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# Development of a PjBL-Based Digital Flipbook Module on Chemical Bonding for Grace XI Students

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***Abstract:*** *Enhancing student engagement and conceptual understanding in chemistry requires innovative and interactive learning materials. This study aims to develop and evaluate a flipbook module based on Project-Based Learning (PjBL) for chemical bonding content. The research adopted the 4D development model—Define, Design, Develop, and Disseminate—focusing on content validity, student responses, and effectiveness in improving learning outcomes. Expert evaluations confirmed the module's high validity, and student feedback indicated strong approval in terms of content, presentation, and language. The module also demonstrated moderate effectiveness in enhancing students' conceptual understanding, as shown by learning gains. These findings suggest that the PjBL-based flipbook module is feasible, pedagogically appropriate, and positively received, making it a valuable resource for supporting active and student-centered chemistry learning in high school settings.*

***Keywords:*** *R&D model; flipbook module; PjBL; chemical bonding*

## INTRODUCTION

Education plays an important role in shaping the character and personality of superior individuals, with the main goal of developing the physical, mental, and social potential of students. In the world of education, one important aspect that must be considered is the quality of teaching provided by teachers. As a facilitator in the learning process, teachers must be able to design strategies and choose the right methods to ensure that each student can learn effectively (Aryana, 2020). One effort to achieve this goal is to use a learning model that suits the needs and characteristics of students. Choosing the right learning model is crucial because it can have a direct impact on students' understanding of the material being taught and improve the quality of their learning outcomes (Wicaksono & Iswan, 2019).

Chemistry, as one of the science subjects at the high school level, has an abstract and complex nature, which is often a challenge for students to understand. The material taught in chemistry includes various concepts related to physical and chemical properties, reactions, and the relationship between particles of matter, all of which require an in-depth understanding and the relationship between one concept and another (Anggriani et al., 2019).

One of the materials considered most difficult by students is chemical bonds, which include discussions about ionic, covalent, and metallic bonds. Understanding chemical bonds is very important because it is the basis for understanding various other chemical concepts. Because of the theoretical and abstract nature of chemical bonding material, if the teacher uses the wrong teaching method, the students' understanding will also be wrong. Because of its abstract nature, students find it difficult to learn chemical bonding material (Silaban et al., 2020).

Based on initial observations at SMA Negeri 21 Medan, it was found that students had difficulty understanding this material, and their learning outcomes were still low, with an average score of only 40. This problem is inseparable from the learning methods used in the classroom, which tend to be teacher-centered. Although the existing curriculum encourages student-centered learning, in practice, many teachers still use lecture methods and conventional approaches that do not accommodate the needs of students to be actively involved in learning. In addition, interactive learning media that can help students understand abstract material are rarely used, which causes students to feel bored and have difficulty understanding the material being taught.

Based on the problems described above, the solution that can be provided is to use a module as one of the teaching materials. A learning module is a concise, structured learning resource that focuses on key concepts (Irfandi et al., 2018). The use of modules gives the impression of greater flexibility because students can learn on their own with the module as a guide. Modules can be used to complement the teaching materials used by teachers in learning activities (Laili et al., 2019).

However, to achieve optimal learning objectives, a method is needed that supports student involvement in the learning process directly. Project-Based Learning (PjBL) is a learning model that prioritizes the use of projects as a medium to encourage students to think critically, creatively, and work together in solving problems that are relevant to real life. PjBL is very suitable for application to chemistry material, because students can be involved in the process of investigation, experimentation, and discussion related to the topics they are studying. By utilizing this model, students not only gain theoretical knowledge but can also apply chemical concepts in real-world contexts (Rokhim et al., 2023). The application of PjBL in chemistry learning can help students to better understand abstract chemical bonding material, as well as improve their skills in solving problems and collaborating with classmates (Sasmono, 2018).

It is necessary to consider the use of educational and constructive teaching materials to improve students' knowledge, skills, and creativity. We can improve students' problem-solving abilities in chemistry by introducing new teaching materials through compiled teaching materials. One way is to develop an integrated tool to develop modules that can be accessed and received online as learning modules that students can use independently (Panggabean & Purba, 2021).

In today's digital era, innovation in learning media is becoming increasingly important. One relevant way that can be done is to develop technology-based teaching materials, such as digital flipbooks, which present materials interactively and interestingly. Flipbooks based on Project-Based Learning (PjBL) will provide a more contextual learning experience because they encourage students to be active in solving problems that are relevant to everyday life.

