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Development of Sanak Belajar Mobile Learning Media on Atomic Structure Material

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ABSTRACT

Mobile learning is increasingly important to support flexible and adaptive learning. This study aims to develop a mobile learning-based Sanak Belajar learning media on atomic structure material, and test its validity, practicality, and effectiveness. The method used is Research and Development (R&D) with a modified ADDIE model at the Analysis, Design, Development, and Implementation stages. The research subjects were purposively selected X-grade students of SMA Negeri 1 Loa Janan. The validation results by experts showed a very high level of validity (score >90%). Practicality based on teacher and student questionnaires is also very high, amounting to 97.92% and 79.81% respectively. The effectiveness of the media is seen from the N-Gain value of 0.64 (medium category) and effect size of 3.39 (very high impact). Thus, Sanak Belajar is declared valid, practical, and effective for use in learning chemistry on atomic structure material, and has the potential to be further developed with more interactive technology.

Keywords: atomic structure, effectiveness, mobile learning, practicality, sanak belajar

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INTRODUCTION

Technology development in the era of Society 5.0 is increasingly rapid, especially in science and technology. These developments have had a major impact on the field of education, especially in the integration of technology into learning activities (Yurtseven et al., 2020). Technology now plays a central role in enhancing students' conceptual understanding, far beyond its traditional role as a supplementary aid. (Jeon & Lee, 2023). However, despite various efforts to improve the quality of learning, student learning outcomes in science still show suboptimal achievements, reflected in low test scores (Wang et al., 2025). To improve students' mastery of the material, technology-based learning media such as mobile learning can be an effective and applicable alternative (Ahmadi et al., 2023). Mobile learning itself is a form of innovation in education that utilizes smartphone devices as a learning tool. Through this approach, students have the

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convenience of accessing teaching materials, doing assignments, and taking evaluations anytime and anywhere (Nefatti et al., 2021). Chemistry, especially in atomic structure and materials, is one of the fields of science that can utilize mobile learning.

Atomic structure is a fundamental concept in chemistry, but it is often difficult for students to understand. According to research by Afrianis & Ningsih (2022), 59.73% of students made mistakes in answering comprehension questions, and 74.91% answered incorrectly on calculation questions. Students understanding of atomic structure material is still relatively low, so technology-based learning media is needed as a solution to support the improvement of mastery of these concepts (Liu et al., 2023). In the conventional learning approach, educators generally provide follow-up in the form of assignments such as student worksheets, practice questions, preparation of papers, or group projects as a strategy to strengthen students' understanding of the material that has been delivered (Moorhouse & Wang, 2022). Therefore, developing mobile learning as a learning supplement can be a solution that allows students to learn flexibly outside of school hours. Some previous studies have developed mobile learning on the development of atomic theory, stoichiometry, and chemical bonding (Ennouamani et al., 2020; Goodall & Lee, 2020; Chiu, 2021; Sun et al., 2021; Nkadimeng & Ankiewicz, 2022;). However, the development is only for students, so the teacher cannot easily update the materials and questions. Therefore, in this study, mobile learning is developed, which is valid on atomic structure material and allows teachers to update the content of materials and questions independently and evaluate the practicality and effectiveness of the Sanak Belajar mobile learning-based instructional media.

METHODS

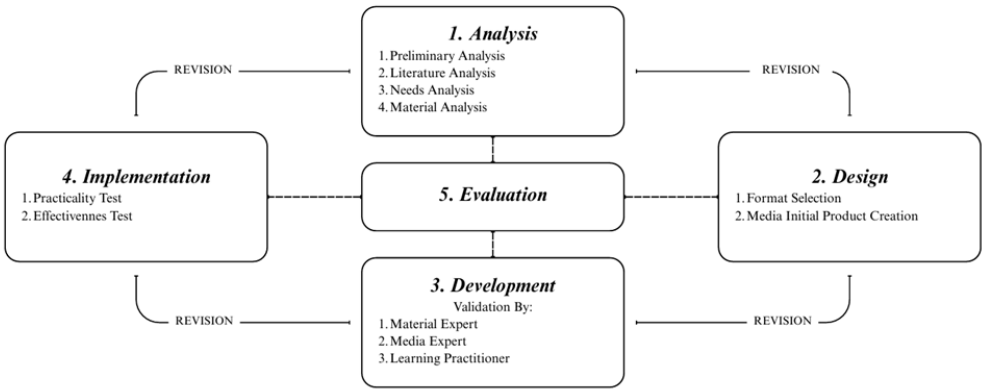

Figure 1. ADDIE Research Scheme

Research Design

This developmental study employed the ADDIE framework to design Sanak Belajar, a mobile learning application aimed at delivering atomic structure concepts. The research followed five stages: Analysis, Design, Development, Implementation, and Evaluation. The research framework is illustrated in Figure

