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DEVELOPMENT OF SCIENCE LITERACY-ORIENTED INTERACTIVE LEARNING MULTIMEDIA ON NANOTECHNOLOGY APPLICATIONS: NANOQUEST

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ABSTRACT

Abstract: This study aimed to develop, validate, and assess the feasibility of an Android-based interactive learning multimedia named *NanoQuest*, which is oriented toward science literacy in the topic of nanotechnology applications. The study employed the Design-Based Research (DBR) method and the ADDIE approach, implemented up to the development stage. The product was validated by subject matter and media experts and tested on chemistry education students. Data were obtained from validations by three expert validators and a feasibility test involving 15 chemistry education students. The validation results showed that all aspects received an average r_{score} of 0.87, indicating a high level of validity. The feasibility test yielded an average score of 87.55%, categorized as "feasible." *NanoQuest* consists of four subtopics and five contextual essay questions designed to develop science literacy components: content, process, context, and attitude. The findings indicate that *NanoQuest* is valid, feasible, and supports the enhancement of students' science literacy.

Abstrak: Penelitian ini bertujuan untuk mengembangkan dan menguji validasi serta kelayakan multimedia pembelajaran interaktif berbasis Android bernama *NanoQuest* yang berorientasi literasi sains pada materi aplikasi nanoteknologi. Penelitian ini menggunakan metode *Design-Based Research* (DBR) dan pendekatan ADDIE, yang dilaksanakan hingga tahap pengembangan. Produk divalidasi oleh ahli materi dan media serta diuji coba kepada mahasiswa Pendidikan Kimia. Data diperoleh dari validasi tiga validator ahli dan uji kelayakan terhadap 15 mahasiswa Pendidikan Kimia. Hasil validasi menunjukkan bahwa seluruh aspek memperoleh nilai rata-rata r_{hitung} sebesar 0,87 dengan interpretasi tinggi. Uji kelayakan menunjukkan rata-rata skor 87,55% dalam kategori "layak". NanoQuest terdiri dari empat subtopik materi dan lima soal kuis berbasis konteks yang dirancang untuk mengembangkan aspek literasi sains: konten, proses, konteks, dan sikap. Hasil penelitian menunjukkan bahwa NanoQuest valid, layak, dan mendukung penguatan literasi sains mahasiswa.

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INTRODUCTION

Improving scientific literacy remains a major challenge in Indonesian higher education. According to the 2022 Programme for International Student Assessment (PISA) report, Indonesia's science literacy ranking improved, but the average score declined compared to the previous assessment, indicating unresolved fundamental issues (OECD, 2023).

Scientific literacy refers to the ability to understand, communicate, and apply scientific knowledge to solve everyday problems (Ulfa et al., 2017). This skill is essential for individuals to make informed decisions on science-related issues and participate in public discourse (OECD, 2023). Scientific literacy encompasses four key aspects: content knowledge, scientific process skills, contextual application, and scientific attitudes (Pratiwi et al., 2019).

However, science literacy among Indonesian students has shown little improvement over the last two decades (Limiansih dkk., 2021). This issue is largely attributed to the limited availability of learning media capable of delivering scientific concepts in a contextual and visual manner, especially for microscopic and abstract chemistry topics.

The topic of nanotechnology applications is highly relevant for enhancing students' science literacy. It involves understanding the unique properties of materials at the nanoscale (1–100 nm), their use in healthcare and environmental fields, and their potential societal impacts (Priyo, 2017). However, due to the complexity and invisibility of particle-level changes, students often struggle to grasp real-world applications (Harso, 2015). Traditional text-based learning approaches are no longer sufficient to bridge this understanding.

Several studies have shown that interactive multimedia improves conceptual understanding, motivation, and student engagement in chemistry learning, particularly for abstract topics. Ihsan & Jannah (2021) found that blended learning-based interactive multimedia significantly

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enhances science literacy due to its ability to visualize microscopic concepts such as redox reactions.

Harahap & Siregar (2020) reported that Adobe Flash-based interactive media increases motivation and learning outcomes in chemical equilibrium topics. Similarly, Zulkarnain (2025) demonstrated the effectiveness of ChemOffice Ultra in helping students comprehend complex molecular structures. Other studies by Priyambodo et al. (2012) dan Desy (2017) concluded that web-based media enhance learner autonomy and interest in science.

Lumbantobing et al. (2023) further affirmed that interactive media significantly boosts learning motivation. In line with this, Simanjuntak & Purba (2024) developed discovery learning-based e-modules using Flip PDF Corporate Edition, showing positive impacts on student engagement and achievement in chemical bonding topics.

