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Developing Android-Based Interactive Learning Media Assisted by Smart Apps Creator on Atomic Structure Material

Faisal[1*], Susilowati[2], Tamar Rumihin[1], and Murtihapsari[1]
[1]Department of Chemistry Education, Faculty of Teacher Training and Education, University of Papua, Jl. Gunung Salju Amban, Manokwari, 98312, Indonesia
[2]Department of Chemistry, Faculty of Mathematics and Natural Sciences, University of Papua, Jl. Gunung Salju Amban, Manokwari, 98312, Indonesia
[*]E-mail: f.faisal@unipa.ac.id

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Abstract

The integration of digital technology in chemistry education necessitates the development of innovative learning media to facilitate students' comprehension of abstract and complex concepts, such as atomic structure. This study aimed to develop and validate an Android-based interactive learning medium and to examine its practicality for chemistry learning. A research and development (R&D) methodology was employed, utilizing the 4-D model comprising define, design, develop, and disseminate stages. During the define stage, students' learning needs and difficulties were identified through classroom observations, interviews, and needs analysis questionnaires. The design stage involved the formulation of learning objectives, content organization, and the development of a media prototype. In the develop stage, the learning media was evaluated using validation instruments completed by experts in chemistry content, instructional media, and learning design. The disseminate stage focused on assessing practicality through student response questionnaires. The results revealed that the developed learning media achieved high validity, with mean expert validation scores of 3.86 for content, 3.80 for media, and 3.85 for design, resulting in an overall mean score of 3.83, categorized as very valid. Furthermore, student responses indicated a high level of practicality, with an average score of 3.55, classified as very positive. These findings suggest that the Android-based interactive learning media is feasible and practical for supporting students' understanding of atomic structure and has strong potential for implementation in chemistry learning contexts.

Keywords: android, atomic structure, interactive learning media, smart apps creator

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1. Introduction

Chemistry education often presents abstract and microscopic concepts that are difficult for students to understand, especially in topics such as atomic structure, electron configuration, and quantum atomic models. These concepts involve invisible phenomena that require strong spatial and symbolic representations. Numerous studies have reported that students experience misconceptions, such as perceiving electrons as static particles orbiting like planets or misunderstanding the probabilistic nature of orbitals in the quantum model (Suparman et al., 2024). Such conceptual difficulties necessitate the use of visualization-based and interactive media that align with the constructivist learning approach, which emphasizes students' active involvement in building their own understanding (Yurchenko, 2025).

The rapid development of Industry 4.0 is marked by advances in science and digital technology. Various multimedia platforms can be integrated into chemistry education to facilitate meaningful learning experiences

(Kayima, 2025). Within the framework of constructivism, students learn more effectively when they interact directly with representations of chemical phenomena, visualize atomic models, and test their understanding through feedback and problem-solving activities (Moju at al., 2025). Therefore, interactive Android-based media using Smart Apps Creator offer an innovative way to strengthen conceptual understanding in chemistry, particularly in visualizing atomic structures and electron configurations through animations, simulations, and interactive quizzes.

The acceleration of Industry 4.0 has been accompanied by the advancement of science and technology. Various digital content and a wide range of multi-platform applications can be utilized by people in all aspects of life, including in the field of education through learning media. Learning media serve as one of the tools to assist students in making the learning process more effective. Engaging learning media inspire students to learn, thereby providing them with an enjoyable learning experience (Jubaerudin et al., 2021).

Innovations in technology use enable the creation of dynamic and interactive visualizations, which help students better understand various concepts. Such innovations can be implemented through the Smart Apps Creator application. This application is a desktop tool designed to develop interactive media content. Its output can be generated in APK, HTML5, and EXE formats, allowing it to be used across various devices such as computers, laptops, tablets, and smartphones (Suhartati, 2021).

The selection of Smart Apps Creator is based on several considerations; its ease of use, its ability to generate application-based outputs, and its offline accessibility, which eliminates the need for an internet connection during use (Fahri, 2022). The presence of interactive features such as simulations, animations, and quizzes provides a more engaging learning experience and motivates students to be more active in the learning process.

