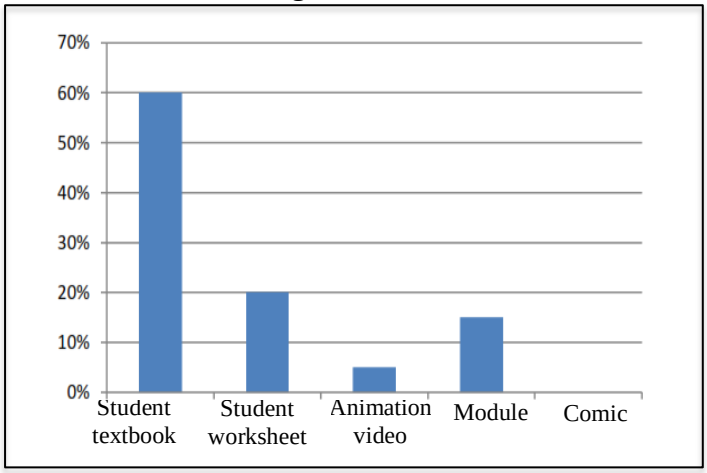

Figure 3. Survey of students' opinions regarding resources for self-learning in science

The findings on students' use of independent learning resources highlight a preference for traditional materials such as package books, worksheets, and modules. However, it is evident that students are less familiar with comics as a learning tool. This gap presents an opportunity to explore alternative resources that could better engage students. In fact, when asked about their preferences for learning materials, 75% or 15 students expressed a desire for resources with plenty of pictures, while 25% or 5 students favored concise and easily understandable books. This suggests that

incorporating visual elements, such as those found in comics, could align well with students' learning preferences and potentially enhance their engagement with the material (seen in Figure 4)

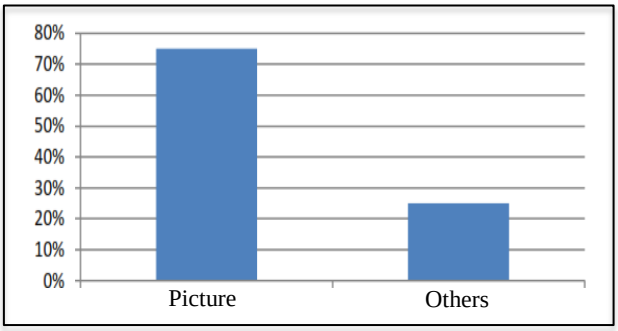

Figure 4. Questionnaire of students' responses about the desired science learning resources

The needs analysis conducted through a questionnaire revealed key insights into students' perceptions and preferences regarding science learning. The majority of students (80%) find learning science challenging, suggesting a need for more engaging and accessible educational approaches. While traditional resources like package books, worksheets, and modules are commonly used, there is little familiarity with comics as an independent learning tool. However, students expressed a strong preference for learning materials with visual elements, as 75% favored resources with lots of pictures. This indicates that incorporating comics, which combine both visuals and educational content, could address students' learning difficulties and better align with their preferences, ultimately enhancing engagement and comprehension in science education.

Design stage

In the design phase, researchers made stages in designing android-based comic media on the material of genetics. During this phase, the design process involves conceptualizing the layout, user interface, and interactive features that will enhance the learning experience. The comic's design uses the application Medibang Paint, IbisPaint X and Microsoft Word 2010. The comic media is crafted to effectively communicate complex inheritance concepts in an engaging and visually appealing way, making use of animations, illustrations, and user-friendly navigation to help students better understand the topic. The goal is to ensure that the content is both informative and entertaining, facilitating easier comprehension and retention of inheritance principles. Initial product planning is to determine basic competencies then collect material related to genetics from journals, digital books, self-study materials, or presentations. The preparation and work on making comics is carried out in several stages, namely, as follows in Figure 5.

