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DEVELOPMENT OF DIGITAL COMICS WITH SPIRITUAL VALUES AS A LEARNING MEDIA FOR CHEMICAL BONDING TOPIC IN CLASS X HIGH SCHOOL

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Abstract

Chemical bonding is a fundamental topic in chemistry that students often find difficult to understand because the concepts are abstract and require strong visualization skills. Therefore, innovative learning media are needed to support students' conceptual understanding and increase their engagement in the learning process. This study aims to develop digital comic learning media integrated with spiritual values for chemical bonding material that meets the criteria of validity, practicality, and student responses. This research employed the Research and Development (R&D) method using the 4D development model consisting of define, design, develop, and disseminate stages; however, this study was limited to the develop stage. Data were collected through needs analysis questionnaires, expert validation sheets, teacher practicality assessment questionnaires, and student response questionnaires. The validation procedure included chemistry content specialists, learning media experts, and spiritual value integration experts. A small study was carried out with tenth-grade pupils at a senior high school. The findings indicated that the designed digital comic media met the feasibility criteria. The validation results yielded an average Aiken's V value of 0.89, which is classified as very valid. The practicality assessment by the chemistry teacher provided an average score of 3.65 out of 4.00, suggesting a very practical area. Student responses also indicated positive results with an average percentage of 78.65%. This study contributes to chemistry education by providing an innovative digital comic learning media integrated with spiritual values that supports students' understanding of abstract chemical bonding concepts.
Keywords: digital comics, spiritual values, chemical bonding, learning media, 4D model.

INTRODUCTION

Education is not only oriented toward intellectual development but also toward the formation of individuals with strong spiritual, moral, and social values, which in the era of globalization must be balanced with the strengthening of scientific knowledge, technological competence, spiritual awareness, and ethical character [1][2]. A holistic educational approach emphasizes the balanced development of intellectual, emotional, social, and spiritual dimensions in students [3]. In Indonesia, this principle is aligned with the national education goals based on Pancasila and the 1945 Constitution, which emphasize the balance between faith, morality, personality, and mastery of knowledge and skills [4]. Therefore, integrating spiritual values into learning is important to develop students' character alongside academic achievement.

In chemistry learning, many students perceive the subject as difficult and less interesting due to its abstract nature. One of the topics that students often find difficult to understand is chemical bonding. Chemical bonding is a fundamental concept that explains the formation of substances and the relationship between molecular structure and properties [5]. However, students often struggle to visualize molecular structures and bonding interactions because these concepts require strong visual–spatial abilities [6]. As a result, students frequently experience difficulties in developing a meaningful understanding of chemical bonding concepts. as supported by the needs analysis results in this study, which show that 73% of students reported difficulties in understanding chemical bonding.

In addition to conceptual challenges, science education also emphasizes the development of scientific literacy. According to the Programme for

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International Student Assessment (PISA), scientific literacy refers to the ability to apply scientific knowledge to explain phenomena and make decisions in real-life situations [7]. However, the results of the 2018 PISA assessment indicate that Indonesian students' science literacy is still below the OECD average [8]. This condition suggests that students often struggle to connect scientific concepts learned in school with real-world contexts.

The integration of values in science education has also been emphasized globally. UNESCO through the concept of Education for Sustainable Development (ESD) highlights the importance of integrating ethical values, spirituality, and sustainability in learning [9]. In chemistry learning, particularly in chemical bonding, the integration of spiritual values can help students understand that scientific phenomena—such as atomic interactions and molecular structures—reflect the order and harmony of nature, thereby fostering gratitude and awareness of the meaning of knowledge [10]. At the same time, learning chemical bonding promotes scientific literacy, as students are encouraged to explain natural phenomena based on scientific concepts, interpret evidence, and relate these concepts to real-life contexts, including environmental issues and sustainable practices [11]. This is aligned with ESD competencies, which emphasize the application of knowledge for responsible and sustainable decision-making [12]. Therefore, through this approach, especially when supported by contextual and visual learning media such as digital comics, the learning process not only enhances students' conceptual understanding but also supports the development of scientific literacy, character formation, and ESD competencies.

The development of digital technology also provides opportunities to innovate learning media. Learning media function as tools that facilitate the delivery of information and support effective interaction in the learning process [13], [14]. For abstract chemistry topics such as chemical bonding, visual and interactive media are particularly important to help students understand microscopic concepts.

