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# Development of a PBL-Based e-Pocket Book with Mnemonic Strategies on Chemical Bonding Material Oriented Toward High School Students' Creative Thinking Abilities

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**Abstract:** Research has been conducted on the development of a PBL-Based e-Pocket Book learning media with Mnemonic Strategies on the topic of Chemical Bonds, oriented towards enhancing the Creative Thinking Skills of high school students. This study aims to assess the feasibility of the PBL-based e-pocket book with mnemonic strategies according to design and learning model experts, evaluate chemistry teachers' assessments, and understand students' responses to the developed media. This research uses the Lee & Owens development model. The research instruments include interview sheets and questionnaires. The developed product was validated by design and learning model experts as well as media and content experts, followed by an evaluation from chemistry teachers, and then tested through one-on-one trials and small group trials. The data analysis techniques used are qualitative data analysis and quantitative data analysis. The results indicate that the developed e-pocket book is deemed feasible based on the validation results from design and learning model experts, as well as media and content experts. The assessment from chemistry teachers also indicates a "very feasible" category. Additionally, students' responses during the one-on-one trial showed a "very good" category, while the small group trial achieved a percentage of 87.90% with a "very good" category, tested on a small group of 9 students. Based on the development results and trials conducted, it can be concluded that the PBL-based e-pocket book with mnemonic strategies is suitable for use as a learning media for chemistry to support the development of high school students' creative thinking abilities.

**Keywords**: e-pocket book; PBL; Mnemonics; Creative Thinking; Chemical Bonds.

**Abstrak:** Telah dilakukan penelitian pengembangan media pembelajaran *e-Pocket Book* Berbasis *PBL* dengan Strategi Mnemonik Pada Materi Ikatan Kimia Berorientasi Kemampuan Berpikir Kreatif Siswa SMA. Penelitian ini bertujuan untuk mengetahui kelayakan *e-pocket book* berbasis *PBL* dengan strategi mnemonik menurut ahli desain dan model pembelajaran serta ahli media dan materi, mengetahui penilaian guru mata pelajaran kimia, serta mengetahui respon peserta didik terhadap media yang dikembangkan. Penelitian ini menggunakan model pengembangan Lee & Owens. Instrumen penelitian yang digunakan berupa lembar wawancara dan angket. Produk hasil pengembangan divalidasi oleh ahli desain dan model pembelajaran serta ahli media dan materi, selanjutnya dilakukan penilaian praktisi oleh guru kimia, kemudian diuji cobakan melalui uji coba satu-satu dan uji coba kelompok kecil. Teknik analisis data yang digunakan yaitu analisis data kualitatif dan analisis data kuantitatif. Hasil penelitian menunjukkan bahwa *e-pocket book* yang dikembangkan dinyatakan sudah layak berdasarkan hasil validasi ahli desain dan model pembelajaran serta ahli media dan materi. Penilaian guru mata pelajaran kimia juga menunjukkan kategori sangat layak. Selain itu, respon siswa pada uji coba satu-satu menunjukkan kategori sangat baik, sedangkan uji coba kelompok kecil memperoleh persentase sebesar 87,90% dengan kategori sangat baik dimana diujicobakan kepada kelompok kecil sebanyak 9 siswa. Berdasarkan hasil pengembangan dan uji coba yang telah dilakukan, dapat disimpulkan bahwa *e-pocket book* berbasis *PBL* dengan


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strategi mnemonik layak digunakan sebagai salah satu media pembelajaran kimia untuk mendukung pengembangan kemampuan berpikir kreatif siswa SMA.