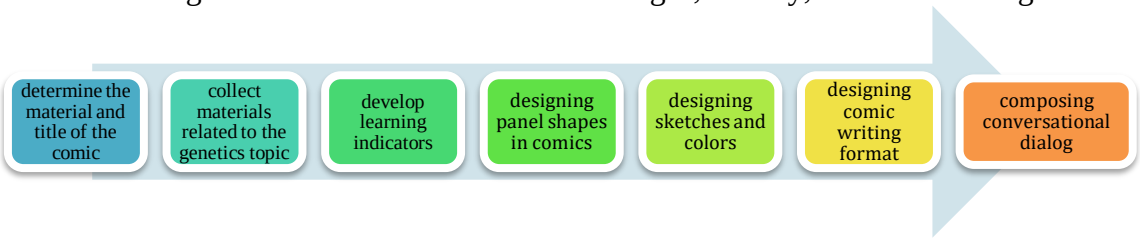

Figure 5. Android-based comic design phase

The process begins with determining the material and title of the comic, which involves selecting the core genetics topics to be covered and choosing a title that reflects the

content's focus. Next, relevant materials related to the genetics topic are collected, including accurate scientific information, visual references, and examples. This is followed by developing learning indicators, which outline the key concepts and objectives the comic aims to convey. The design phase then moves to creating the panel shapes for the comic(Figure 6), ensuring they are structured to enhance readability and engagement.

Figure 6. Paneling in Comics

Once the panel layout is decided, sketches and colours are designed to visually represent the content, with careful attention to aesthetic appeal and clarity.

Figure 7. Sketching and Coloring the Comic

The comic's writing format (seen in Table 2) is then designed, ensuring it aligns with the educational goals and provides clear, concise explanations.

Table 2. Comic writing format

Comic Section	Font Type	Font Size
Comic Cover	Comic Sans	10 pt
Foreword Core	Comic Sans	10 pt
Competencies (KI) and Basic Competencies (KD)	Comic Sans	10 pt, 8 pt
Introduction of Characters	Comic Sans	10 pt, 8 pt
Material	Comic Sans	8 pt
Image Explanation	Comic Sans	8 pt

Finally, the conversational dialogue is composed, ensuring that it is both informative and accessible, using language that is appropriate for the target audience while also engaging readers in an enjoyable learning experience.

Realization/Construction Phase

The realization or construction phase follows the design phase and focuses on the actual development of the learning products and necessary instruments. In this phase, the ideas and concepts developed during the design stage are brought to life, with a specific emphasis on creating the educational tools required for the project. This includes the actual construction of the android-based comics, which are designed to address the learning needs identified in the earlier stages. The development process involves transforming the visual and interactive elements into a working format that is suitable for students to use on their devices. The outcome of this realization phase is the creation of Prototype I, which serves as the first iteration of the android-based comic learning product (seen in Table 3).

Test, evaluation, and revision Phase

At this stage there are three main activities carried out, the first is to find out how the validation of material, media and language experts on android-based comics, the second is to find out how the practicality of android-based comics and the third is to find out how students respond to android-based comics.

a. Material Validation Result

The results of questionnaire research from material expert validation are seen in Figure 9.

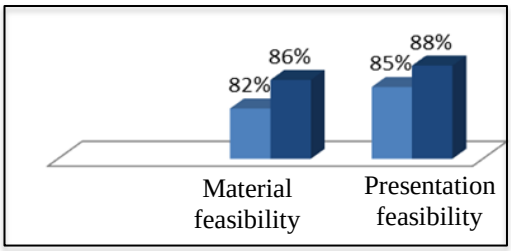

Figure 8. Material Expert Validation Assessment Results

Based on the results of material expert validation by validators related to material aspects, the first assessment on the feasibility aspect of the material was 82% while the second assessment was 86%. Furthermore, in the aspect of presentation feasibility in the first assessment obtained 85% while in the second assessment 88%. The overall average value of 86.3% if converted based on quantitative data guidelines to qualitative data, the android-based comic product as a science learning resource on the material of inheritance of properties developed is included in the very good criteria.

b. Media Validation Result

The results of questionnaire research from media expert validation are seen in Figure 10. Based on the results of media expert validation by validators related to media aspects, the first assessment was 68% and the second assessment on the material feasibility aspect was 75%. Furthermore, in the aspect of presentation feasibility in the first assessment and the second assessment obtained 75%. In the language aspect, the first assessment was 73% and the second assessment in the language aspect was 75%.