Based on the results of a preliminary needs analysis conducted with chemistry teachers at SMAN 2 Medan in 2025, chemistry learning still tends to use conventional methods with limited learning media. Teachers generally rely on textbooks and PowerPoint presentations when explaining chemical bonding materials. Also, students' answers show that they are not very interested in doing chemistry activities. Then, the incorporation of spiritual values into learning has not been done well, even though these values are very important for shaping students' character.

Digital comics are one way to learn that could help with these problems. Digital comics use pictures and simple language to teach, which makes them easier and more fun for students to learn from [15]. Comics can help students understand abstract ideas and teach them about morals and spirituality at the same time. This way, they can learn scientific ideas while also thinking about moral and spiritual lessons [16].

Previous research has demonstrated that the incorporation of spiritual values and visual learning media can enhance students' comprehension and involvement [17]. Other research also reported that teaching materials integrated with spiritual values through a Problem-Based Learning model improved student learning outcomes [18]. Meanwhile, research on comic-based learning media has shown that comics can effectively visualize chemical bonding concepts and increase student engagement [19], [20]. However, studies that integrate digital comic media with spiritual values in chemical bonding learning are still limited.

Therefore, this study aims to develop and evaluate the feasibility of digital comic-based learning media integrated with spiritual values for chemical bonding materials in grade X senior high school, focusing on its characteristics, validity, practicality, and students' responses.

METHOD

This study employed a Research and Development (R&D) design using the 4D model consisting of Define, Design, Develop, and Disseminate stages proposed by Thiagarajan et al. (1974). However, this research was limited to the

Develop stage due to research scope limitations. The 4D model was chosen because it provides a systematic framework for developing instructional media and has been widely applied in educational research.

The research was conducted in North Sumatra Province. Teacher practicality data were collected from chemistry teachers across the province through online questionnaires, while student response data were collected at SMAN 2 Medan.

The subjects of this study consisted of two types of respondents, namely students and teachers, who were involved at different stages of the 4D development model, particularly in the develop stage. Students were involved in the limited trial to measure student responses to the developed media, consisting of one class of grade XI students at SMAN 2 Medan who had previously studied chemical bonding material. Meanwhile, teachers were involved in assessing the practicality of the media, consisting of 56 senior high school chemistry teachers who are members of the Perkumpulan Pendidik Sains Kimia Indonesia (PPKSI) of North Sumatra.

The data collection instruments consisted of non-test instruments in the form of questionnaires. The instruments included a needs analysis questionnaire, expert validation questionnaire, teacher practicality questionnaire, and student response questionnaire. All questionnaires used a four-point Likert scale consisting of Strongly Disagree, Disagree, Agree, and Strongly Agree.

The development process of digital comic learning media integrated with spiritual values was conducted through the stages of the 4D development model. The overall development procedure used in this study is illustrated in Figure 1.

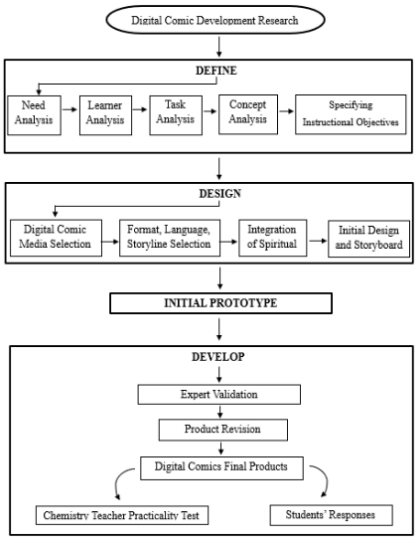

Figure 1. Research Procedure

1. Define Stage

The Define stage aimed to identify the basic needs for media development. At this stage several analyses were conducted, including needs analysis, learner analysis, task analysis, concept analysis, and formulation of instructional objectives. Needs analysis was carried out by distributing questionnaires to three chemistry teachers and 33 grade XI students who had studied chemical bonding material. This stage aimed to identify learning difficulties, obstacles in teaching chemical bonding, and expectations regarding the characteristics of the learning media to be developed.

2. Design Stage

The Design stage focused on preparing the initial design of the learning media. At this stage the researchers determined the appropriate learning media, selected the format of the digital comic, and developed the initial storyboard. The digital comic was made to teach people about chemical bonding using pictures, character conversations, and story explanations. The story included spiritual values like honesty, compassion, sharing, and truthfulness to help the characters grow and the reader understand the ideas.