**Kata Kunci:** *e-pocket book*; *PBL*; Mnemonik; Berpikir Kreatif; Ikatan Kimia.

## INTRODUCTION

Education plays a strategic role in ensuring the survival of future generations by Pendidikan memiliki peran strategis dalam mengembangkan potensi dan kepribadian peserta didik sesuai amanat UU No. 20 Tahun 2003, namun kualitas pendidikan Indonesia masih menghadapi tantangan serius, tercermin dari peringkat PISA 2022 yang rendah. Untuk menjawab tuntutan pembelajaran abad ke-21, pemerintah menerapkan Kurikulum Merdeka (Kepmendikbudristek No. 56/M/2022) yang memberi fleksibilitas pembelajaran kontekstual dan berpusat pada siswa, sejalan dengan teori konstruktivisme yang menekankan pembelajaran bermakna (Mansyur et al., 2024), serta didukung penelitian yang menunjukkan peningkatan keterlibatan dan motivasi belajar melalui pendekatan student-centered (Masgumelar & Mustafa, 2021). Penguatan ini dilengkapi dengan pendekatan deep learning yang diformalkan pada 2025, berlandaskan teori belajar bermakna Ausubel, yang menekankan mindful, meaningful, dan joyful learning, terbukti mampu meningkatkan pemahaman konseptual jangka panjang dan transfer pengetahuan (Arifin & Mu'id, 2024).

Within the framework of the Merdeka Curriculum and the *deep learning* approach, chemistry emerges as a particularly suitable subject for implementing meaningful and in-depth learning through the Problem-Based Learning (PBL) model. PBL is grounded in problem-centered learning theory, which prioritizes higher-order thinking, open-ended problem solving, and collaborative knowledge construction (Asrifah et al., 2020). Recent studies have shown that the application of PBL in chemistry education significantly improves students' conceptual understanding, creative thinking skills, and collaborative abilities (Nafizatunni'am, et al 2024). Moreover, PBL enables students to connect abstract chemical concepts with authentic phenomena encountered in everyday life, thereby increasing the relevance and meaningfulness of learning experiences (Nurlaeli, 2022). Consequently, chemistry learning extends beyond mere concept mastery and plays a strategic role in fostering higher-order thinking skills particularly creativity and collaboration in alignment with the objectives of the Merdeka Curriculum and the principles of *deep learning*.

Chemical bonding is one of the essential topics in 11th-grade chemistry (F phase) and is highly complex. This topic covers abstract concepts such as interatomic interactions, attractive forces, and the formation of ionic, covalent, coordinate covalent, and metallic bonds. Mastering the concept of chemical bonding is a crucial foundation for understanding advanced chemistry topics. However, various studies show that this material still poses difficulties for students. Consistent with the research by Supiyanti & Iriyadi (2022) which stated that 90.62% of students experienced difficulties in learning chemical bonding material with an average score of 52%, and over 50% of students held misconceptions about various types of bonds. In line with this, Putri & Yerimadesi (2025) stated that over 80% of students had difficulty connecting the concept of attraction between atoms with the process of chemical compound formation, which was caused by students' tendency to memorize formulas without fully understanding the interconnectedness of the concepts.


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The results of the needs analysis conducted on 35 students of class XI F2 at SMAN 1 Muaro Jambi showed that 85.8% of students experienced difficulties in understanding chemical bonding material due to the limited use of learning media. Consequently, 40.1% of students stated that they did not like chemistry as a subject. This condition was further supported by teacher interview findings indicating that learning activities are still teacher-centered and the utilization of learning media has not been optimal. The impact of this situation is the low level of students' creative thinking skills, even though these skills are essential 21st-century competencies, which include fluency, flexibility, elaboration, and originality (Hermawan, 2025). In chemistry learning, creative thinking plays an important role in connecting atomic concepts, attractive forces, and compound formation; therefore, an appropriate learning model is required. Problem-Based Learning (PBL) is considered effective because it actively engages students in solving contextual problems, encourages divergent thinking and collaboration, and promotes the development of multiple solutions and original ideas (Wijayanti & Purnomo, 2024).

To support the optimal implementation of PBL, interactive learning media such as an e-pocket book are required, as they are practical, easily accessible, and capable of presenting material concisely and attractively through the integration of text, visuals, and videos. This need is further justified by the fact that 91.4% of students in class XI F2 at SMAN 1 Muaro Jambi already own smartphones. In addition to learning media and instructional models, learning strategies such as mnemonics have been proven effective in strengthening memory and enhancing understanding of abstract and complex chemical concepts (Sawitri, 2023). Although Problem-Based Learning (PBL) and mnemonic strategies have been widely studied, the development of a PBL-based e-pocket book integrated with mnemonic strategies and oriented toward improving students' creative thinking skills in chemical bonding material remains limited. Therefore, this study aims to develop a PBL-based e-pocket book integrated with mnemonics that is valid, practical, and effective in enhancing senior high school students' creative thinking skills. The e-pocket book incorporates various multimedia components to create meaningful learning experiences and encourage active student engagement.