Despite these findings, existing literature indicates a lack of specifically developed Android-based interactive multimedia focused on science literacy in nanotechnology applications. Given its complex and abstract nature, and its relevance to health and environmental issues, nanotechnology is a promising context for enhancing students' scientific literacy.

Thus, it is necessary to develop a learning medium that not only presents nanotechnology content visually and interactively but also integrates the four aspects of science literacy. This study aims to develop, validate, and assess the feasibility of science literacy-oriented interactive multimedia titled *NanoQuest*, focusing on nanotechnology applications as a comprehensive solution to improve students' scientific literacy.

RESEARCH METHOD

This study employed a Design-Based Research (DBR) approach, emphasizing iterative development and evaluation of products in real-world settings (McKenney and Reeves, 2019). The instructional design followed the ADDIE model (Analyze, Design, Develop, Implement, Evaluate), but was limited to the development phase (Hidayat et al., 2021).

Participants included expert validators (content and media) and sixth-semester students from the Chemistry Education program at UIN Sunan Gunung Djati Bandung. The study was conducted from May 19–26, 2025,

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with the primary goal of developing and testing the feasibility of *NanoQuest* multimedia.

This research is only carried out until the development stage, Implementation, and Evaluation stages can be used as further research. The following are the stages that will be carried out:

1. Analysis Stage

The analysis stage was conducted through a needs analysis based on literature review and curriculum analysis to determine the scope of nanotechnology application content and relevant science literacy indicators. The material analyzed included the basic concepts of nanotechnology, atomic structure and its application in nanotechnology, nanotechnology applications, and the impacts of nanotechnology usage. In addition, the software tools used in the development process were identified, including Canva, PowerPoint, iSpring, and APK 2 Build, which were utilized for media design and development.

2. Design Stage

This stage involved the preparation of flowcharts and storyboards to serve as a reference for navigation flow and content visualization within the application. The media design considered logical structure, user interface (UI), and the construction of science literacy-oriented quiz questions. The product was designed using visual, interactive, and contextual approaches to foster students' critical thinking skills.

3. Development Stage

The third stage was the development phase, in which the *NanoQuest* application was developed based on the previously designed blueprint. Once the prototype was completed, it underwent validation by three expert lecturers in content and media, followed by a limited-scale feasibility test involving chemistry education students to evaluate the product's usability.

The research data consisted of both qualitative and quantitative data. Qualitative data were obtained from expert and student feedback, while quantitative data were derived from validation and feasibility assessment scores. The research instruments used consisted of two components:

a. Validation Questionnaire

This questionnaire was designed to assess the validity level of the developed multimedia. The validation instrument employed a 3-point Likert scale to evaluate various aspects, including content, comprehension, quizzes, language, visual appearance, visibility, graphic elements, and software engineering.

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The collected data were compared to the critical value of the correlation coefficient (r = 0.300). If the calculated r-value exceeded the critical threshold, the data were considered valid (Nurgiyantoro dan Gunawan, 2014). The interpretation of validation values is presented in Table 1.

Table 1. Interpretasi *of Validation Value*

Validation Value	Interpretation
0,00 ≤ *r* ≤ 0,20	Very Low
0,21 ≤ *r* ≤ 0,40	Low
0,41 ≤ *r* ≤ 0,60	Moderate
0,61 ≤ *r* ≤ 0,80	High Enough
0,81 ≤ *r* ≤ 1,00	High
0,00 ≤ *r* ≤ 0,20	Very Low

b. Feasibility Questionnaire

This questionnaire was used to evaluate the feasibility of the developed multimedia. The assessment employed a 5-point Likert scale to measure the technical quality, visual appearance, content, quizzes, and language aspects. The percentage and interpretation criteria for feasibility evaluation are outlined as follows:

Table 2. Percentage and Interpretation of Feasibility

Percentage	Interpretation
< 60	Very Unfeasible
60 – 69	Less Feasible
70 - 79	Decent Enough
80 – 89	Worth
90 -100	Very Feasible
< 60	Very Unfeasible

RESULTS AND DISCUSSION

This study produced an interactive learning multimedia product titled *NanoQuest*, which is oriented toward science literacy in the topic of nanotechnology applications. *NanoQuest* integrates the principles of interactive multimedia through a combination of text, animation, audio, video, and interactive features that allow students to directly engage with the content. This aligns with the assertions of Mayer (2005) and Shoumi (2019), who emphasize that multimedia is effective when it combines multiple elements of information presentation to enhance understanding.