Flipbooks are digital-based learning media that combine text, images, animations, and sound in an attractive and interactive format (Sari & Ahmad, 2021). Flipbooks have the potential to increase student engagement in learning because this medium allows students to learn independently and actively through easy-to-understand visual content. In

addition, flipbooks can also be accessed anytime and anywhere, providing more flexibility for students in learning.

Based on the existing problems, this study aims to develop and evaluate a flipbook module based on Project-Based Learning on chemical bonding material at SMA Negeri 21 Medan. This module is designed to help students understand abstract chemical concepts, increase their involvement in learning, and support student-centered learning. This study also aims to measure the effectiveness of the flipbook module in improving student learning outcomes through validity tests, student responses, and analysis of module effectiveness using the N-Gain test. To achieve rapid learning progress, student flexibility is needed. Teachers equip students with 21st-century skills. The main goal of 21st-century education is to develop students' educational potential and help them grow as active, independent, and successful lifelong learners (Panggabean et al., 2021) The PjBL-based flipbook module is expected to provide a more interesting and contextual learning experience for students. By using interactive and project-based learning media, students can more easily understand chemical bonding material and develop 21st-century skills, such as critical thinking, creativity, and collaboration.

According to research results in 2021 by (Panggabean, Silitonga, et al., 2021) found that flipbook modules can improve students' HOTS. This study also received positive responses from students who said that flipbook modules are easily accessible through various electronic devices, so they can be used anytime and anywhere. The development of this module is also expected to be an alternative in improving the quality of chemistry learning at SMA Negeri 21 Medan and provide a positive contribution to the teaching of chemistry subjects in general. Structured digital-based learning media has proven effective in improving students' critical thinking skills. Previous studies have shown that the development of digital and context-based learning media, such as LKPD oriented to Guided Discovery Learning with Internet Assisted Learning (Ma'sumah & Mitarlis, 2021) and LKPD based on STEM with the PjBL model that utilizes surrounding materials (Ma'sumah & Mitarlis, 2021), has proven effective in improving students' critical thinking skills and conceptual understanding.

These findings are in line with this study, which developed a digital flipbook module based on Project-Based Learning on chemical bonding material, which is designed to be a valid, interactive learning medium that supports active student involvement. In line with (Purba & Fitri, 2021) research shows that enriched project-based chemistry teaching materials can increase students' activity and understanding through a contextual approach and interactive visualization. This is in line with developing a PjBL-based digital flipbook module in this study, which integrates project elements and visual media to support learning of chemical bonding material in a more interesting and meaningful way.

## LITERATURE REVIEW

### 1. Research and Development

Research and Development (R&D) is a method designed to create and assess the effectiveness of a product that addresses specific educational problems (Waruwu, 2024) (Ekawati et al., 2021). In the context of education, R&D is commonly used to develop learning resources through systematic stages such as needs analysis, product design, development, evaluation, and dissemination (Purnama, 2016). While numerous studies have utilized R&D to develop various instructional materials, many do not explicitly integrate innovative technology formats such as digital flipbooks, nor do they emphasize alignment with student-centered learning models like Project-Based Learning (PjBL). This gap highlights the need for research that not only develops learning media but also evaluates their pedagogical integration and digital accessibility.

### 2. Learning Module

Learning modules are self-contained instructional units that promote student

independence and allow learning at an individual pace (Irfandi et al., 2018) (Siregar et al., 2024). They offer flexibility in terms of time and space, and function as both primary and supplementary learning tools (Laili et al., 2019). Despite the benefits, prior studies often focus on the general benefits of modules without investigating how specific design principles—such as interactivity, digital navigation, and visual engagement—affect student outcomes. Additionally, the application of these principles in digital environments remains underexplored, especially in science subjects like chemistry, where abstract concepts require dynamic representations.

### 3. Flipbook

Digital flipbooks represent a modern evolution of instructional materials, combining multimedia elements such as audio, video, animation, and interactive navigation to support flexible learning (Khairunnisa et al., 2023) (Ni'mah et al., 2024). They are increasingly used to increase student interest and facilitate deeper understanding of complex materials (Silalahi & Budiono, 2023) (Syarifah et al., 2023). In line with the research of (Panggabean et al., 2024) The use of interactive media in the development of teaching materials has proven effective in improving students' thinking skills and learning outcomes. However, most existing studies emphasize the *technical features* of flipbooks rather than their pedagogical impact, particularly when used in conjunction with constructivist learning models. Few studies have explored the effectiveness of flipbooks within a structured learning model like PjBL, leaving a research gap in understanding how flipbooks can support project-oriented learning in a digital format.

