Development of E-Comic Learning Media on the Immune System Integrated with Wahdatul Ulum

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Article Info	ABSTRACT (9)
	Students' understanding of the immune system topic remains low due to its abstract nature and the lack of interactive learning media integrated with Islamic values. This issue is worsened by the dominance of lecture-based teaching methods. This study aims to develop an e-comic learning media integrated with the Wahdatul Ulum concept to improve students' learning outcomes on the immune system material. The research employed a Research and Development (R&D) method using the 4D model (Define, Design, Develop, Disseminate). Validation was carried out by media experts, biology content experts, and Wahdatul Ulum experts. Practicality tests were conducted with teachers and students, and effectiveness was measured using pretest and posttest. The validation results indicated a very high level of validity, with average scores exceeding 89%. The media was also rated very practical by teachers (88%) and students (96.32%). Its effectiveness was demonstrated by an increase in student scores from 36.52 (pretest) to 81.68 (posttest), with an average N-Gain of 0.71, categorized as high. In conclusion, the immune system e-comic integrated with Wahdatul Ulum is feasible and effective for use in biology learning to enhance student understanding and outcomes

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1. INTRODUCTION

Education plays a role in developing individual potential through the learning process (Fitri 2021). As times evolve, education must adapt to produce high-quality human resources (Triadi et al. 2022). The rapid advancement of science and technology demands improvements in learning quality (Surata et al. 2020). Information technology can be utilized to provide innovative learning that increases students' learning motivation (Yoriska, 2022). Therefore, the appropriate use of technology in education becomes crucial (Muhfahroyin, 2021), with teachers acting as facilitators who provide suitable learning resources and media (Nurhaliza et al. 2023).

Learning media serves as a tool to convey messages or information during the teaching and learning process (Winda et al. 2021). It plays a role in delivering knowledge effectively (Wati et al. 2021). Additionally, learning media can help students understand difficult material (Nasution et al. 2021). In biology education— particularly in the topic of the immune system, which requires deep conceptual understanding—the use of appropriate media can transform abstract concepts into more tangible and understandable ones (Alawiyah et al. 2021). This is especially important because immunology often involves complex, abstract, and microscopic processes that are not directly observable and can be confusing for students. Therefore, strong visualizations such as 3D animations, interactive diagrams, and visual narratives are essential to help students construct mental models of how immune responses work (Faggioni et al. 2019).

Initial observations at SMAS Al Mashum Kisaran BRT revealed that students struggled to understand the concept of the body's defense mechanisms, as they found it hard to imagine processes such as antigen infection, cellular responses, and the role of cytotoxic T cells. This led to low comprehension and lack of learning interest. Moreover, survey results indicated that the learning process was considered boring due to the lack of interactive media. The learning process is still mostly dominated by lecture-based methods that do not encourage active

student participation. Hence, there is a need for more innovative and engaging learning media. One possible solution is the development of educational comics on the immune system.

Comics are character-based illustrations that present a story sequentially to entertain readers (Daryanto, 2013; (Astuti et al. 2023). With technological advancements, digital comics are more favored by those aged 13–25 due to their easy access (Ramadhan and Rasuardie 2020). Digital comics used in education can increase students' reading interest and learning motivation (Yulandari, 2019). The use of digital comics as learning media also received an assessment score of 34.47% and is categorized as a beneficial medium(Hanifah et al. 2023).

The immune system is a topic that requires an interactive visual approach due to its abstract nature, which makes it difficult for students to understand. An interactive visual learning approach makes it easier for students to study the topic. As the body's defense system, the immune system protects against foreign elements that can disrupt bodily functions (IM, 2017). The immune system reflects the greatness of Allah in human creation, as mentioned in His words: "We have certainly created man in the best of stature" (QS. At-Tin: 4). Understanding it not only broadens scientific knowledge but also fosters spiritual awareness to maintain health as a form of gratitude to Allah (As-Syiba et al. 2023).

Various studies have shown that using digital comics as learning media can improve students' understanding and learning outcomes. Febriana, (2022) reported that biology-literacy-based digital comics effectively enhance understanding of immune system concepts and motivate students to learn. Additionally, Astuti et al. (2023) studied the use of e-comics on immune system topics and found an 18.28% increase in learning outcomes, categorized as a moderate improvement. Aprilia (2019) also found that Android-based comics were effective, with 81% of students achieving mastery and an average score of 79.44.