In the current digital era, students are in constant and close interaction with technological devices, particularly Android smartphones, in their daily lives. Learning through Android-based interactive multimedia has been shown to significantly enhance students' motivation and academic achievement, as demonstrated by empirical research on Android applications in education (Andriani & Suratman, 2021). However, its application in learning activities has not been fully optimized: a considerable portion of students' smartphone usage remains devoted to entertainment, social media, and gaming. These non-academic usage patterns have been linked to reduced concentration and lower engagement (Fitria et al., 2023).

These tendencies indicate that although smartphones possess substantial potential to support digital literacy and learning resources, students often fail to leverage these devices meaningfully for academic development. This misalignment between potential and actual usage underscores the importance of establishing stronger guidance, digital discipline, and purposeful learning strategies to ensure that smartphones contribute positively to students' educational outcomes.

According to Gagné and Briggs, media in the learning process are means used to deliver instructional content, functioning to stimulate students' learning interest as well as encourage their engagement in learning activities (Efendi et al., 2023). Digital learning media can be understood as technology-based tools that enable the delivery of instructional messages in an interactive, directed, and structured manner. These media function not only as communication tools between teachers and students but also as rich learning resources that encourage active learner engagement and enhance the effectiveness of the learning process. Recent studies have shown that the use of digital learning media can strengthen motivation, improve conceptual understanding, and expand access to various learning materials (Aini et al., 2023). Thus, learning media are not merely instruments for conveying information, but also platforms that create meaningful learning experiences and facilitate the comprehensive development of students' competencies. According to Mangawe et al. (2025), interactive learning media function not only as a channel for delivering material from teachers to students but also as a motivator, a learning resource, and a means for developing student skills. Therefore, it can be concluded that media in the learning process is a means of delivering instructional messages that provide meaningful learning experiences for students.

Interactive media represents an effective solution for improving the quality of chemistry education. Students benefit significantly in connecting chemical concepts because such media can present the material in a tangible and multi-sensory form, using visualization through text, images, audio, video, and animation, which helps information become more memorable and better internalized (Bahriah et al., 2022).

Research by Arnandi et al. (2022) demonstrated that Android-based learning media using Smart Apps Creator for integer number topics can be utilized as a highly feasible medium for learning, categorized as "very feasible." The development of this learning media follows the ADDIE model and helps students understand the material being taught. Similarly, Ariani et al. (2023) conducted development research at SMK Negeri 1 Banyuanyar using the ADDIE model. The results of the study, based on questionnaire responses, showed scores of 4.75 from material experts, 4.55 from media experts, and 4.73 from design experts, indicating that the media product is highly feasible to use. User responses regarding the use of the learning media as instructional material were also very positive, with scores of 4.63 from peer teachers and 4.73 from the larger group of students.
Furthermore, Mahuda et al. (2021) found that Android-based learning media developed with Smart Apps Creator were highly valid, practical, and have the capability to enhance mathematical problem-solving skills of students at Universitas Bina Bangsa. Supporting this, Sirait et al. (2024) reported that the development of Smart Apps Creator 3 learning media based on STEAM for mathematics content in elementary school students has great potential to improve learning quality. Likewise, the research carried out by Wiliyanti et al. (2023) showed that physics learning media developed for mobile phones using Smart Apps Creator for senior high school students were considered highly feasible by both students and expert validators, and also demonstrated an increase in students' interest in learning.

Based on the above explanation and the observations made by the developer so far, research using Smart Apps Creator has never been conducted in Papua. The novelty of this study lies not only in the regional context but also in the variables examined; the enhancement of students' learning motivation and engagement through the use of interactive learning media based on Smart Apps Creator. Thus, this research presents novelty in terms of location, media approach, and the variables investigated. Therefore, this presents a new opportunity to develop interactive Android-based learning media with the help of Smart Apps Creator. The development of interactive Android-based chemistry learning media is a relevant and strategic step in improving the quality of chemistry education in this digital era. The development of Android-based learning media assisted by Smart Apps Creator for the topic of atomic structure is expected to help students, teachers, and lecturers achieve better learning outcomes.