Research Objectives

The target objects in this study were grade X students at SMA Negeri 1 Loa Janan in the 2024/2025 school year. The study population included all grade X students, consisting of five classes. The sampling was conducted using a purposive sampling technique, where the selected

students must meet specific criteria, such as having adequate access to technological devices for mobile learning. In addition, the selected students should also have learned basic chemistry concepts in daily life. Based on these criteria, the samples used in this study were students from X IPA 1 and X IPA 2 classes. Both classes participated in the implementation stage to evaluate the practicality and effectiveness of the developed Sanak Belajar mobile learning media.

Research Instruments

The assessment instrument in this study consists of several types. The teacher interview sheet was used to find out the constraints of learning atomic structure, and the media used to develop more suitable media. Questionnaires were used to determine the needs of students, assess the content and appearance of the media by experts, and assess the practicality and response of users. Storyboard and media design were prepared to design the appearance and flow of using mobile learning-based media. Pre-test and post-test were used to measure the improvement of students' understanding, while the observation sheet was used to see the involvement of students and teachers during the learning process.

Research Analysis

Interview and validation data from experts and practitioners were used to provide feedback for product improvement. Likert-scale results were analyzed using: Percentage = (score obtained / maximum score) × 100%. The validity data obtained is then categorized using the validity criteria in the following table (Indarta et al., 2023).

Table 1. Validity Criteria

Validity Percentage (V) (%)	Criteria
$80\% < V \leq 100\%$	Very High Validity
$60\% < V \leq 80\%$	High Validity
$40\% < V \leq 60\%$	Moderate Validity
$0\% < V \leq 40\%$	Low Validity

The practicality of learning media is measured through a questionnaire, which is analyzed using the percentage formula, percentage = (score obtained / maximum score) × 100%. The results are categorized based on the level of practicality, which is adapted from Dahal et al., (2023), in Table 2.

Table 2. Practicality Category

Practicality Percentage (P) (%)	Category
$82 < P \leq 100$	Very Practical
$71 < P \leq 81$	Practical
$60 < P \leq 70$	Fairly Practical
$0 < P \leq 59$	Impractical

Observations were made to assess student and teacher activities during learning. Data from the observation sheet was analyzed using the formula Percentage = (score obtained / maximum score) × 100%. Student observation sheets were measured using a Likert scale, and the results were categorized in Table 3, while teacher observation sheets were measured using a Guttman scale and categorized in Table 4.

Table 3. Category of Student Learning Activities (Cents-Boonstra et al., 2021)

Student Learning Activity (SLA) (%)	Category
$81 < SLA \leq 100$	Very Active
$61 < SLA \leq 81$	Active
$41 < SLA \leq 61$	Fairly Active
$21 < SLA \leq 41$	Less Active
$0 < SLA \leq 21$	Not Active

Table 4. Teacher Learning Activity Criteria (Nurramadhani, 2025)

Teacher Learning Activity (TLA) (%)	Category
$81 < TLA \leq 100$	Very Active
$61 < TLA \leq 81$	Active
$41 < TLA \leq 61$	Fairly Active
$21 < TLA \leq 41$	Less Active
$0 < TLA \leq 21$	Not Active

The N-Gain test was conducted to determine the effectiveness before and after treatment using Sanak Belajar, a mobile learning-based learning media. N-Gain was calculated using the formula N-Gain = (Posttest Score- Pretest Score) / (Maximum Score- Pretest Score). After processing using the formula, the N-Gain calculation value is matched with Table 5, which is adapted from (Olii et al., 2024).

Table 5. N-Gain Category

N-Gain Value	Category
$0.7 < g \leq 1$	High
$0.3 < g \leq 0.7$	Medium
$0 \leq g \leq 0.3$	Low

If the N-gain value increases, the next step is to measure the effect size for one group using the formula Effect Size = (Average Posttest-Average Pretest) / (Standard Deviation Pretest). After processing using the formula, the effect size category can be seen in Table 6. Meanwhile, student responses to learning media are measured through questionnaires, and the results are categorized in Table 7.