A similar study by Kristina dan Ismiati (2020) showed that comics as learning media enhanced students' cognitive skills, with a 12.2% increase in learning outcomes. These findings highlight the potential of digital comics as innovative learning media. Based on this background, this study aims to produce and analyze the feasibility and user response of the developed Wahdatul Ulum-integrated e-comic learning media. Integrating Wahdatul Ulum into this learning media is essential, considering that SMAS Al Mashum Kisaran BRT is a school that implements Islamic values. However, the learning media used at the school has not yet been integrated with Islamic values, making the development of this media an important step toward improving the quality of learning\

2. RESEARCH METHOD

This research was conducted from February to May 2025 with the research subjects being 11th-grade students at SMAS Al Ma'shum Kisaran BRT. The type of research used is developmental research or Research and Development (R&D) using the 4D (Four-D) model. According to Thiagarajan et al. (1974, as cited in Slamet 2022), this model consists of four main stages: Define, Design, Develop, and Disseminate.

The Define stage aims to identify and determine the needs in the learning process through observation and interviews. Analysis was conducted on modules, materials, and learning media, as well as their relevance to the Wahdatul Ulum concept in order to integrate Islamic values into the content. Interviews were also carried out to explore students' characteristics, learning styles, and difficulties. The Design stage focuses on designing the e-comic as a learning medium. This process begins with formulating learning objectives, followed by developing immune system material integrated with the Wahdatul Ulum concept. Next, the storyboard and comic script were created to design a compelling and easy-to-understand storyline, dialogue, and illustrations. Visual design and interactive elements were also tailored to suit students' characteristics and learning needs. The Develop stage involves producing the e-comic into a complete product, which is then validated by media experts, biology subject matter experts, and Wahdatul Ulum experts to ensure the quality of content and integration of Islamic values. The final stage, Disseminate, involves distributing the designed e-comic. The distribution of this e-comic was carried out among 11th-grade students at Al Mashum Senior High School, Kisaran BRT. Large-scale dissemination was carried out through Heyzine Flip Book and the publication of this scientific article.

The instruments used to collect data include: 1) Interviews, consisting of questions directed at biology teachers to obtain information regarding the teaching process, 2) Field observation, aiming to directly observe learning activities and the use of teaching tools in the classroom, 3) Questionnaires, used to obtain validation from experts and responses from teachers and students toward the Wahdatul Ulum-based e-comic, and 4) Tests, used to measure student learning outcomes through pretest and posttest. The data analysis techniques aim to produce an e-comic that meets the criteria of being valid, practical, and effective, using both quantitative data (validity, practicality, and effectiveness) and qualitative data (comments, feedback, and suggestions). Validity analysis is based on assessments from media, content, and Wahdatul Ulum validators. Practicality is analyzed from the responses of students and teachers after using the e-comic in learning. Effectiveness is measured through the results of 10 essay questions that were validated by assessment experts. All validation and practicality data were then analyzed to assess the overall feasibility and practicality of the e-comic using Table 1.

Table 1. Rating scale guidelines for response questionnaires and validation sheets

Rating	Score
Strongly Agree (SA)	5
Agree (A)	4
Neutral (N)	3
Disagree (D)	2
Strongly Disagree (SD)	1

(Source: Sugiyono 2015)

The percentage of validity and practicality of the developed immune system e-comic is calculated using the following Likert scale formula:

$$Presentase\ \% = \frac{\textbf{Total Score Obtained } X\ \textbf{100\%}}{\textbf{Maximum Total Score}}$$

The obtained percentage values are then converted using the validity level criteria shown in Table 2, and the practicality level criteria in Table 3.