2. Research Method

This research employs a Research and Development (R&D) design using the 4-D model (Define, Design, Develop, and Disseminate). The validation process was conducted by chemistry content experts and media/design experts to ensure scientific accuracy and pedagogical relevance. Three validators were involved: a chemistry content specialist (to verify the correctness of atomic structure concepts), a chemistry education expert (to align with learning theories), and a media/design expert (to assess interactivity, usability, and visual quality). This thorough validation ensures that the developed media not only meets technical standards but also supports students' conceptual understanding in chemistry. The use of the 4-D Thiagarajan model for validation has also been adopted in more recent R&D studies in chemistry education, proving its continued relevance (Muslim & Ardhana, 2023; Sahrawati et al., 2024).

The definition stage aims to identify the requirements for developing interactive learning media. The analyses conducted included front analysis, student characteristics analysis, task analysis, concept analysis, and learning objectives analysis. 4-D development model can be seen in Figure 1.

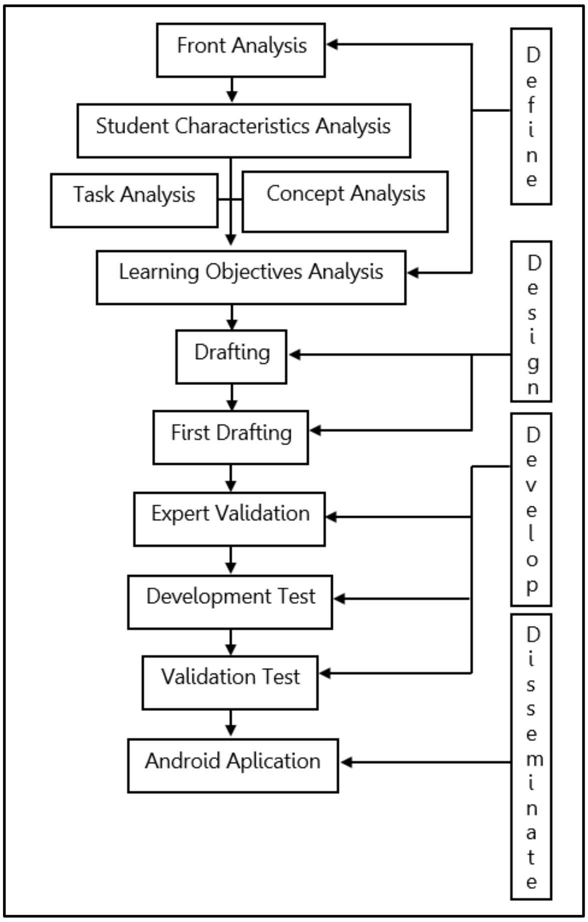

Figure 1. 4-D Development Model Modified

At the design stage, the material is adjusted based on the results of the above analysis by determining the learning flow for presenting the content. The design is carried out after the material planning is completed, so that the design to be created aligns with the material. Subsequently, instruments were developed to assess the feasibility of the learning media in terms of material and media aspects. The development stage involves searching for and gathering all reference sources needed for developing the material and aligning it with the learning objectives. Then, validation of the learning media is carried out by validators to determine its feasibility in terms of content and visuals. Next is the dissemination stage. At this stage, the Android-based interactive learning media that has passed the development phase and has been declared feasible for use will be distributed in the form of an android application.

The data collection in this study was designed based on the research needs; the validity and practicality of the developed Android-based learning media. The details regarding the data collection techniques are as follows: Validity is measured using teaching material validation developed by the researcher and submitted to expert validators to validate the Android-based learning media. Practicality is measured using a research instrument in the form of a questionnaire. The questionnaire aims to assess students' responses regarding the practicality of the learning media in the form of an Android application used in the learning process.