Table 6. Effect Size category adapted from Cohen in (Kallogjeri & Piccirillo, 2023)

Effect Size (ES) (%)	Category
$ES > 1.10$	Very High
$0.75 < ES \leq 1.10$	High
$0.40 < ES \leq 0.75$	Medium
$0.15 < ES \leq 0.40$	Low
$ES \leq 0.15$	Very Low

Table 7. Category Percentage of Student Response (Handayani et al., 2021)

Percentage of Student Response (ES) (%)	Category
$85 < SR \leq 100$	Very Positive
$70 < SR \leq 84$	Positive
$21 < SR \leq 69$	Less Positive
$0 \leq 20\%$	Negative

RESULT AND DISCUSSION

Analysis Stage

The developed mobile learning media is named “Sanak Belajar”. The term “Sanak” originates from the Kutai language and refers to close friends or companions who are considered like family, reflecting the role of the media as a learning companion for students. The development of this media begins with the initial analysis stage, which reveals two main problems in learning chemistry in schools, namely, students' dependence on the internet to find instant answers without understanding concepts, and the use of learning media that is still monotonous due to limited mastery of technology by teachers. In the literature analysis stage, several previous mobile learning studies were reviewed to identify existing weaknesses and design media development innovations, as shown in Table 8 below.

Table 8. Mobile learning media literature analysis results

Weaknesses	Researcher Innovation
The scope of the material is limited to only 1 subject matter	Adding a Teacher Account
Content and components in mobile learning are difficult to insert and update	
Has a large file size	Implementing youtube embed technology

Furthermore, student needs analysis was conducted through a questionnaire to students of class X SMAN 1 Loa Janan to determine the content, design, and features expected in the learning media. The results can be seen in Figure 2 below.

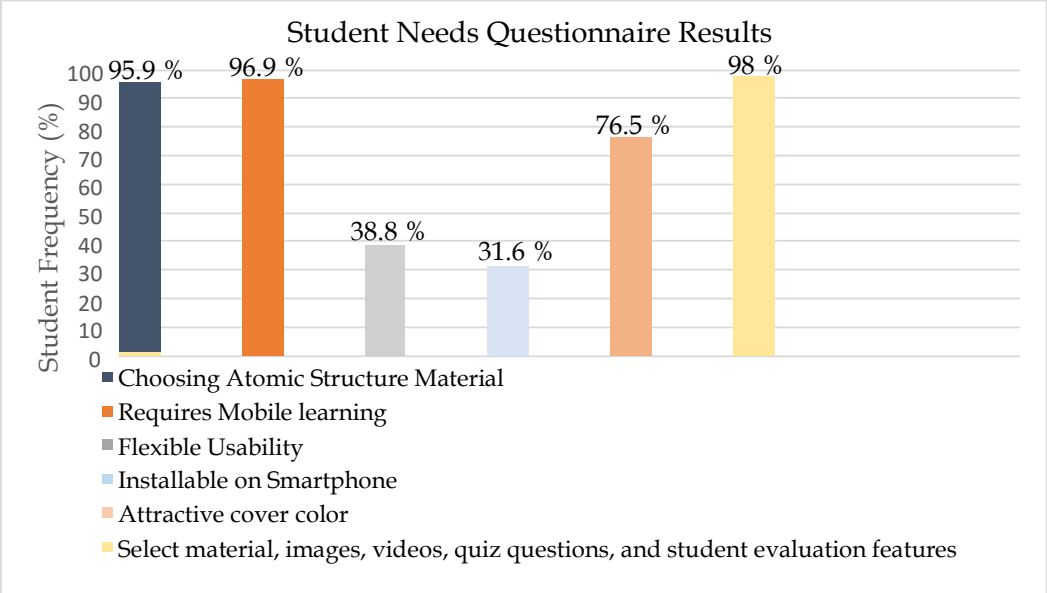

Figure 2. Results of Student Needs Questionnaire Analysis

Based on the analysis results, the atomic structure material from the independent curriculum of class X phase E was chosen as the primary material developed, with the learning objective that students can understand atomic theory, fundamental particles, isotopes, isotones, isobars, and electron configuration.

Design Stages

Format selection is the stage of designing media by selecting the components and features used. The elements that will be added to this media

include materials, videos, quiz questions, and student evaluations. A feature that will be added to this media is a special account for teachers, which aims to encourage teachers' creativity and support them in the learning process (König et al., 2020).

