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Development of ARSA (Augmented Reality Struktur Atom) Based on Android as an Independent Learning Resource for High School Students

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Abstract

This research aims to determine the characteristics, feasibility, and student responses to the Android-based ARSA as an independent learning resource for high school/Islamic high school (SMA/MA) students. The research method used is a mixed-methods approach with an exploratory sequential design. The data obtained includes qualitative descriptive data in the needs analysis, expert validation test, and peer reviewer feasibility test. For the feasibility test by reviewers and the student response test, qualitative data were converted into quantitative data using a Likert scale and then analyzed using ideal conversion guidelines to determine the feasibility of the product in each aspect and overall. The research results show that the ARSA learning resource has the following characteristics: it features interactive 3D visualizations of atomic models, can be used without an internet connection, and serves as an independent learning resource for SMA/MA students. The ARSA learning resource was declared feasible for use after adjustments were made based on comments/suggestions from prospective teachers as peer reviewers and chemistry teachers as reviewers. It was also declared suitable for use by students.

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INTRODUCTION

Chemistry is one of the Natural Sciences (IPA) subjects that is important to study in schools. However, many students lack interest in learning it (Hemayanti et al., 2020). This is because chemistry is considered a difficult subject, which discourages students from studying it (Budiariawan, 2019). Chemistry materials are challenging for students to understand due to their abstract nature (Putri, 2017). One of the abstract chemistry topics is atomic structure (Rizawayani et al., 2017).

Atomic structure is a fundamental topic in high school/Islamic high school (SMA/MA) chemistry education. Due to it's abstract nature, students often struggle to understand this concept (Langitasari et al., 2021). This difficulty is exacerbated by teaching methods in schools that tend to only present concepts, theories, and laws from textbooks without providing other examples that could help students understand the material more thoroughly (Andriani et al., 2019). Consistent with the findings of Afrianis & Ningsih (2022), students often merely memorize concepts without fully understanding atomic structure. Therefore, an engaging independent learning resource is needed to enhance students' understanding of the atomic structure material.

Learning resources are anything utilized by teachers and students to enhance the effectiveness of learning (Supriadi, 2015). Learning can be effective if the process is enjoyable (Lubis, 2019). An enjoyable learning process can be achieved, among other ways, by utilizing technology. (Aka, 2017). One technology that can be leveraged in the development of learning resources is augmented reality (AR).

AR technology enables the integration of the real world with the virtual world in real-time 3D, helping students visualize abstract concepts (Lusa et al., 2020). The development of AR-based learning resources accessible

through Android devices offers an appealing solution to enhance students' understanding of atomic structure. Android was chosen as the platform because many students use smartphones with this operating system (Wulandari et al., 2019). Research shows that 87% of students use Android smartphones and tend to be more active in using these devices compared to books (Heswari & Patri, 2022).

This research develops an AR-based independent learning resource for SMA/MA students on the topic of atomic structure. This learning resource is expected to present atomic structure concepts visually and interactively, helping students to visualize and better understand the material. The learning resource, named ARSA (Augmented Reality Struktur Atom), can be accessed anytime and anywhere, according to the user's needs without internet connection.

METHODS

Research Design

This development research uses mixed methods with an exploratory sequential design. However this research is limited to the qualitative step, which consists of qualitative data collection, qualitative data analysis, qualitative data results, product development, and first interpretation.

Subject of Research

The product will be validated by 2 chemistry education experts, feasibility testing by peer reviewers (3 prospective chemistry teachers) and reviewers (6 teachers), user response test involving 50 students. The research procedure, conducted in several high schools (SMA) and Islamic high schools (MA) in Bantul Regency, Special Region of Yogyakarta.