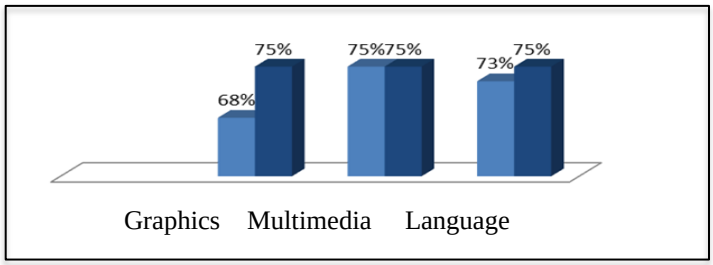

Figure 9. Media Expert Validation Assessment Result

The overall average value of 75% when converted based on quantitative data guidelines to qualitative data, the android-based comic product as a science learning resource on the material of inheritance of traits developed is included in the good criteria.

c. Language Validation Result

The results of questionnaire research from media expert validation can be seen in Figure 11.

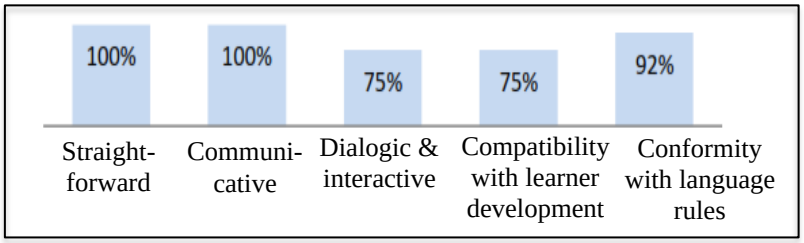

Figure 10. Language Validation Result

Based on the results of the validation of linguists by validators related to linguistic aspects, a score of 100% was obtained on the straightforwardness of the language which means very good, 100% on communicative language which means very good, 75% on dialogical and interactive language which means good, 75% on conformity with language development which means good, and 92% on conformity with language rules which means very good. The overall average value is 92.5%, if converted based on quantitative data guidelines to qualitative data, the android-based comic product as a science learning resource on the material of inheritance of properties developed is included in the very good criteria.

d. Results of Practicality

The results of the practicality questionnaire assessment of educators/teachers can be seen in Figure 12.

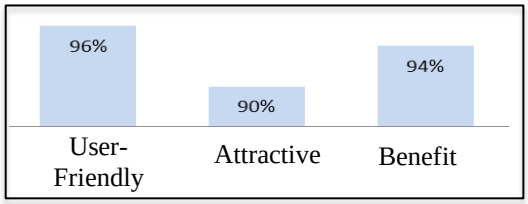

Figure 11. Results of Practicality

Based on the results of the analysis of practicality by science teachers, a score of 96% was obtained in the aspect of ease of use, 90% in the attractiveness of the presentation, and 94% in the benefits. The overall average value of teacher

practicality is 96.7%, which means that android-based comics as a science learning resource on the material of inheritance of properties developed includes the criteria "Very Practical".

e. Data on Learner Response Results

The results of the assessment of the learner / student response questionnaire can be seen in Figure 13.

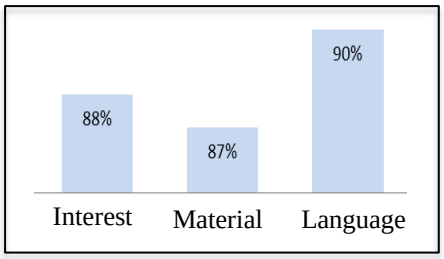

Figure 12. Results of the Learner Response Assessment

Based on the results of the analysis of the responses of one class of 20 students, 88% interest aspects, 87% material aspects and 90% language aspects were obtained. The overall average value of the assessment of the response of one class of students is 88.3%, which means that android-based comics as a science learning resource on the material of inheritance of properties developed includes the criteria "Very Good". The following are the results of evaluations from validators related to Android digital comics named MiGiRo.

Table 3. Summary of prototype 1, evaluation results from validators and revisions

Evaluation results from validators	Revisions made by researchers
Improvements to the cover, adding class and semester writing	 (a) (b)
Adding pages in the indicator section	 (a) (b)

Evaluation results from validators	Revisions made by researchers
Changing the series of words in the preface	 (a) (b)
Adding words to the character introduction	 (a) (b)
Adding pictures and words to the comic material description	 (a) (b)
notes (a) before revision or Prototype 1 and (b) after revision	

Based on the evaluation results, some improvements need to be made to improve the quality and clarity of the material. One of them is the improvement of the cover design, by adding class and semester information that will make it easier for readers to identify the purpose and use of the material. The addition of this information also gives a professional and structured impression to the learning product. In addition, it is necessary to add a page in the indicator section that explains in more detail the objectives and achievements expected from the use of this media. This aims to clarify learning objectives and provide more systematic guidance for teachers and students in using comics as a learning resource.