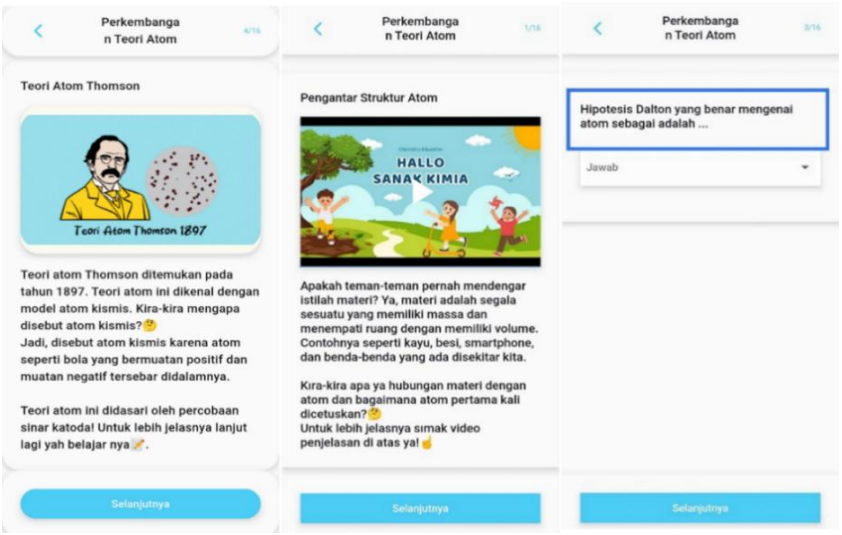

Figure 3. a) Material Display, b) Video Display, c) Quiz Question View

Sanak Belajar media displays an engaging and interactive learning flow through three main views. Figure 3a displays material about Thomson's Atomic Theory with illustrations and communicative language to facilitate student understanding. Figure 3b shows an introduction in the form of a video that relates the concept of atoms to objects around, thus making the material more contextual and relevant. Meanwhile, Figure 3c shows a quiz question about Dalton's hypothesis to measure the extent of students' understanding after learning. These three displays support mobile-based self-learning that is fun and meaningful.

Figure 4 shows two important features of the Sanak Belajar media. Figure 4a shows the student evaluation display, where learners are asked to answer image-based questions related to Thomson's atomic model, with interactive multiple-choice and raisin bread atom visualizations. This evaluation is designed to test students' understanding of the material directly. Meanwhile, Figure 4b shows the teacher account view, which presents teacher profile data and access to student lists and grades within the class, supporting digital and structured learning management. Both views reinforce the integration of learning and academic control.

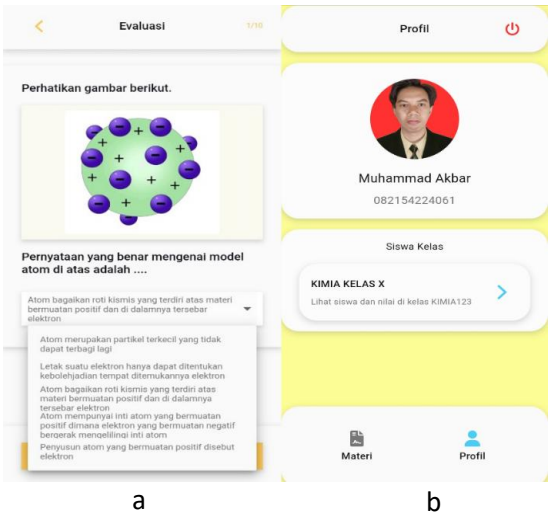

Figure 4. a. Student Evaluation Display, b. Teacher Account Display

Development Stages

At this stage, the validator team assesses the media that has been developed and provides suggestions and corrections needed so that the final product meets the eligibility and validity criteria. Material experts validate three main aspects: content feasibility, language, and presentation. Validation by media experts includes two aspects, namely presentation and graphics. Meanwhile, validation by learning practitioners covers four aspects: content feasibility, language, presentation, and graphics. Table 9 below displays the validation results from the three categories of validators.