This research is driven by students' difficulties in understanding abstract chemical bonding concepts, low motivation, and limited creative thinking development, compounded by the use of static and less interactive learning media. In line with the Merdeka Curriculum's emphasis on student-centered and technology-integrated learning, a PBL-based e-Pocket Book with mnemonic strategies is needed to support independent learning, strengthen memory retention, and foster creative thinking.

## RESEARCH METHOD

### Research Type

This research uses the ADDIE development model, specifically the Lee & Owens version, which is structured and systematic, as the procedural model. This model is suitable for developing a PBL-based e-pocket book with mnemonic strategies on chemical bonding material because it consists of five interconnected stages:


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assessment, design, development, implementation, and evaluation. Clear stages ensure the product meets learning needs and is proven effective.

## Research Subjects

The research subjects were 35 students of class XI F2 at SMAN 1 Muaro Jambi, and the study was conducted from September 17 to November 26, 2025.

## ADDIE Development Procedure

The development procedure in this study is adapted from the module development procedure and the ADDIE model design development procedure. An explanation of the development procedure in this study can be seen in Table 1.

**Table 1.** Explanation of the procedure for developing a PBL-based e-pocket book with mnemonic strategies

| ADDIE Stages | Description |
|---|---|
| Analysis | Researchers collected data thru curriculum observation, student questionnaires, and teacher interviews to identify learning problems. The analysis focused on student needs and characteristics, learning objectives, materials, and educational technology, which served as the basis for developing PBL-based materials with mnemonic strategies for chemical bonding. The analysis covered five main aspects: (1) learning needs, (2) student characteristics, (3) learning objectives, (4) learning materials, and (5) the use of educational technology. |
| Design | Researchers developed an initial design for learning media to produce a PBL-based e-pocket book with mnemonic strategies tailored to learning needs. The design process is carried out thru a series of systematic activities as the basis for media development. |
| Development | A PBL-based e-pocket book with mnemonic strategies was developed using Canva and converted into an interactive format via Heyzine, with a printed version also provided. The product was validated by experts and practitioners, and qualitative analysis of their feedback indicated that the e-pocket book is feasible for chemistry learning. |
| Implementation | Researchers implemented a PBL-based e-pocket book with mnemonic strategies in learning. Individual trials were conducted with three students to obtain qualitative data regarding ease of use and clarity of material, while small group trials with nine students yielded quantitative data on the attractiveness and effectiveness of the media. The test results are used as the basis for revisions and improvements before wider implementation. |
| Evaluation | Researchers assessed the feasibility and effectiveness of a PBL-based e-pocket book with mnemonic strategies thru expert validation, teacher assessment, and individual and small group trials with students. The evaluation results were used as a basis for product improvement and assessing the effectiveness of the learning media. |

## Data Collection Methods

Qualitative data were obtained through observations and in-depth interviews to identify learning needs. The results of the observations and interviews consisted of suggestions, comments, and field notes collected during the research process. Based on these findings, the e-pocket book was considered feasible for use because it was easy to understand, had an attractive appearance, and did not present significant obstacles during the learning process.

Quantitative data were collected through a needs analysis questionnaire and a student response questionnaire using Likert-scale scores. The data were analyzed by calculating the mean score of each aspect attractiveness, ease of use, usefulness, and


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content clarity to determine the product's feasibility level based on students' perceptions. The feasibility percentage was calculated using the following formula:

$$\text{Percentage (\%)} = \frac{\text{Total Score of Data Collection Results}}{\text{Maximum Score} \times \text{Total Number of Items} \times \text{Total Number of Respondents}} \text{ x } 100\%$$

Based on the interpretation of the scores, it can be stated that:

**Table 2.** Criteria for Student Response Levels

| No | Percentage (%) | Kriteria |
|---|---|---|
| 1. | > 80 – 100 | Very Good |
| 2. | > 60 – 80 | Good |
| 3. | > 40 – 60 | Fair |
| 4. | > 20 – 40 | Poor |
| 5. | 0 – 20 | Very poor |

Furthermore, the validity, practicality, and effectiveness of the product were evaluated in stages. The validity of the PBL-based e-pocket book with mnemonic strategies on chemical bonding material was assessed using expert validation sheets by two validators: an instructional design and learning model expert, and a media and content expert. After revisions were made based on the validators' feedback, a one-to-one trial was conducted with three students to obtain qualitative data related to readability, appearance, and ease of use of the product. Subsequently, the product was tested through a small-group trial to examine its practicality and initial effectiveness, which was further supported by student questionnaires as quantitative data.