Data Analysis Technique

This development research uses 3 aspects: linguistic, content, and product characteristic. The feasibility testing by reviewers uses a total of 20 indicators, consisting of 5 for linguistic, 7 for content, and 8 for product characteristic. Meanwhile, the student response test uses a total of 10 indicators, consisting of 3 for linguistic, 4 for content, and 3 for product characteristic. The qualitative data obtained is then converted into quantitative data using a Likert scale with scores of 5 (Very Good), 4 (Good), 3 (Fair), 2 (Poor), and 1 (Very Poor). The score for each component is then analyzed by calculating the total score and the average score for each indicator. This calculation can be done using the following formula:

$$\overline{X} = \frac{\sum X}{n}$$

$\overline{X}$ = average score
$\sum X$ = total score of all indicators
N = total number of respondent

The results of these calculations can be categorized into five different categories: Very Good, Good, Fair, Poor, and Very Poor. Prastowo (2013) stated that to determine the category of each data point based on the interval, a formula can be used, as shown in Table 1.

Table 1. Ideal Conversion Guidelines

No	Score	Categories
1	$\overline{X}$ > Mi + 1,8 SDi	Very Good
2	Mi + 0,6 SDi < $\overline{X}$ ≤ Mi + 1,8 SDi	Good
3	Mi - 0,6 SDi < $\overline{X}$ ≤ Mi + 0,6 SDi	Fair
4.	Mi - 1,8 SDi < $\overline{X}$ ≤ Mi - 0,6 SDi	Poor
5.	$\overline{X}$ ≤ Mi - 1,8 SDi	Very Poor

The developed product can be considered feasible if the average score obtained is at least in the "Good" category. Next, the percentage of product ideality is calculated using the following formula:

$$\text{Ideality percentage} = \frac{\text{Average score}}{\text{Maximum ideal score}} \; x \; 100\%$$

FINDINGS AND DISCUSSION

Findings

This research produced an Android-based independent learning resource for high school/Islamic high school (SMA/MA) students on atomic structure material by utilizing AR (Augmented Reality) technology, which was named ARSA (Augmented Reality Struktur Atom), as shown in Figure 1. The development of ARSA was based on the results of needs analysis, exploration, and literature review. ARSA was developed through several steps, including expert validation test, peer reviewer review test, reviewer feasibility test, and student response test.

Figure 1. User Interface of ARSA

Based on the overall reviewer feasibility test results as presented in Table 2, ARSA is considered suitable as independent learning resource as it achieved an average score of 92.8 in the "Very Good" category with an ideality percentage of 93%. Reviewers assessed that ARSA excels in atomic structure content and its features. This is evidenced by the highest ideality percentage being in the aspects of content and product characteristic, both at 93%

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Table 2. Overall Reviewer Feasibility Test Results

Reviewer	Aspects			
	Linguistic	Content	Product Characteristic	Total
1	23	33	37	93
2	25	34	39	98
3	25	32	39	96
4.	23	33	37	93
5.	21	32	36	89
6.	21	32	35	88
Total	138	196	223	557
Average	23	32,7	37,2	92,8
Score Range	$\bar{X} > 21$	$\bar{X} > 29,4$	$\bar{X} > 33,6$	$\bar{X} > 84$
Maximum Ideal Score	25	35	40	100
Categories	Very Good	Very Good	Very Good	Very Good
Ideality Percentage	92%	93%	93%	93%

Based on the overall student response test results as presented in Table 3, ARSA can be used as independent learning resource by SMA/MA students, as it achieved an average score of 45 in the "Very Good" category with an ideal percentage of 90%. Students rated ARSA highly for the language style used and the features of the application. This is reflected in the highest ideal percentage, which is 91% for both the linguistic and product characteristic aspects.

Table 3. Overall Student Response Test Results

	Aspects			
	Linguistic	Content	Product Characteristic	Total
Total	683	883	686	2252
Average	13,7	17,7	13,7	45
Score Range	$\bar{X} > 12,6$	$\bar{X} > 16,8$	$\bar{X} > 12,6$	$\bar{X} > 42$
Maximum Ideal Score	15	20	15	50
Categories	Very Good	Very Good	Very Good	Very Good
Ideality Percentage	91%	89%	91%	90%

Discussion

ARSA was developed for the Android operating system, utilizing several software tools during its development, including Unity, CorelDraw, Vuforia Engine, Microsoft Visual Studio, and 3D Blender. The 3D animations produced by ARSA can be zoomed in, zoomed out, rotated, scrolled up, and scrolled down, making ARSA an effective tool for visualizing interactive 3D atomic models. This interactive 3D visualization is supported by supplementary materials, quizzes, usage instructions, and developer information. ARSA can also be used anytime and anywhere without an internet connection (after being downloaded from Google Playstore), making it a suitable independent learning resource for high school (SMA/MA) students.