Table 9. Validation Results of Sanak Belajar Mobile Learning Media

Stage 1		
Validator	**Percentage (%)**	**Category**
Material Expert	81.7	Very High Validity
Media Expert	79.2	High Validity
Learning Practitioner	93.1	Very High Validity
Stage 2		
Validator	**Percentage (%)**	**Category**
Material Expert	95	Very High Validity
Media Expert	95.4	Very High Validity
Learning Practitioner	100	Very High Validity

The validation of the Sanak Belajar learning media involved two phases and was carried out by three categories of assessors: material specialists, media specialists, and instructional practitioners. In the initial phase, the material specialist assigned a validity rating of 81.7%, which falls under the "Very High Validity" classification. This score was based on an evaluation of aspects such as content accuracy, clarity of language, and the suitability of the presentation. However, several areas were identified for improvement, including better alignment of learning goals, refinement of the material introduction, revision of quiz items, and the inclusion of questions that target higher-order thinking skills. Meanwhile, the media expert scored the media at 79.2%, categorized as high validity, based on presentation, effectiveness, and graphics. The media expert pointed out issues such as the lack of a summary feature, unappealing graphic displays, and videos that could not be played in landscape mode. The learning practitioner awarded a score of 93.1%, indicating very high validity, with suggestions including changing the term “learning outcomes” and adding student subjects in the learning objectives. After revisions addressing these points, the second stage of validation showed marked improvement. The material expert raised the score to 95%, the media expert to 95.4%, and the learning practitioner to a perfect 100%, all within the Very High Validity category. These results indicate that the media is highly valid and feasible for educational use, meeting standards in terms of content, media quality, and learning effectiveness without requiring further revision.

Implementation Stages

During the implementation phase, research was conducted to evaluate the practicality and effectiveness of the Sanak Belajar mobile learning media on atomic structure material. Practicality was assessed through questionnaires completed by teachers and students, as well as observations of the learning process. The questionnaire results are presented in Table 10.

Table 10. Results of Teacher and Student Practicality Questionnaires

Practicality Questionnaires	Percentage (%)	Category
Teacher	97.92	Very Practical
Student	79.81	Practical

The results of the questionnaire on the practicality of Sanak Belajar mobile learning-based learning media show a good assessment from teachers and students. Teachers assessed with an average of 97.92% (very practical category), media practicality data by teachers contained in Table S7 shows the readability and usefulness aspects of getting a perfect score of 100%. In comparison, the appearance is 95%, and ease of use is 96.67%. Students gave an average rating of 79.81% (practical category). Media practicality data by students contained in Table S8 shows learning independence obtained the highest score of 81.27%, followed by display 80.51%, readability 79.26%, usefulness 79.12%, and ease of use 78.90%. This assessment is supported by various studies that highlight the importance of using simple language in learning media, the role of attractive visual design, ease of access and use of technology, strengthening learning independence, and the effectiveness of media in increasing student motivation and interest (Abdulrahaman et al., 2020; Bernacki et al., 2020; Major et al., 2021; Yu et al., 2021; Almasre, 2024). The data that supports the results of the student practicality questionnaire are the results of observations taken during teaching and learning activities by teachers and students; the percentage of observations can be seen in Figure 5.

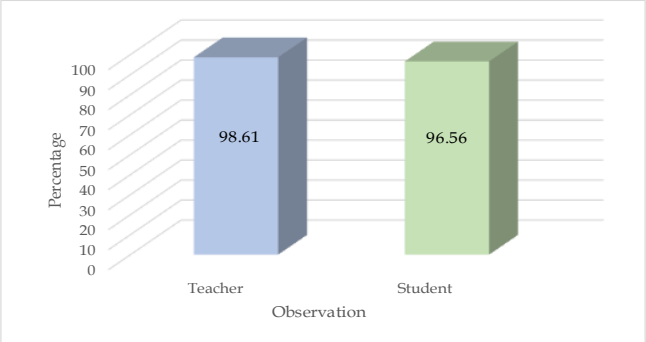

Figure 5. Teacher and student observation results

Figure 5 presents the average percentage of teacher activity during the learning process using the Sanak Belajar mobile learning media on atomic structure material, reaching 98.61%, categorized as excellent. Similarly, student activity averaged 96.56%, also falling into the very active category. Descriptive statistics of the pretest and posttest scores are presented in Table 11. The results indicate an increase in students' average scores after using the Sanak Belajar mobile learning media.