Table 2. Validity level criteria for e-comic

Score Percentage	Criteria	Description
81% – 100%	Very Valid	Usable without revision
61% – 80%	Valid	Usable with minor revisions
41% – 60%	Fairly Valid	Not recommended for use
21% – 40%	Less Valid	Not usable
0 – 20%	Not Valid	Not usable

(Source: Akbar 2015: 41)

Table 3. Practicality level criteria for the e-comic

Score Percentage	Practicality Criteria
81% – 100%	Very Practical
61% – 80%	Practical
41% – 60%	Fairly Practical
21% – 40%	Less Practical
0 – 20%	Not Practical

(Source: Akbar 2015: 41)

To assess the effectiveness of the e-comic, a normalized gain (N-Gain) analysis is used to measure the increase in student learning outcomes before (pretest) and after (posttest) using the media. The N-Gain is calculated using the following formula:

$$Standart\ Gain = \frac{\text{Posttest Score } - \text{ Pretest Score}}{\text{Maximum Score } - \text{ Pretest Score}}$$

The effectiveness classification of e-comic usage is determined based on the N-Gain value categories shown in Table 4:

Table 4. Effectiveness level criteria of e-comic learning media

Average N-Gain	Classification	Effectiveness Level
N-Gain ≥ 0.70	High	Effective
0.30 ≤ N-Gain < 0.70	Medium	Moderately Effective
N-Gain < 0.30	Low	Less Effective

(Source: Parapat et al. 2023)

3. RESULT AND DISCUSSION

The development of the Wahdatul Ulum-integrated e-comic learning media on the immune system was carried out using the 4D model: Define, Design, Develop, and Disseminate. Comic media was used as a tool to deliver learning material through a series of sequentially arranged images accompanied by a storyline related to the taught topic (Rosyida 2018). In the Define stage, an analysis was conducted on various learning components including modules, teaching materials, and instructional media previously used in the learning process at SMAS Al Ma'shum Kisaran BRT. The analysis results showed that the immune system material taught was still text-based and lacked integration of Islamic values, particularly the Wahdatul Ulum concept, which is the integration of general and religious sciences. The available learning media were limited to textbooks and PowerPoint presentations, which were one-way and not interactive, thus failing to meet students' learning needs comprehensively.

Interviews with teachers and students revealed that the majority of students had visual and kinesthetic learning styles. They found it easier to understand information through visual media such as images, animations, and engaging storylines. However, in practice, the media used were still predominantly text-based and lacked illustrations, resulting in low learning interest and difficulty in understanding abstract concepts such as the body's defense mechanisms and cell interactions within the immune system. This condition led to a lack of student motivation to study immune system material and poor conceptual understanding, ultimately causing low learning outcomes. Based on this needs analysis, an e-comic learning media on the immune system integrated with the Wahdatul Ulum concept was developed.

The design stage of the development of the Wahdatul Ulum-integrated e-comic learning media on the immune system was carried out systematically through a series of interrelated steps. The first step was determining the learning objectives, formulated based on the basic competencies to be achieved in the immune system topic. These objectives served as the main reference for the content and storyline development of the comic media. Next, the learning materials were developed by integrating scientific concepts of the immune system with Islamic values, such as the inclusion of relevant Qur'anic verses and spiritual reflections on the greatness of Allah's creation. This integration aimed to foster students' awareness that studying biology is part of worship and a form of gratitude for the blessing of health granted by Allah.

After the materials were developed, the next step was to create the comic's storyline and storyboard. This was done in a structured manner, starting from the introduction of characters and setting, the development of conflicts related to immune system concepts, and concluding with a resolution that conveyed both moral and scientific messages. This narrative structure allowed students to understand the concepts gradually and contextually. Subsequently, comic character designs were created using Storyboardthat software, with characters tailored to reflect typical students to build emotional engagement. The characters were designed to act as guides, delivering information in an engaging and educational manner. The comic pages were arranged using Canva to ensure an attractive visual appearance, neat layout, and consistent color and font choices that support readability. A thoughtful combination of illustrations, narration, and dialogue between characters was designed to make students interested and actively engaged while reading.

Finally, assessment instruments were developed in the form of validation questionnaires, designed based on assessment grids covering aspects such as content quality, visual presentation, and the appropriateness of Wahdatul Ulum integration. These instruments were validated by three expert groups—biology content experts, instructional media experts, and Wahdatul Ulum experts—whose feedback formed the basis for revising and refining the media before its implementation in the learning process.

The development stage includes the creation of the product followed by expert validation and subsequent revisions.