### 4. Project-Based Learning (PjBL) Model

PjBL engages students in meaningful projects that reflect real-world problems and promote deeper learning through active participation (Lestari & Yuwono, 2022) (Sasmono, 2018). This model fosters skills such as collaboration, problem-solving, and decision-making (Anggriani et al., 2019) (Fitrianingrum, 2020). Although PjBL has been successfully implemented in science education, many studies still focus on traditional project implementation without leveraging digital tools to enhance engagement. Moreover, few investigations have addressed how interactive digital modules—like flipbooks—can be designed to align with PjBL stages and enhance conceptual understanding in chemistry, a subject often perceived as abstract and difficult. This indicates a clear research gap where technological integration into PjBL remains limited and warrants further study.

## METHODS

This study uses a Research and Development (R&D) approach to develop and evaluate a digital flipbook module based on the Project-Based Learning (PjBL) model for chemical bonding material. The research was conducted at SMA Negeri 21 Medan involving students of class XI-2. The development process followed the 4D model (Define, Design, Develop, Disseminate) (Arum, 2020).

### 1. Define Stage

At this initial stage, determine the needs of students during the learning process. All information is collected from various sources, such as interviews with subject teachers and direct classroom observations during the learning process. This analysis process includes needs analysis and curriculum analysis. In the needs analysis, the focus is on the textbooks used by teachers and students during the learning process, the learning media that teachers have used, and what learning models that teachers apply in the classroom. Meanwhile, curriculum analysis is carried out to ensure that the teaching materials developed are in line with the needs of the curriculum applied in schools.

### 2. Design Stage

At this stage, a draft of the module was developed based on the analysis results from the define phase. The process included

outlining the module framework, determining essential components, and designing evaluation tools such as validation instruments, pretest and posttest items, and student response sheets.

**3. Development Stage**

It is the process of producing and testing the developed module. The module that has been designed in the previous stage is developed into a product to be tested. After the module has been developed, the module is validated by 2 expert lecturers and teachers. In this validation process, the validator uses the prepared instrument. This validation aims to determine whether the module is suitable for use. At this stage, a trial is also carried out on students whose classes have been selected.

**4. Disseminate Stage**

At this stage, the validated module is distributed to see the students' responses and learning outcomes after using the flipbook module. At the end of this study, a product will be produced in the form of a flipbook learning module based on Project Based Learning (PjBL) on the chemical bonding material for class XI SMA, which module can be distributed to parties who will use it, such as teachers, students or other educational institutions.

**5. Data Analysis**

Validation and student response data were analyzed using a Likert scale, while effectiveness was measured using the N-Gain formula based on established interpretation criteria.

**Table 1** Percentage Score Criteria (Wahyuni & Puspasari, 2017)

| Percentage (%) | Information |
|---|---|
| 81% – 100% | Very Worth It |
| 61% – 80% | Good or Decent |
| 41% – 60% | Quite Decent |
| 21% – 40% | Less Worthy |
| 0% – 20% | Very Less Worthy |

The effectiveness of the module is calculated using the N-Gain formula.

$$(\bar{g}) = \frac{\text{Spos} - \text{Spre}}{\text{Maximum score} - \text{Spre}}$$

**Table 2** Grain Value Criteria (Ramdhani et al., 2020)

| N-Gain Acquisition | Information |
|---|---|
| $\bar{g} > 0{,}7$ | High |
| $0.3 < \bar{g} \leq 0.7$ | Medium |
| $\bar{g} \leq 0.3$ | Low |

The interpretation categories of N-Gain effectiveness can be expressed in percentage (%) form as follows:

**Table 3** Gain Value Percentage Category (Thahura et al., 2024)

| Percentage (%) | Information |
|---|---|
| < 40 | Ineffective |
| 40 – 55 | Less Effective |
| 56 – 75 | Quite Effective |
| > 75 | Effective |

## RESULT AND DISCUSSION

The validation results of the Project-Based Learning (PjBL) flipbook module were assessed based on the BNSP validity criteria by three validators. The validation of material experts obtained a feasibility percentage of 93.76%, while the validation of media experts reached 97.41%. With this score, the module is categorized as *"Very Worth It"* for use in chemistry learning.