Table 11. Descriptive Statistics of Pretest and Posttest Scores

Class	Test	Mean	SD
X IPA 1	Pretest	30.00	11.88
X IPA 1	Posttest	74.71	7.76
X IPA 2	Pretest	31.18	14.31
X IPA 2	Posttest	74.41	7.86

As shown in Table 11, students average scores increased substantially after using the Sanak Belajar mobile learning media. In Class X IPA 1, the mean score increased from 30.00 to 74.71, while in Class X IPA 2 it increased from 31.18 to 74.41. These findings indicate an improvement in students' understanding of atomic structure concepts following the implementation of the developed media

Table 12. N-Gain and Effect Size Results

Class	N-Gain	Category	Effect Size	Category
X IPA 1	0.64	Medium	3.76	Very High
X IPA 2	0.63	Medium	3.02	Very High
Average	0.64	Medium	3.39	Very High

Prior to the N-Gain analysis, prerequisite tests were conducted to determine data normality and homogeneity. The results of the N-Gain and effect size analyses are presented in Table 12. The average N-Gain score of 0.64 was categorized as medium, indicating a moderate improvement in students' learning outcomes. Furthermore, the average effect size was categorized as very high, demonstrating a strong impact of the developed media on students' understanding of atomic structure concepts. The raw pretest and posttest data used for the N-Gain and effect size calculations are provided in the supplementary material.

Evidence supporting the effectiveness of the media in this study is obtained from a questionnaire measuring students' responses to using Sanak Belajar mobile learning-based learning media to improve their understanding of the atomic structure material. The result in Figure 6.

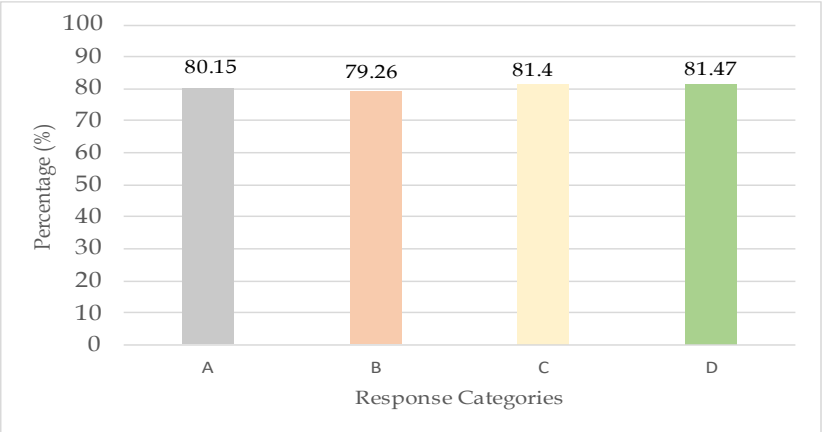

Figure 6. Results of student response questionnaire analysis

Description:

A: Ease of Understanding the material
B: Activeness in Learning
C: Mobile Learning Based Learning Media Sanak Belajar
D: Student Interest

Based on the data collected from student questionnaires, the Sanak Belajar learning media has a positive effect on the learning process. This is evident from all indicators, which show favorable results. The ease of understanding the material scored 80.15%, indicating that students find the content easier to comprehend. Student engagement during learning also received a positive rating of 79.26%. Furthermore, students' responses to the media were positive, with a percentage of 81.40%, and

their interest in the media was similarly high at 81.47%. This proves that this media helps understanding and encourages students' interest and participation in learning. In line with previous findings, which show that interactive media can improve learning outcomes, innovative media can promote interest and activeness in learning, and good learning media play an essential role in increasing students' active involvement in learning (Chans & Portuguez, 2021; Hight et al., 2021; Syafruddin et al., 2024). Based on the practicality and effectiveness analysis results, Sanak Belajar mobile learning-based learning media proved to be very practical and effective in supporting atomic structure learning. This media makes it easier for teachers to deliver material and provides a more interesting and interactive learning experience for students

CONCLUSION

Based on the findings, the Sanak Belajar mobile learning media shows a very high level of validity, practicality, and effectiveness in helping students understand atomic structure. Validation from material experts, media experts, and teachers shows that this media meets good quality standards and is suitable for learning. Teachers and students found the media easy to use, interesting, and able to increase student participation. The pre-test and post-test result also showed a significant improvement in student understanding, proving that this media has a strong impact on learning outcomes. Therefore, Sanak Belajar can be an innovative option to support chemistry learning, especially on atomic structure. Further research can explore its use in other chemistry topics.

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