### Data Analysis Methods

The data analysis techniques in this study were adjusted to the types of data obtained, namely qualitative and quantitative data. Qualitative data were analyzed descriptively by examining the results of observations, interviews, and feedback from validators and students during the one-to-one trial stage. The qualitative data were used as a basis for revising and refining the developed product.

Quantitative data analysis was used to assess the validity and practicality of the product. Quantitative data were obtained from the scores on student response questionnaires administered during the small group trial and were analyzed using percentage calculations and interpreted based on feasibility criteria. This study did not include an effectiveness testing stage; therefore, effectiveness analysis was not conducted.

## RESULT AND DISCUSSION

The result of this development study is a PBL-based e-pocket book with a mnemonic strategy for high school students on the topic of chemical bonding, designed to help students understand abstract concepts while simultaneously developing their creative thinking skills. The e-pocket book was created using Canva and converted into an interactive digital format via Heyzine flipbook, making it practical and easily accessible on smartphones, laptops, or computers with internet access. This study employed the Lee & Owens development model, which comprises five main stages: analysis, design, development, implementation, and evaluation. This model was chosen because it is considered suitable for producing interactive digital learning


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media, such as an e-pocket book, thereby supporting the optimal implementation of PBL with a mnemonic strategy in chemistry learning (Utami, 2025).

**Analysis Phase**

The analysis phase identifies the needs and characteristics of SMAN 1 Muaro Jambi students, who still experience difficulties in understanding the abstract concepts of chemical bonding. Previous research indicates that chemistry topics, particularly chemical bonding, are often considered abstract and challenging for students to grasp without visualization or interactive media (Putri & Yerimadesi, 2025). Therefore, an interactive, visual, and student-centered PBL-based e-pocket book with a mnemonic strategy was developed. The use of smartphones as a learning medium is supported by studies showing that mobile learning can enhance students' motivation, conceptual understanding, and creative thinking skills (Rosmayadi et al., 2024). Consequently, this media is expected to support independent learning while simultaneously strengthening students' conceptual understanding and creative thinking abilities.

**Design Phase**

At the design stage, the PBL-based e-pocket book with mnemonic strategies was developed by organizing the material, creating a storyboard, and selecting media suitable for smartphone use. The design draws on cognitivism, which emphasizes the role of students' mental processes in understanding information, and constructivism, which highlights that students actively construct knowledge through experience and problem-solving (Badriyah et al., 2023). Previous studies have shown that using interactive, PBL-based media can enhance students' conceptual understanding and creative thinking skills in chemistry learning (Wulansari et al., 2024) while mnemonic strategies have been proven effective in helping students remember abstract concepts more easily (Rahmadina, 2025). Therefore, this e-pocket book design is expected to support independent learning, improve students' understanding of chemical bonding concepts, and develop their creative thinking skills through the combination of PBL and mnemonic strategies.

**Development Phase**

During the development phase, the product was validated using the Delphi technique by design experts, learning model experts, and media and materials experts thru three rounds until it was declared valid and ready for testing.

1. Validation by Instructional Design and Learning Model Experts

Product testing in research and development (R&D) serves as a formative evaluation to identify weaknesses and guide revisions before large-scale implementation. In learning media development, expert validation is essential to ensure content validity and pedagogical alignment, particularly in the implementation of the Problem-Based Learning (PBL) model (Ferdino et al., 2025). Therefore, the results of product testing and expert validation were used to revise the PBL-based e-pocket book with mnemonic strategies on chemical bonding material to ensure that the developed media are valid, practical, and effective.