After the required data were collected, data analysis was conducted. The research data is analyzed using descriptive statistical analysis as follows. The product's validity is assessed by several validators, including experts in the development of learning tools and learning media experts. The activities carried out in the data validity analysis process are as follows: Recapitulating the assessment results from the experts into a table that includes: aspects ($\overline{A\imath}$), criteria ($\overline{K\imath}$), and the total score from the validator's assessment ($\overline{V\imath\jmath}$). Determining the average score of the validation results from all validators for each criterion using the equation 1:

$$\overline{Ki} = \frac{\sum_{j=1}^{n} \overline{Vij}}{n} \quad (1)$$

Information :
$\overline{Ki}$ = The average score for criterion-i
$\overline{Vij}$ = The score of the assessment for criterion-i by validator-j
n = The number of validators

Calculating the overall average ($\overline{Va}$) using the equation 2:

$$\overline{\mathrm{Va}} = \frac{\sum_{\mathrm{i}=1}^{\mathrm{n}} \overline{\mathrm{Ai}}}{\mathrm{n}} \quad (2)$$

Information :
$\overline{Va}$ = Overall average
$\overline{Ai}$ = The average score for aspect-i
n = The number of aspects

Determining the validity category for each criterion ($\overline{Ki}$), the average aspect ($\overline{Ai}$), or the overall average ($\overline{Va}$) using the predefined validation categories. The validity categories are as follows:

Table 1. Validity Level Categories

Score	Category
3.6 ≤ V ≤ 4	Very valid
2.6 ≤ V < 3.5	Valid
1.6 ≤ V < 2.5	Quite valid
0 ≤ V < 1.5	Not valid

Based on the table above, V is the average validity score from all validators. The threshold for reaching the valid category is within the interval 2.6 ≤ V < 3.5. (Sugiyono, 2022).

The practicality of the learning media is measured by analyzing the students' response questionnaires, which are then analyzed using percentages. The activities carried out to analyze the students' response data are as follows: Recapitulating the students' and teachers' response results into a table that includes: aspects (Ai) and the total score (Vij) for each student. Calculating the overall average ($\overline{Xi}$) using the equation 3:

$$\overline{Xi} = \frac{\sum_{i}^{n} 0^{Ai}}{n} \quad (3)$$

Information :
$\overline{Xi}$ = Overall average
Ai = Score for criterion-i
n = The number of criteria

Determining the category of student responses for each criterion (Ki) or overall average (Xi) based on the established response evaluation criteria as follows:

Table 2. Practicality Level Categories

Score	Category
3.6 ≤ Xi ≤ 4	Very positive
2.6 ≤ Xi < 3.5	Positive
1.6 ≤ Xi < 2.5	Quite positive
0 ≤ Xi < 1.5	Not positive

Based on Table 2, Xi is the average score of the respondents. If it reaches the positive category within the interval 2.6 ≤ Xi < 3, it is considered practical (Sugiyono, 2022).

3. Result and Discussion

This research is a development study (Research and Development/R&D). The learning media developed follows the 4-D model, which consists of Define, Design, Develop, and Disseminate stages. After going through the development phase, the media will be tested on students to determine the responses of students from the Physics Education and Mathematics Education study programs in the odd semester of the 2024-2025 academic year, enrolled in the General Chemistry course at the University of Papua, toward the developed Android-based learning media.

3.1. Define

At this stage, the primary focus is the needs analysis, specifically on the topic of atomic structure. The purpose is to identify existing problems and student needs related to chemistry learning. The define stage consists of five steps, described as follows.

3.1.1. Front Analysis

This step aims to gather information related to problems in chemistry learning. Basic problems in chemistry learning were identified through observations and student interviews, followed by a direct analysis of the interview data. The interview findings, it was revealed that: (a) Students experience difficulty in understanding chemistry concepts, particularly the topic of atomic structure, which is still abstract; thus, students require concrete visualizations to grasp these concepts. (b) Students only receive material from textbooks and student worksheets. (c) Android-based media and variations in learning methods are not yet available.

3.1.2. Student Characteristics Analysis

The analysis was conducted using needs assessment questionnaires and direct interviews. The results showed that 80% of students reported that the materials presented in the textbooks and Student Worksheets were difficult to understand. Therefore, they expressed the need for more accessible learning resources, such as Android-based media that includes materials, animations, observable videos, practice exercises, and quizzes enhanced with engaging images and colors.

Based on these findings, the researcher was motivated to develop interactive Android-based learning media that leverages advancements in digital technology. This media is designed as an application that can be installed on smartphones and used to support the learning of atomic structure concepts.