3. Develop Stage

The purpose of the Develop stage was to make the product and see if it would work.

During this phase, experts checked the product, made changes to it, and ran a few small tests.

The expert validation was done by three validators who were experts in material, media, and spiritual values. All of the validators looked at the digital comic from all sides, including whether the content was possible, how well the media was designed, how clear the language was, and how well it included spiritual values.

The product was changed after the validation process based on the validators' suggestions. After that, the updated product was tested in two ways, one with teachers and one with students. First, a practicality test was conducted by distributing online questionnaires to high school chemistry teachers in North Sumatra. Second, a limited trial was conducted with one class of grade XI students at SMAN 2 Medan to obtain students' responses after using the developed digital comic media.

The collected data were analyzed using quantitative descriptive techniques. The validity of the media was analyzed using Aiken's V formula, which is commonly used to determine the content validity of an instrument based on expert judgment. The formula used is presented in Equation:

$$V = \frac{\Sigma s}{n\,(c-1)}$$

The results of the Aiken's V calculation were then interpreted using the validity criteria presented in Table 1.

Table 1. Expert Validation Criteria [21]

Value Range	Criteria
0.81-1.00	Very valid
0.61-0.80	Valid
0.41-0.60	Quite Valid
0.21-0.40	Invalid
0.00-0.20	Very Invalid

The practicality of the developed media was measured through a teacher practicality questionnaire using a four-point Likert scale. The practicality score was calculated using the following formula:

$$\bar{x} = \frac{\Sigma x}{n}$$

The practicality results were interpreted using the criteria presented in Table 2.

Table 2. Practicality Criteria (Adapted [22], [23])

Range	Criteria
3.26-4.00	Very Practical
2.51-3.25	Practical
1.76-2.50	Moderately Practical
1.00-1.75	Impractical

Student responses toward the developed media, covering aspects of attractiveness, clarity of material, and perceived usefulness, were analyzed using descriptive percentage analysis. The percentage was calculated using the following formula:

$$\%ideality = \frac{the\ average\ score}{ideal\ maximum\ score} \times 100\%$$

The interpretation of student response results is presented in Table 3.

Table 3. Student Responses Criteria [24]

Percentages (%)	Criteria
81-100	Very Positive
61-80	Positive
41-60	Fair
21-40	Negative
0-20	Very Negative

RESULTS AND DISCUSSION

The development of digital comic learning media integrated with spiritual values was conducted using the 4D development model proposed by Thiagarajan et al. (1974), which consists of four stages: define, design, develop, and disseminate. However, this study was limited to the develop stage due to research scope limitations. The results and discussion of each stage are presented as follows.

Define Stage

To find out what teacher and student needed in chemical bonding learning, the surveys was carried out to three chemistry teachers and thirty grade XI students who had already learned about chemical bonding. The results showed that people often think of chemical bonding as an abstract subject that needs a lot of conceptual understanding.

The questionnaire results showed that the average percentage of teacher needs was 76% and

the average percentage of student needs was 73%. Both of these numbers were quite high. Students struggle to visualize processes like the transfer of electrons, electrostatic interactions, molecular structure, etc., without the appropriate learning materials. Furthermore, according to their responses, conventional media in the form of textbooks and presentation slides continue to play an integral role in the learning process.

Students find learning materials boring, and the visualization of microscopic chemical processes becomes difficult for them. Therefore, there is a need for developing visual learning materials for better comprehension of the concept of chemical bonds. Then, both the students and the teacher have showed tremendous appreciation towards digital comic media supplemented with spiritual values during the chemistry lessons.

Moreover, the incorporation of spiritual values like responsibility, honesty, respect, empathy, cooperation, and integrity is necessary to enhance personality building along with the cognitive development.

Design Stage

This stage is targeted at creating the prototype of the learning media for the digital comic through the findings from the needs analysis performed in the define stage. The structural form, storytelling style, language, integration of spiritual values into the comic, among other features, were created systematically in order to make learning about chemical bonding easier for the students.

Digital comics were selected as learning tools due to their visual and narrative elements like drawings, dialogues, and explanation of complex ideas, which can facilitate students' comprehension of abstract chemistry principles. Visualization of electron movement, transfer, and interaction with molecules through each step of the process will make abstract chemistry principles easier to comprehend. In addition, the digital medium allows easy access through any electronic device and fosters student-centered learning.