Figure 1. Front Cover Before (A) and After (B) Revision Based on Suggestions from the Media Expert.
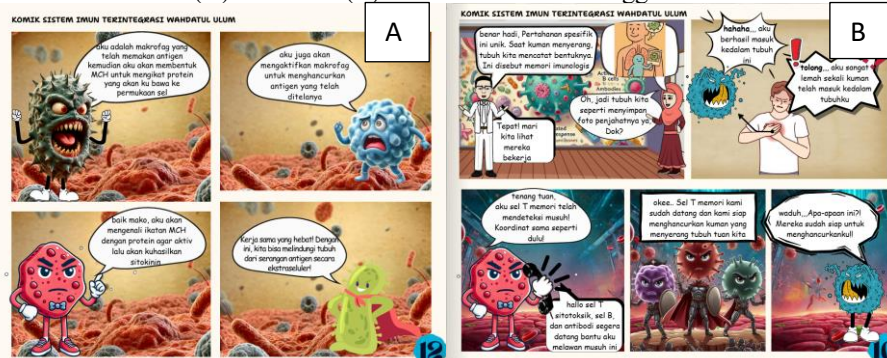

Figure 2. Immune System Material Before (A) and After (B) Revision Based on Suggestions from the Content Expert.
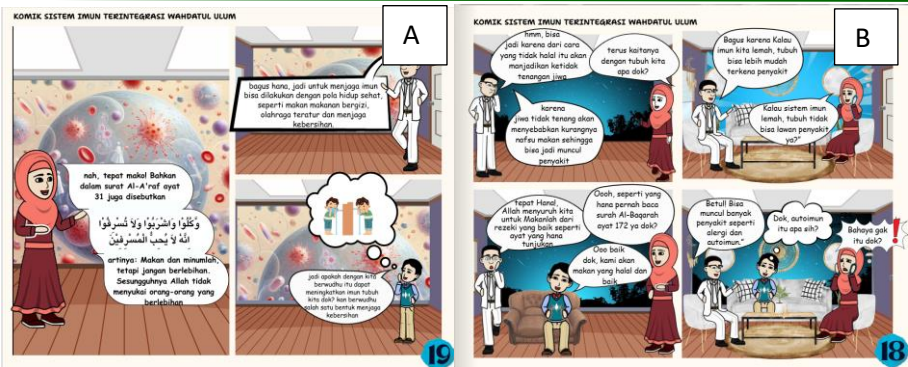
Figure 3. Wahdatul Ulum Integration Before (A) and After (B) Revision Based on Suggestions from the Wahdatul Ulum Expert.

Table 5. Expert Validation Test Results

Expert Field	Assessment Aspect	Score Obtained	Maximum Score	Percentage	Criteria
Media	Text Appearance	23	25	92%	Very Valid Very Valid
	Image Appearance	24	25	96%	
	Attractiveness	19	20	95%	
	Integration of Wahdatul Ulum Design	14	15	93.33%	
	Average Percentage			94.11%	
Content	Content Material	32	35	91.42%	Very Valid Very Valid
	Material Construction	35	40	87.5%	
	Average Percentage			89.33%	
Wahdatul Ulum	Relevance of Wahdatul Ulum Concept	57	60	95%	Very Valid

The development stage was carried out by producing the e-comic product, which was then validated by media, content, and Wahdatul Ulum experts. The media validator gave an average score of 94.11%, which falls under the very valid category. However, several suggestions for improvement were provided, such as adjusting the title placement on the cover to be slightly lower, using a more appealing font in the introduction and learning objectives section, and modifying the comic character design to better reflect Islamic values. All of these suggestions were accommodated through a revision process, the results of which are shown in Figure 1, as part of visual quality enhancement and strengthening the integration of Islamic values in the learning media.

The validation results showed that the content validator gave an average score of 89.33%, also classified as very valid. Nonetheless, there were some suggestions for improvement, including refining the language to make it less rigid and increasing interactivity in content presentation. All recommendations from the validators were thoroughly implemented in the revision process. The revised version can be seen in Figure 2, which presents the improved material based on expert advice and recommendations.

Validation by the Wahdatul Ulum expert yielded an average score of 95%, which is in the very valid category. Nevertheless, some suggestions were made for improving the material, including sharpening the focus on the Wahdatul Ulum concept by adding relevant hadith references and clarifying the Islamic values embedded in the content. All suggestions were accepted and addressed through revisions, making the material more comprehensive and aligned with the principle of knowledge integration within the framework of Wahdatul Ulum. The final revised version is shown in Figure 3.