Other improvements include changes to the wording of the preface to improve reader comprehension and appeal. A more structured introduction will give a better impression and make it easier for readers to understand the context and benefits of this learning media. In addition, the addition of words in the character introduction section is also important to enrich the information and help students more easily identify and understand the characters in the comic. Last but not least, the addition of pictures and words to the description of the comic material will make learning more interesting and easier to understand. With clearer visual elements, students can more easily capture the

message to be conveyed in each material taught through comics, and can enrich their learning experience.

Discussion

The product developed by researchers is a learning resource in the form of an Android-based comic called MiGiRo. MiGiRo designed can be used by teachers as a learning resource during the learning process. MiGiRo by students is used to understand inheritance material independently which can be accessed anytime and anywhere. MiGiRo is designed to be very attractive and practical to attract students' interest in learning through smartphones. The smartphone used runs the Android operating system which was chosen because it is the most commonly used operating system compared to others. The use of this learning media is very easy and allows students to learn independently. This is because MiGiRo is portable, this learning media can be accessed anytime and anywhere.

The appeal of comics lies in their combination of engaging illustrations, well-structured plots, and accessible language, making them an excellent medium for both children and adults (Aprilia, 2019; Qismawa & Jumini, 2020). Given their effectiveness in capturing attention and stimulating creativity, comics are increasingly incorporated into educational materials to enhance learning experiences. To create such comic content, digital tools like Medibang Paint offer an ideal platform. This software enables users to easily create and manipulate images and illustrations, making it a popular choice for digital artists. With its user-friendly interface and light file size, Medibang Paint allows for the production of high-quality comic designs that can be used in educational contexts, supporting independent learning and fostering student imagination (Gunawan & Sujarwo, 2022).

Medibang Paint is a digital painting software that, while primarily focused on digital artwork, also allows for editing and manipulating images and photos. Available for free through Google Playstore or the official Medibang Paint Inc. website, it is accessible to anyone, especially digital artists, for both hobby and commercial purposes. Its user-friendly interface and relatively light file size make it popular among digital artists despite its many features (Subudiartha, et al., 2023). This software can be particularly useful in creating comics, which are known for presenting engaging, simple stories with relevant visuals that resonate with students. Comics are not only easy to understand but also have the advantage of being highly portable, especially when delivered through Android applications, allowing students to learn anytime and anywhere (Aprilia, 2019). By combining the creative flexibility of Medibang Paint with the engaging nature of comics, this medium can provide a visual and interactive learning experience that boosts students' motivation and makes learning more enjoyable (Gunawan & Sujarwo, 2022).

Comics have the advantage of presenting funny pictures and simple stories that are relevant to the experience of students, and are informative so that they are easy to understand. In addition, comics available in Android applications are very practical to carry anywhere (Aprilia, 2019). The use of comics can further stimulate learners visually, even audibly if the comic media used is equipped with sound. This stimulation helps increase students' motivation in learning (Gunawan & Sujarwo, 2022). Therefore, Android-based comics can be used at school with teachers or at home as a learning resource. One of the materials that can be taught through comics is genetics in science subjects, which studies the transmission of genetics from parent to child. This material

can be very complicated and difficult to understand if only explained verbally by the teacher. Therefore, the use of storylines and images in Android-based comics is expected that students can more easily understand the material taught through messages or information that aims instructional and educational.

CONCLUSION

Based on results obtained in this line of research, it can be concluded that the development of Android-based comics as a source of learning science on the material of inheritance of properties has very good quality. According to the need analysis, students require more engaging and visually stimulating learning materials, like comics, to help them comprehend science concepts that have proven challenging. This comic has excellent assessment criteria and is very viable to employ in the learning process, according to the professional validators' assessment. Junior high school science teachers also gave this Android-based comic a very high rating for usefulness, stating that it was highly useful for teaching science to junior high school students. Students in class IX also responded favorably, demonstrating that this Android-based comic was highly engaging and successful for teaching science, particularly when it came to the topic of property ownership. Therefore, this Android-based comic has been shown to be a reliable, useful, and engaging educational tool to enhance junior high school science students' comprehension.

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