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**Table 3.** Design and Learning Model Validation Results

| Aspect | Validation I | Validation II | Validation III |
|---|---|---|---|
| Learning Alignment | Not yet appropriate, alignment between learning objectives, content, and activities needs improvement | Alignment has begun to form, and learning objectives are more focused | Thus, the developed e-pocket book is appropriate and feasible. |
| Learning Strategy | Not yet appropriate, the PBL strategy has not been optimally integrated and is inconsistent across activities | Still not fully appropriate, the PBL strategy is integrated into most learning activities | Thus, the developed e-pocket book is appropriate and feasible. |
| Implementation of the PBL Model | Not yet appropriate, the PBL syntax is not sequential and the problems are insufficiently contextual | Appropriate, the PBL syntax is clearly reflected at each stage of learning | Thus, the developed e-pocket book is appropriate and feasible. |
| Learning Assessment | Assessment does not fully support the achievement of learning objectives | Assessment is more aligned with the objectives but still requires reinforcement of higher-order thinking skills (HOTS) | Thus, the developed e-pocket book is appropriate and feasible. |
| Learning Design & Integration | Integration among learning components is not yet systematic | The learning design is more structured and well-integrated | Thus, the developed e-pocket book is appropriate and feasible. |
| Motivation & Engagement | Learning activities have not optimally encouraged student motivation and active participation | Learning activities begin to enhance students' learning motivation | Thus, the developed e-pocket book is appropriate and feasible. |
| Media Clarity & Implementation | The learning flow and usage instructions are not yet fully clear | The flow and instructions are clearer, although minor refinements are still needed | Thus, the developed e-pocket book is appropriate and feasible. |

The validation results from two experts indicate that the PBL-based e-pocket book with mnemonic strategies is highly valid. One-to-one and small-group trials show that the product is easy to use, engaging, and effective in supporting students' understanding, with student responses categorized as very practical and initially effective. Improvements at each validation stage confirm that the aspects of content suitability, strategy, PBL model implementation, evaluation, design, motivation, and media clarity have met the eligibility criteria. In line with cognitive and constructivist learning theories, effective learning occurs through systematic material presentation, visual and mnemonic support, and problem-based learning that promotes active knowledge construction and creative thinking skills (Ulfa, 2020). Therefore, this e-pocket book is appropriate and feasible for chemistry learning, particularly chemical bonding, and is ready for field trials and independent learning.


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2. Media and Material Expert Validation

Product testing in research and development (R&D) aims to identify product weaknesses as a basis for improvement through formative evaluation. This testing provides empirical data regarding the suitability of content, design, and the implementation of learning media, which are subsequently used to revise the product to enhance its quality (Hermansyah & Mandailina, 2024). Furthermore, validation by media experts and subject-matter experts is required to ensure content validity and pedagogical appropriateness, particularly in the implementation of Problem-Based Learning (PBL), which requires alignment among materials, learning activities, and learning objectives (Taufina, 2020).

**Table 4.** Media and Material Expert Validation Result

| Aspect | Validation I | Validation II | Validation III |
|---|---|---|---|
| Content Feasibility | The content is relevant to the topic, however, the depth and contextualization are not yet optimal | The content is more specific and contextual in accordance with the learning objectives | Thus, the developed e-pocket book is appropriate and feasible. |
| Simplicity | The content is not yet concise and still requires simplification for better understanding | The content is more concise and easier for students to understand | Thus, the developed e-pocket book is appropriate and feasible. |
| Language Feasibility | The language is fairly communicative, but there are still inconsistencies in terminology | The language is clearer and appropriate to students' cognitive level | Thus, the developed e-pocket book is appropriate and feasible. |
| Presentation Feasibility | The sequence of content presentation is not yet systematic. | The presentation is more structured and logical | Thus, the developed e-pocket book is appropriate and feasible. |
| Integration | The integration of content, illustrations, and activities is not yet optimal | Integration among components begins to be evident. | Thus, the developed e-pocket book is appropriate and feasible. |
| Emphasis | The emphasis on key concepts is not yet clear | Key concepts begin to be emphasized through visuals and summaries | Thus, the developed e-pocket book is appropriate and feasible. |
| Color and Shape | The selection of colors and shapes is fairly attractive but lacks consistency | Colors and shapes are more harmonious and support readability | Thus, the developed e-pocket book is appropriate and feasible. |
| Balance | The layout between text and visuals is not yet balanced | The layout balance has improved | Thus, the developed e-pocket book is appropriate and feasible. |