3.1.3. Task Analysis

Task analysis was guided by the sub-course learning outcomes which require students to explain atomic theory, atomic structure, and the periodic table**.** The indicators include the ability to explain atomic concept, determine the number of electrons, protons, and neutrons in an atom, and determine the element’s position in the periodic table**.**

3.1.4. Concept Analysis

Concept analysis involves determining the content of the material to be included in the Android-based learning media. The developed media will include atomic structure material supplemented with learning activities that can serve as a learning resource for students.

3.1.5. Learning Objective Analysis

Learning objective analysis is the process of formulating the intended learning goals. These objectives guide the development of the Android-based learning media, ensuring that the content and activities provided can help students master the material about atomic structure effectively.

3.2. Design

The results of the analysis in the definition stage are used as a reference for designing Android-based learning media on atomic structure material. The design stage includes: Development of Android-based Learning Media. The learning media designed is based on students' needs for learning materials that include content along with images, animations, and videos related to the material, design, and attractive color schemes. The appearance and content of the learning media are designed to make students more interested in reading and make it easier for them to study chemistry, particularly the atomic structure material. The design format used is as follows:

3.2.1. Template Creation

Figure 2. Template

The Android-based learning media template was designed using Canva Pro (Figure 2). Once the template was completed, it was filled with materials according to the design and then imported into the Smart Apps Creator software to make it interactive.

3.2.2. Cover

The cover serves as the initial display of the Android-based learning media. The cover is designed to be simple with an attractive color scheme (Figure 3).

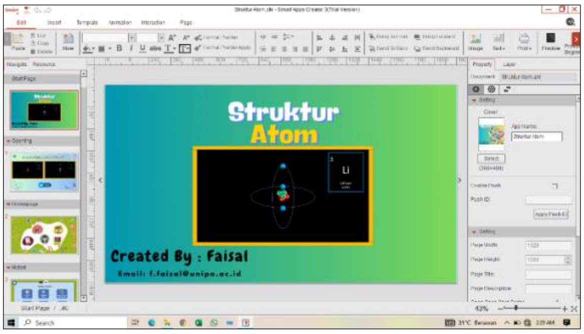

Figure 3. Android-Based Learning Media Cover

3.2.3. Menu List

The creation of a menu that can be accessed in this learning media includes: material, video, quiz, and about the APK. Figure 4 shows the Android-based learning media menu.

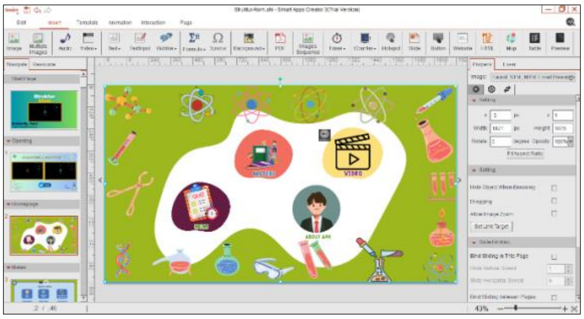
Figure 4. Android-Based Learning Media Menu

3.2.4. Content List of the Material

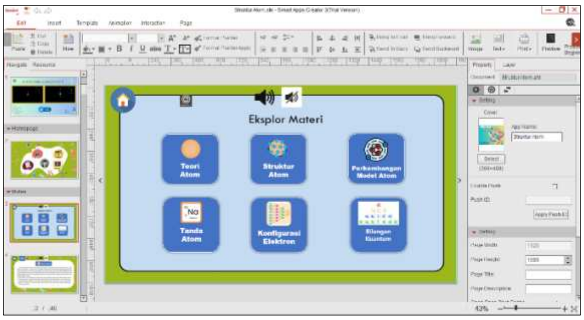

Figure 5. Display of Atomic Structure Material

This stage involves creating a list of materials, which is part of the material menu, containing the key topics of the subject matter. The display of the content list shown in Figure 5.

3.2.5. Content of the Learning Media

At this stage, the development of the learning media continues with the inclusion of the atomic structure material. Figure 6 depicts the display of learning media content.