Dissemination Stage At this stage, the designed e-comic was distributed. The distribution was carried out among 11th-grade students of Madrasah Aliyah or senior high schools. Furthermore, large-scale dissemination was conducted through Heyzine Flip Book and the publication of this scientific article.
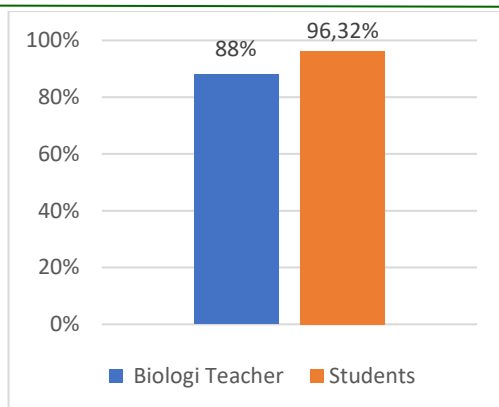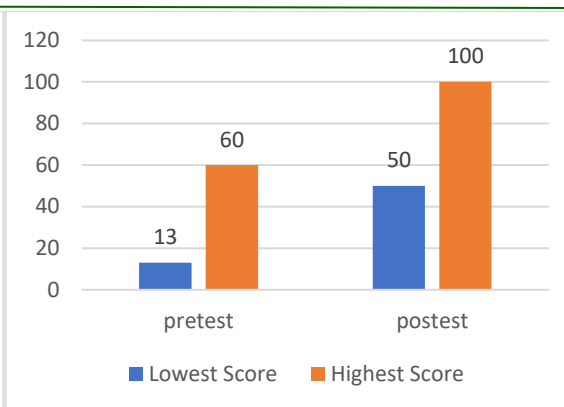
Figure 4. Media Practicality Scores

Figure 5. Pretest and Posttest Scores

Based on the results of the practicality questionnaire, the e-comic learning media on the Immune System integrated with the concept of *Wahdatul Ulum* received positive responses from both teachers and students. The teachers' responses showed a percentage of 88%, which falls into the "very practical" category, indicating that the media is considered easy to use, relevant to the teaching material, and supportive of learning that integrates scientific aspects and Islamic values. Meanwhile, the students' responses reached 96.32%, also categorized as very practical, reflecting that the media is not only easy to understand and access but also capable of increasing students' interest in learning. The presentation of material in the form of an interactive digital comic makes the learning process more engaging and enjoyable, as well as helping students understand the immune system concept more contextually. The integration of *Wahdatul Ulum* values was also appreciated for providing a clear understanding between science and Islamic teachings. Overall, the responses indicate that this e-comic learning media is highly suitable to be used as an innovative alternative in biology learning based on the *Wahdatul Ulum* approach. These findings are in line with Indriyana (2011) who stated that engaging media can enhance student involvement in learning and facilitate the understanding of abstract concepts.

Table 6. Average Scores Of Pretest, Posttest, And N-Gain

Pretest	Posttest	N-Gain
36,52	81,68	0.71

The results of the effectiveness test of the *Wahdatul Ulum*-integrated e-comic learning media on the Immune System showed a significant improvement in students' understanding. The average pretest score of 36.52 increased to 81.68 in the posttest after using the media, with an average N-gain of 0.71, which falls into the high category. These findings indicate that the e-comic media is effective in helping students understand the immune system concept while also internalizing Islamic values through an integrative approach. This improvement in learning outcomes aligns with the opinion of Muhasim (2017), who stated that the use of digital technology in learning can increase students' interest and motivation, create a more effective learning process, and positively impact learning achievement. In addition, according to Rodiyah et al. (2023), well-designed and effective learning tools can organize learning activities, enhance motivation, and support the improvement of student learning outcomes. Therefore, this e-comic media is considered suitable to be used as an innovative alternative in biology learning that integrates scientific knowledge and Islamic values.

4. CONCLUSION

The development of the *Wahdatul Ulum*-integrated immune system e-comic learning media is considered highly valid based on evaluations by media, content, and *Wahdatul Ulum* experts. The media is also deemed highly practical based on feedback from teachers and students, and proven effective in improving student learning outcomes, with an N-Gain score of 0.71 (high category). Therefore, this e-comic media is suitable to be used as an innovative alternative in biology learning, particularly in delivering abstract topics such as the immune system integrated with Islamic values.

5. ACKNOWLEDGEMENT

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