The validation results show that the e-pocket book has significantly improved in every aspect. The presentation of the material is now more systematic, the language is more communicative and appropriate for students' cognitive levels, and the visual and text layout is more balanced and engaging. This result aligns with cognitive theory and constructivism, which emphasize that improving the systematic presentation of material, clear visuals, and appropriate mnemonic strategies can strengthen learning coherence, encourage students to actively construct knowledge, and develop creative thinking skills. In addition, previous studies have shown that well-designed learning


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media and varied instructional strategies play an important role in increasing students' learning motivation and engagement in science learning (Natalia et al., 2025). Thus, this e-pocket book is not only suitable for use in the chemistry learning process but also has the potential to improve students' motivation, conceptual understanding, and higher-order thinking skills, making it ready for wider implementation in field trials and independent learning.

3. Teacher Evaluation

Teacher assessment is conducted to evaluate the feasibility and classroom implementation of the PBL-based e-pocket book with mnemonic strategies. Teacher feedback serves as formative evaluation to provide practical insights into the suitability of learning materials with real classroom conditions and student needs, and to guide product improvement (Rhamayanti, 2025). Therefore, the results of the teacher assessment are used as the basis for revising the e-pocket book and are presented in the following table.

**Table 5.** Teacher Evaluation Result

| Aspect | Suggestions/Comments |
|---|---|
| Accuracy | The e-pocket book presents the concept of chemical bonding accurately and in accordance with scientific principles, the material is arranged in alignment with learning indicators and objectives, the PBL stages are clearly illustrated with contextual cases, and the mnemonic strategies are relevant and effective. Overall, this media is suitable for use without revision. |
| Feedback | The practice questions and reflection activities in the e-pocket book are already HOTS (C4–C6), supporting students' creative, analytical, and metacognitive thinking. Formative exercises and tests are already available, with improvements to the question wording and assessment rubrics to make them clearer and easier for teachers to use. The media provides adequate feedback thru discussion of answers and brief explanations, allowing students to correct conceptual errors. |
| Learning Control | The navigation, menu structure, and buttons in the e-pocket book are neat, clear, and easy for students to use. Media allows students to learn independently with flexible materials, exercises, videos, and summaries. The instructions and usage guidelines are already concise, clear, and easy to understand. Overall, the e-pocket book is very supportive of self-directed learning, aligning with the characteristics of PBL. |

This result aligns with cognitive theory and constructivism, which emphasize that the scientific presentation of material and the use of mnemonic strategies effectively improve students' understanding and retention. Meanwhile, regarding HOTS, reflection, and context-based PBL activities, they encourage students to actively construct knowledge thru problem-solving (Husna et al., 2024). Thus, this e-pocket book not only meets the aspects of accuracy and ease of use, but is also capable of supporting the development of students' critical, creative, and metacognitive thinking abilities.

## Implementation Phase

During the implementation phase, one-on-one and small group trials were conducted with students in class XI F2 of SMAN 1 Muaro Jambi to determine the feasibility of the PBL-based e-pocket book learning media with a mnemonic strategy. One-on-one trials were conducted to get direct feedback from students individually. This allows researchers to identify and correct media weaknesses that might not be apparent during the initial validation stage. Thru one-on-one testing with 3 students,


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the researcher was able to evaluate the extent to which this e-pocket book helped improve students' understanding and creative thinking skills.

1. Student Response One-To-One Trail

One-on-one trials were conducted to determine the readability, usability, and content clarity of the PBL-based e-pocket book with mnemonic strategies from the students' perspective. The results of the one-on-one trials were used as the basis for initial product improvements before proceeding to small group trials. The results of the one-on-one trials are presented in the following table.