Figure 6. Display of Learning Media Content

3.2.6. Interactive Quiz

At this stage, questions are prepared as exercises to assess conceptual understanding. Figure 7 depicts the quiz interface.


Figure 7. Interactive Quiz Display

3.2.7. Animated Video

Figure 8. Animated Video Display

The animated video presents a collection of visual clips to illustrate the topic of atomic structure. As shown in Figure 8, this component provides dynamic visualizations that support students' conceptual understanding.

3.2.8. APK Conversion

The final stages involves converting the learning media into an APK format to ensure compatibility with smartphones. As shown in

Figure 9, this process enables the application to be installed and operated on students' devices.

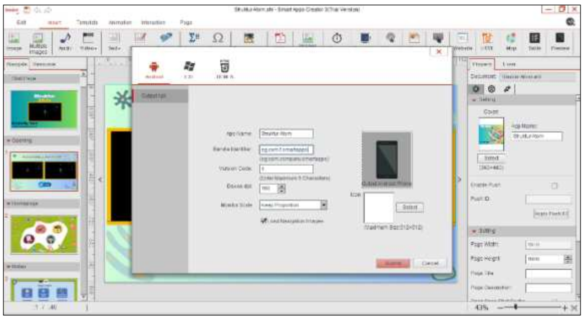

Figure 9. APK Conversion

3.3. Development

At the development stage, the learning media underwent a validity analysis. The results of the design phase were evaluated by three validators: a subject-matter expert, a media expert, and a design expert. These validators were chemistry education lecturers and chemistry subject teachers. After being declared valid, the learning media were tested on students from the Physics Education and Mathematics Education study programs at the University of Papua who were enrolled in the General Chemistry course in the 2024-2025 odd semester.

The developed Android-based learning media were then subjected to further validation. The validation aimed to assess the suitability of the media through evaluations by subject-matter, media, and design experts. Validation by the subject-matter expert aimed to examine the completeness, depth, accuracy, and organization of the material. Validation by the design and media experts evaluated the media's appearance, quality, and overall appropriateness. The results of the expert validation are presented in Table 3.

Table 3. Learning Media Validation Results

Material Validator	Media Validator	Design Validator	Average	Category
3.86	3.80	3.85	3.83	Very valid

Based on Table 3, the average validation score from the material expert was 3.86. The average validation score from the media expert was 3.80, and from the design expert was 3.85. Therefore, the overall average was 3.83, which falls into the very valid category. Based on these validation results, the developed Android-based learning media meets the valid criteria. This is in line with Sugiyono's statement that if the validation score falls within the range of $2.6 \leq V < 3.5$, it is considered valid. Based on the explanation above, it can be concluded that the Android-based learning media developed by the researcher is feasible and valid to be used by students, achieving a very valid category.

Table 4. Average Student Responses in the Limited Trial

Item	Average	Category
I1	3.60	Very Positive
I2	3.50	Positive
I3	3.50	Positive
I4	3.50	Positive
I5	3.30	Positive
I6	3.40	Positive
I7	3.50	Positive
I8	3.40	Positive
I9	3.70	Very Positive
I10	3.40	Positive
I11	3.50	Positive
I12	3.80	Very Positive
Overall average: 3.51 → Positive (approaching Very Positive)		

A limited trial was conducted with 10 students using an instrument in the form of a student response questionnaire consisting of 12 items (Table 4). The responses were measured using a 4-point Likert scale.

The practicality of the developed Android-based learning media is measured using an instrument in the form of a student response questionnaire. The average student responses to the Android-based learning media can be seen in Table 5.