Design process entailed the creation of characters, development of a plot, panel composition, and incorporation of chemical ideas in dialogue form. Researchers relied on artificial intelligence technology for preliminary visualization and dialogue design. Scientific accuracy and educational value of these ideas were reviewed and refined manually by researchers. Comic panels, illustrations, and dialogues were then created using the Canva software in order to produce the first prototype of digital comics.

The comic is structured into several sections covering the introduction of chemical bonding concepts, ionic bonds, covalent bonds, and metallic bonds. Each section is presented through sequential panels containing visual illustrations, character dialogues, and concept explanations. The narrative begins with a contextual problem that triggers discussion among characters, followed by concept exploration and visualization of bonding processes.

Spiritual values such as responsibility, honesty, cooperation, respect, and gratitude are integrated contextually within the storyline and reflection panels at the end of each subtopic. This integration is based on the needs analysis, which indicates that students' scientific literacy skills still need improvement, particularly in explaining scientific phenomena and relating concepts to real-life contexts, as also reflected in international assessments [11]. These values are also shown through analogies that are related to how chemicals bond. For instance, the fact that atoms want to be stable shows how important balance and responsibility are for keeping order. The transfer of electrons in ionic bonding shows how giving and receiving are like being responsible and fair in interactions. In covalent bonding, the idea of the exchange of electrons reflects how well people are cooperating and respecting one another. However, in case of metallic bonding, Delocalized electrons demonstrate unity and joint responsibility. The purpose of this union is to assist students in growing spiritually while learning the theoretical information at the same time.

A digital flipbook of this comic is designed in this study, using the Heyzine Flipbook application. This application enables the readers to enjoy reading the digital comic with its digital turning-page function. Examples of the design of digital comics, along with the utilization of language, storylines, and incorporation of spiritual aspects, are illustrated in Figure below.

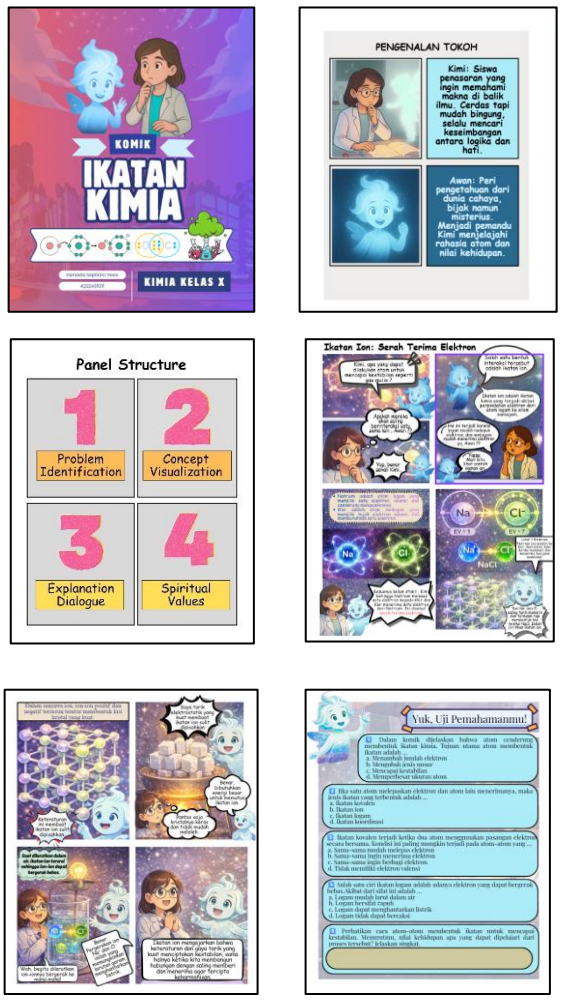

Figure 2. Initial Design of Digital Comic Learning Media

This design becomes the first prototype that is further validated using expert judgment in the develop phase. Moreover, it must be mentioned that the incorporation of spirituality values along with chemical bonding theories can also be seen clearly in the comic pictures, as depicted in **Figure 2.** In this regard, the picture of ionic bonding explains how the ions are arranged orderly within a crystal lattice, thereby signifying the values of balance, harmony, and gratefulness for the structure of the matter.

Develop Stage

The develop stage aims to evaluate the feasibility of the developed digital comic media through expert validation, product revision, and limited trials.

At this stage, the media that were developed were initially validated by the experts to determine their feasibility. Following the revision process from the expert's suggestion, the media product was assessed using teachers' and student response trials.