**Table 6.** Student Response One-to-one Trial Results

| Aspek | Student 1 | Student 2 | Student 3 |
|---|---|---|---|
| Media Display | The e-pocket book's appearance is attractive and well-liked by students, the text is readable despite being somewhat lengthy, and the navigation/menu is easy to use so students don't get confused. | The e-pocket book's appearance is attractive, the text is partially long but still easy to understand, and the menus/buttons are easy to use. | The e-pocket book is attractive and interactive with clear navigation, though some chemical terms need more real-world examples and quicker access to exercises. |
| Materi | The material in the e-pocket book is easy for students to understand, although the section on Lewis structures is a bit challenging, the examples and illustrations provided effectively aid in concept comprehension. | The e-pocket book material is easy to understand, even tho the section on metallic bonding is somewhat abstract, but the examples and illustrations/videos help clarify the concepts. | The material is clear and challenging; although covalent and coordinate covalent bonding are difficult, mnemonics and illustrations help reinforce understanding. |
| Learning | Students can learn independently with e-pocket books, feel more interested, and easily follow the usage instructions. | Students can learn independently using the e-pocket book, feel more interested due to the illustrations and mnemonics, and the usage instructions are easy to follow. | Students can learn independently with greater interest; mnemonics are helpful and the instructions are clear and easy to follow. |

Overall, the pocket book is considered interesting, interactive, and easy to use. The material is easy to understand, although some concepts are challenging, with illustrations, mnemonics, and videos supporting comprehension. This media supports independent learning, increasing student interest, challenges, and engagement. According to cognitive theory and constructivism, e-pocket books strengthen memory, facilitate the construction of active knowledge, and develop students' higher-order thinking skills (Basyir et al., 2022).

2. Student Response to Small Group Trail

Small group trials were conducted to determine students' responses to the attractiveness, ease of use, and usefulness of a PBL-based e-pocket book with mnemonic strategies in learning. The results of the small group trial are used to evaluate the initial effectiveness of the product before proceeding to the field trial stage. The results of the small group trial are presented in the following table.


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**Tabel 7.** Results of Student Responses in Small Group Trials

| Total score | Average Secore | Description |
|---|---|---|
| 356 | 87,90% | Very Good |

Based on the results presented in Table 6, the small group trial shows that the PBL-based e-pocket book with mnemonic strategies obtained an average score of 87.90%, which falls into the *Very Good* category. This result indicates that students responded very positively to the attractiveness, ease of use, and usefulness of the e-pocket book in the learning process. Such positive student responses suggest that the learning media is practically applicable and able to support student engagement and motivation, which is consistent with previous studies emphasizing that well-designed instructional media can enhance students' learning motivation and participation (Della et al 2022). Therefore, it can be concluded that the product demonstrates high initial effectiveness and is feasible to proceed to the field trial stage.

### Procedure for Using a PBL-Based e-Pocket Book with Mnemonic Strategies on Chemical Bonding Material

The procedure for using a PBL-based e-pocket book with mnemonic strategies is designed to guide the systematic and student-centered learning of chemical bonds. Learning begins with an orientation to contextual problems, followed by concept exploration thru interactive materials, mnemonics, and Javalab simulations, culminating in task completion and reflection. Students learn in small groups following the PBL syntax, supported by introductory quizzes, concept investigations, and creating their own mnemonics. Evaluation is conducted thru reflection and digital exercises. The test results show that this procedure is practical, easy to implement, and effective in improving students' conceptual understanding and creative thinking skills.

### Evaluation Phase

The e-pocket book evaluation was conducted formatively thru expert validation, teacher response, and one-on-one and small group trials. The evaluation results show that all aspects of the media are in the "very feasible" category, with positive responses from teachers and students regarding the appearance, navigation, content, and mnemonic strategies. The small group test achieved a percentage of 87.90%, confirming the effectiveness of the media in increasing student engagement, concept understanding, and creative thinking skills. Overall, the PBL-based e-pocket book with mnemonic strategies is declared feasible and effective as a supporting medium for learning chemical bonding. The systematic, visual, and interactive presentation of the material aligns with cognitive and constructivist theories, supporting both classroom learning and independent study as required by 21st-century learning.

## CONCLUSION

The results of this development research indicate that the PBL-based e-pocket book with a mnemonic strategy for chemical bonding was developed through needs analysis, material and media design, and expert validation, and was declared suitable for use. The learning procedure begins with problem orientation, followed by interactive learning activities and the application of mnemonic strategies to strengthen students' memory and creative thinking. The trial results showed positive student responses, with the e-pocket book categorized as *Very Feasible* (87.90%), indicating


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that the developed media is effective, easy to use, and supports students' understanding of chemical bonding concepts and creative thinking skills.

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