Table 5. Student Response Score Results

No	Item											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	4	3	4	4	3	4	4	4	4	3	4	4
2	4	4	4	3	3	2	3	3	4	3	4	4
3	4	3	4	4	4	4	4	4	4	3	4	4
4	4	4	4	3	3	4	3	3	3	3	4	4
5	4	4	4	4	4	4	4	4	4	4	4	4
6	4	4	4	4	4	4	4	4	4	4	4	4
7	3	3	3	3	3	3	3	3	3	3	4	4
8	4	4	4	4	4	4	4	4	4	4	4	4
9	3	3	3	3	3	3	3	3	3	3	2	4
10	3	3	3	3	3	3	3	2	3	3	2	3
11	4	4	4	3	4	4	4	3	3	4	4	4
12	4	4	4	4	4	4	4	4	4	4	4	4
13	4	3	4	3	4	4	4	4	4	4	4	4
14	4	4	4	4	4	4	4	4	4	4	3	3
15	4	4	4	4	4	4	4	4	4	4	4	4
16	3	3	3	3	3	4	3	4	3	3	4	4
17	2	4	4	4	4	4	3	3	3	4	2	4
18	4	4	4	3	3	3	3	3	4	3	4	4
19	4	4	4	4	4	4	4	4	4	4	4	4
20	4	3	3	4	3	4	4	4	4	4	3	4
21	3	3	3	3	4	4	4	2	3	4	4	4
22	3	3	3	3	3	3	3	3	3	3	3	3
23	3	3	3	3	3	3	3	3	3	3	3	3
24	4	4	4	4	4	4	4	4	4	4	4	4
25	4	4	4	4	4	4	4	3	4	4	4	4
26	4	2	3	3	3	2	2	2	3	2	3	3
27	3	4	4	2	4	4	4	4	4	3	1	4
28	4	3	3	3	3	3	4	3	3	3	3	3
	102	98	102	96	99	101	100	95	100	97	97	106
	3.64	3.50	3.64	3.43	3.54	3.61	3.57	3.39	3.57	3.46	3.46	3.79
Total	**42.60**											
Average	**3.55**											
Criteria	**Very positive**											

Based on Table 5, the students' responses to the practicality aspects of the Android-based learning media yielded an average total of 3.55, which falls into the "very positive" category. A learning medium is considered practical if it falls under the "positive" category with the interval $2.6 \leq Xi < 3.5$.

The Android-based learning media developed by the researcher, which is used by students, is considered practical as it falls within the very positive category. The practicality of the Android-based learning media on the topic of atomic structure is supported by its ease of use, which can be seen from the students' response sheets as a result of the media's practicality level. This aligns with the opinion of Van den Akker that the practicality of a developed product refers to the extent to which users like it and can use it easily under normal conditions (Harahap et al., 2023).

3.4. Disseminate

At this stage, the interactive Android-based learning media, which has successfully passed the development phase and been validated for use, will be distributed as an Android application. The dissemination will take place at YPPK Santos Arnoldus High School, Bintuni.

4. Conclusion

The developed Android-based interactive learning media on the topic of atomic structure has been proven to be valid and practical, with validation scores of 3.86 (material), 3.80 (media), and 3.85 (design), categorized as very valid. Student response scores averaged 3.55, categorized as very positive. Beyond feasibility, the developed media effectively enhances students' conceptual understanding of atomic structure, electron configuration, and quantum atomic models. Through animations, interactive simulations, and constructivist-oriented learning design, students can visualize abstract concepts, correct misconceptions, and build deeper, meaningful chemical understanding. Therefore, this interactive media is recommended for chemistry education to promote active and conceptually grounded learning.

Based on the research and data analysis, it can be concluded that the Android-based learning media on the topic of atomic structure, developed using the 4-D model—Define, Design, Develop, and Disseminate—has been proven to be feasible. At the define stage, the results of observations, interviews, and needs analysis indicated that students experienced difficulties in understanding abstract concepts of atomic structure and required interactive, Android-based media. At the design stage, the learning objectives, material outlines, prototypes, and templates were developed using Canva and Smart Apps Creator to ensure an attractive and user-friendly interface. At the develop stage, validation results from experts showed average scores of 3.86 (material), 3.80 (media), and 3.85 (design), with an overall mean of 3.83 categorized as very valid. At the disseminate stage, the limited trial involving 10 students obtained an overall mean response score of 3.55 categorized as very positive, indicating the practicality of the media. Thus, the Android-based learning media developed in this study is categorized as very valid and very practical, and it has the potential to improve students' understanding and engagement in learning atomic structure.

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