NanoQuest consists of nine sections designed to support student comprehension of nanotechnology application content through a science

literacy approach. The initial interface (loading screen) and main menu (Figure 1) introduce students to a structured navigation layout. Several functional buttons are provided, such as information, competencies, material, quizzes, sound settings, and an exit button.

Figure 1. NanoQuest Home Page and Main Menu

The information section (Figure 2) includes menus directing users to the application usage instructions and developer profile.

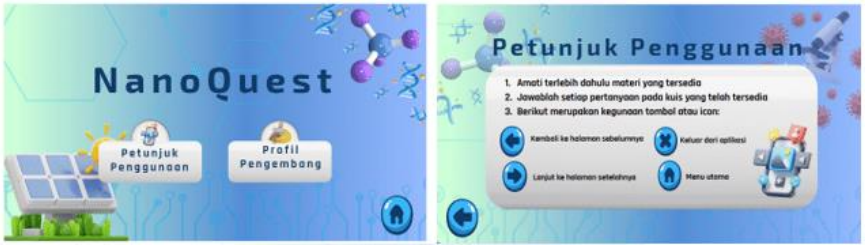

Figure 2. Information Display and Instructions for Use

Additionally, the competencies and material menu presents four main subtopics (Figure 3).

Figure 3. Competency Display and Material Menu

Subtopic 1 (Figure 4) is presented narratively and focuses on atomic structure and its application in nanotechnology. It provides students with foundational concepts regarding atomic composition and its relevance to material properties. The literacy aspects developed include content and knowledge to understand the role of electrons in determining material characteristics.

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Figure 4. Subtopic Atomic Structure and Nanotechnology Applications

Submateri 2 (Figure 5) covers the basic concepts of nanotechnology. It uses comparative animations between macro and nano-scale objects to help students visualize the nanometer scale. The content aspect emphasizes the relationship between nanotechnology and everyday life, while the knowledge aspect is developed through explanations about nanometer measurements and the importance of atomic and molecular arrangements at the nanoscale in determining material properties. This visual approach is intended to help students conceptualize the nano world, which is often difficult to grasp (Aisyah, 2021).

Figure 5. Subtopic Basic Concepts of Nanotechnology

Subtopic 3 (Figure 6) presents real-world applications of nanotechnology through educational videos that link scientific concepts to real-life products such as textiles, sunscreens, and solar panels. This presentation aims to strengthen the connection between theoretical scientific concepts and their practical applications (Agnesti & Amelia, 2020).

The literacy dimensions developed include content and knowledge where the content emphasizes direct relationships between nanotechnology and everyday products, and knowledge is built through explanations of nanoparticle structures and their functions.

Figure 6. Subtopic Nanotechnology Application

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Subtopic 4 (Figure 7) addresses the impacts of nanotechnology use, presented through animated content on the potential toxicity of nanoparticles. The content aspect in this section is not only informative but also aims to raise students' critical awareness of the possible adverse effects of widespread nanotechnology use (Wijaya et al., 2023). In terms of scientific attitude, the animation encourages students to think critically and reflectively about technological developments.

Gambar 7. Subtopic Impact of Nanotechnology

In addition to content delivery, *NanoQuest* also provides an interactive quiz consisting of five essay questions, each aligned with a dimension of scientific literacy (Figure 8).