The qualitative data obtained from expert validation tests and feasibility test, including peer reviewer and reviewer were used to improve ARSA. The results of the expert validation test served as the basis for Revision I, while the results of the reviewer feasibility test served as the basis for Revision II. Quantitative data from the reviewer feasibility test and student response test were used to analyze the product's feasibility and readability.

In the reviewer feasibility test, the highest ideality percentage was found in the aspects of content and product characteristic, both at 93%. In terms of content aspects, ARSA as a learning resource had high material accuracy, making it more effective for students to learn about atomic structure. This aligns with the research of Pathiyah (2019), which states that appropriately presented material results in more focused, effective learning and has a positive impact on curriculum objectives. In terms of product characteristic, ARSA had good alignment in design and layout. This aligns with the research of Purnomo & Ardiansyah (2018), which emphasizes that a good User Interface (UI) and User Experience (UX) can increase user convenience and comfort in operating an application. ARSA also features high-quality images, videos, audio, and 3D animations. This quality makes ARSA an informative learning resource. This is consistent with the research of Abdillah (2021), which suggests that good multimedia (including images, videos, audio, and 3D animations) can facilitate the presentation of information. The lowest ideality percentage was found in the language aspect at 92%. This indicates that ARSA still had some shortcomings, one of which is a few ineffective sentences that were difficult for users to understand. Effective sentences in learning materials are easier for readers to comprehend and convey ideas more accurately (Nadhifa et al., 2023).

Based on the results of the reviewer feasibility test, which was assessed through three aspects linguistic, content, and product characteristic an ideality percentage of 93% was achieved, falling into the "Very Good" category. This assessment indicates that ARSA, as an Android-based learning resource, is feasible for development and use. This product can assist teachers and students in the learning process because its use of AR technology makes learning more engaging, the material on atomic structure is presented comprehensively, and it can be used anytime and anywhere. Teachers can instruct students to engage in independent learning using ARSA on their respective Android devices, even outside the classroom. The widespread use of Android smartphones among students implies that teachers should facilitate the educational ecosystem with Android-based learning resources (Ismanto et al., 2017).

In the student response test, the highest ideality percentage was found in the aspects of linguistic and product characteristic, both at 91%. In terms of linguistic, ARSA already used appropriate words and effective sentences, making it easier for students to understand the material on atomic structure. This is in line with Hasanudin & Praptiningsih (2019), who stated that the selection of precise words can make sentences easier to understand. Nadhifa et al. (2023) also pointed out that effective sentences are more easily understood by readers. In terms of

product characteristic, ARSA can be used as an independent learning resource for high school (SMA/MA) students. This is due to the use of AR technology, which allows ARSA to be accessed without being limited by space and time. This is consistent with the research of Utama et al. (2023), which highlights AR as a flexible feature that can be used anytime and anywhere. The lowest ideality percentage was found in the material aspect at 89%. This indicates that some parts of the material did not align with what teachers taught in school, making it harder for students to understand. Material that aligns with what teachers present is more easily understood by students (Aisyah et al., 2020).

Based on the results of the student response test, which was assessed through three aspects including linguistic, content, and product characteristic was achieved an ideality percentage of 90%, falling into the "Very Good" category. This assessment indicates that ARSA, as an Android-based learning resource, has been tested and proven to be readable by students. Comprehensive material, simple and understandable language, and the use of AR technology make this product feasible for use. AR technology provides interactive elements that captivate students and create an engaging learning ecosystem (Kuswinardi et al., 2023).

CONCLUSION

The results of this research show that the ARSA Android-based learning resource that has been developed has the following product characteristics: interactive 3D visualization of atomic models, usability without an internet connection, and accessibility anytime and anywhere. These features make ARSA a suitable independent learning resource for high school (SMA/MA) students. The ARSA learning resource was declared feasible for use after incorporating comments/suggestions from prospective teachers as peer reviewers and chemistry teachers as reviewers. The ARSA learning resource was also deemed usable by students.

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