**Table 4** Results of validation by material and media experts

| Validation Aspect | Percentage of Eligibility (%) | Category |
|---|---|---|
| Material (content) | 93.76 | Very Worth It |
| Media | 97.41 | Very Worth It |

**Table 4** shows the results of module validation based on aspects of content, language, presentation, and graphic suitability by BNSP standards.

The results of each aspect based on content and media can be seen in **Table 5** and **Tabel 6** below.

**Table 5** Results of the Expert Validator Assessment of Material

| In Terms of Material (content) | Score (%) | Category |
|---|---|---|
| Content Eligibility | 91.67 | Very Worth It |

| | | |
|---|---|---|
| Presentation Eligibility | 92.86 | Very Worth It |
| Language Eligibility | 92.31 | Very Worth It |
| Graphic Eligibility | 98.21 | Very Worth It |
| Average score | 93,76 | Very Worth It |

**Table 6** Results of the Expert Validator Assessment of Media

| In Terms of Media | Score (%) | Category |
|---|---|---|
| Display Eligibility | 94.79 | Very Worth It |
| Presentation Eligibility | 96.94 | Very Worth It |
| Language Eligibility | 97.92 | Very Worth It |
| Graphic Eligibility | 100.00 | Very Worth It |
| Average score | 97.41 | Very Worth It |

Based on the results of this assessment, the flipbook module based on Project-Based Learning (PjBL) that has been developed is declared feasible and can be used as teaching material in the teaching and learning process in schools. The average positive evaluation of the validators shows that the flipbook module has met the expected criteria.

The validated flipbook module was distributed to 33 students of grade XI-2. Students then read, understand, and evaluate the flipbook module in terms of interest, material, and language. The module was distributed after a pretest was given to students, and then students were asked to give their responses to the flipbook module.

**Table 7** Student Responses to PjBL-Based Flipbook Modules

| Assessment Components | Percentage of Satisfaction Level (%) | Satisfaction Level Criteria |
|---|---|---|
| Interest | 82.24 | Very Satisfied |
| Material | 82.14 | Very Satisfied |
| Language | 81.63 | Very Satisfied |
| Average Score | 82.00 | Very Satisfied |

Based on the average value, the percentage of student responses to the flipbook module in terms of interest, material, and language reached 82.00%, which is included in the *"Very Satisfied"* category. Therefore, it can be concluded that the flipbook module that has been developed provides satisfaction and facilitates students' understanding and learning of chemical bonding material.

The effectiveness of the module was analyzed using the N-Gain test. The results obtained from the N-Gain test showed a significant increase in learning outcomes, with an N-Gain score of 0.65 and a percentage of 65%, which is included in the moderate criteria and the fairly effective category.

**Table 8** N-Gain Test Results Recapitulation

| Test Results | Average Score |
|---|---|
| Pretest Score | 40.73 |
| Posttest Score | 78.91 |
| N-Gain Test | 0.65 |
| Criteria | 65% |
| N-Gain Test Percentage | Medium |
| N-Gain Percentage Category | Quite Effective |

Based on **Table 8** and **Figure 1**, it can be seen that the results obtained from the N-Gain test show a significant increase in learning outcomes, with an N-Gain score of 0.65 and a percentage of 65%, which is included in the moderate criteria. This means that the PjBL-based flipbook module developed is quite effective in improving student learning outcomes in chemical bonding material. This is in line with the opinion of (Ni'mah et al., 2024) who said that this flipbook module can have a positive impact on student learning outcomes, which can help improve the effectiveness of student learning and understanding.

## CONCLUSION

The results of this study demonstrate that the flipbook module based on Project-Based Learning (PjBL) meets the established validity criteria according to BNSP standards, with validation scores of 93.76% from material experts and 97.41% from media experts, indicating a high level of feasibility. Student responses also showed strong approval, with an average score of 82.00%, suggesting that the module is engaging, easy to understand, and supportive

of the learning process. Furthermore, the N-Gain score of 0.65 (moderate category) reflects a meaningful improvement in students' understanding of chemical bonding concepts.

These findings provide clear answers to the research questions regarding the validity, student acceptance, and effectiveness of the developed module. The study confirms that the PjBL-based flipbook module is not only feasible and moderately effective but also contributes to a more interactive and student-centered learning experience. This innovation has the potential to enhance the integration of digital media in chemistry education, support the development of 21st-century skills such as critical thinking and digital literacy, and serve as a model for future implementations of technology-enhanced science instruction.

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