Validity of Digital Comic

The validity of the developed digital comic media was assessed by three validators consisting of a material expert, a media expert, and a spiritual value expert. The validation process looked at a number of things, such as how well the content worked, how clear the language was, how well the media was presented, and how well spiritual values were integrated.

The recapitulation of the validation results is presented in Table 4.

Table 4. Validation Recapitulation

Aspect	Aiken Value	Criteria
Matter Expert	0.88	Very valid
Media Expert	0.91	Very Valid
Spiritual Expert	0.88	Very Valid
Overal	0.89	Very Valid

Based on Table 4, the overall Aiken's V value of 0.89 indicates that the developed digital comic is categorised as very validThis result indicates that the product satisfies the standards of content accuracy, visual design quality, and suitable integration of spiritual values. Nieveen as cited Sulistio (2022), states that validity shows how well the content fits, how accurate the concepts are, and how good the instructional design is in a developed learning product. Thus, the developed digital comic is deemed viable for advancement to the subsequent stage of development with minimal revisions.

Product Revision

Based on feedback from validators, changes were made to the product. The changes made to the book included making scientific terms clearer, making some chemical ideas clearer, making the electron transfer illustrations more clear, changing the layout of the panels, and making the reflection section about spiritual values stronger. This revision process is in line with the way development research works, where experts give feedback to improve the product before it is used in learning activities [25].

The improved version of the comic was then developed in interactive flipbook form using Heyzine Flipbook for easy accessibility by

students. Below is the link to access the whole comic: https://bit.ly/KOMIKIKATANKIMIA

Practicality of the Developed Media

Teacher assessments using practicality questionnaires delivered to chemistry teachers from North Sumatra was employed to determine the practicality of the developed digital comic media. Practicality assessments was performed considering some aspects such as user-friendliness, clarity of directions, alignment with teaching goals, and attractiveness of the media. The results of the practicality test are presented in Table 5.

Table 5. Results of Teacher Practicality

Respondents	Item	Score	Criteria
56	15	3.66	Very Practical

Based on the results presented in Table 5, The average practicality score of 3.66 indicates that the digital comic media is very practical and easy to use in the learning process. Teachers reported that the media helps explain abstract concepts in chemical bonding and increases students' interest in learning. Visual narrative media such as educational comics are known to support student engagement because concepts are presented through storytelling and illustrations [26].

Student Responses

Student responses toward the developed digital comic media were obtained through a limited trial involving one class of grade XI students at SMAN 2 Medan.

Student responses were collected from 30 students using a questionnaire consisting of 13 statements. The recapitulation of the results is presented in Table 6.

Table 6. Student Responses Result

Indicator	Percentage (%)	Criteria
Interest & Motivation	76	Positive
Material Understanding	80	Positive
Display Design	80	Positive
Usefulness	78	Positive
Overall	78.65	Positive

Based on Table 6, the results show that the developed digital comic media received overall average response of 78.65% indicates that students responded positively to the use of digital comic media. The best scores were in the indicators of material comprehension and visual design, indicating that the integration of illustrations and narrative explanations facilitates students' grasp of abstract chemical bonding concepts. This discovery aligns with multimedia learning theory, which posits that learning is enhanced when information is conveyed through both visual and auditory modalities [27]. The comic's visual storytelling also helped students relate abstract chemical ideas to real-life situations.

This research proves that digital comic media containing spiritual values could improve not only comprehension but also character building in chemistry lessons. This study serves as a reliable source of reference for educational establishments and teachers in introducing a value-based approach to teaching utilizing creative media technology.

CONCLUSION

This study offers a scientific basis for educational organizations as well as teachers in helping students learn meaningfully and effectively through innovation in media, while making it easier for curriculum designers to include spiritual and character values within science subjects. The digital comic learning media that incorporates spiritual values for chemical bonding material has been found to be very valid and useful according to the test results. The digital comic media got Aiken's V score of 0.89, meaning it is a very valid category. Furthermore, the chemistry teachers awarded the digital comic media a practicality rating of 3.66, meaning it is very practical. These findings indicate that digital comics that incorporate spiritual values may assist in helping students understand concepts relating to chemical bonding and promote interest in studying. However, this study was limited to the develop stage of the 4D model and involved a limited trial in one school. Future research is recommended to examine the effectiveness of the developed media on students' learning outcomes through wider implementation.

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