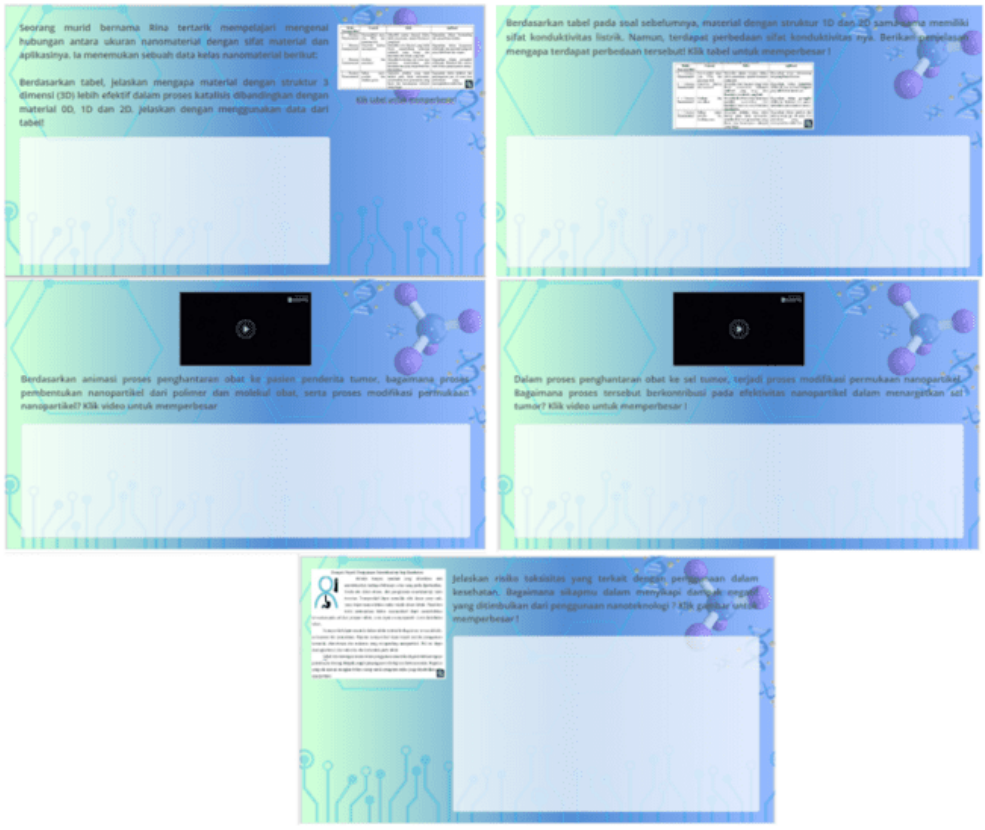

Figure 8. NanoQuest Quiz Questions

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Based on validation results by three content and media expert lecturers, aspects including content, comprehension, quizzes, language, visual appearance, visibility, graphic elements, and software engineering were assessed. All aspects achieved an average validity score (r) of 0.87, which is interpreted as high, indicating that the product meets content and technical validity standards. The overall average can be seen in Table 3.

Table 3. *Average* r $_{calculated}$ *Each* Aspect

No.	Aspect Assessed	r calculated	r critical	Results	Interpretation
1.	Material	0,8	0,3	Valid	High
2.	Understanding	0,83	0,3	Valid	High
3.	Quiz	0,9	0,3	Valid	High
4.	Linguistics	0,77	0,3	Valid	High Enough
5.	Multimedia Display	0,86	0,3	Valid	High
6.	Visibility	0,83	0,3	Valid	High
7.	Graphic Elements	1	0,3	Valid	High
8.	Software Engineering	1	0,3	Valid	High
	Average r $_{calculated}$	0,87	0,3	Valid	High

Experts provided feedback that while the material presentation was generally strong, it could be improved further by structuring the atomic structure and nanotechnology application section in a more itemized format. In terms of language and visibility, validators appreciated the readability, consistency of icons, and intuitive navigation. These findings are consistent with Azis (2021) dan Hasibuan (2019), who assert that well-designed user interfaces positively impact learning effectiveness.

The feasibility test was conducted with chemistry education students at UIN Sunan Gunung Djati Bandung who had previously studied the material. The assessed aspects included technical performance, visual design, content and quiz quality, and language use. The average scores showed that all aspects fell within the "feasible" to "highly feasible" categories, with an overall mean score of 87.55%. Detailed feasibility data are presented in Table 4.

Table 4. Total Score of Feasibility Test Results

No.	Aspect Assessed	Percentage	Description
1.	Teknis	86,22	Worth
2.	Tampilan	83,99	Worth
3.	Materi & Kuis	88,88	Worth
4.	Kebahasaan	91,1	Very Feasible
Average		87,55	Worth

NanoQuest effectively integrates the principles of science literacy and multimedia learning theory. The success of this development supports Mayer's (2005) dual-channel processing theory, in which combining text and visuals enhances conceptual understanding. Moreover, the science literacy approach used aligns with the frameworks of OECD (2023) and Brookhart (2010), which emphasize the importance of content, process, context, and attitude in science education. Therefore, *NanoQuest* is not only valid and feasible as a chemistry learning medium but also relevant for strengthening students' scientific thinking skills in understanding complex topics such as nanotechnology applications in real life.

CONCLUSIONS

The development of the interactive multimedia *NanoQuest* successfully addresses the need to overcome students' low levels of science literacy, particularly in understanding nanotechnology applications. The product is not only valid and feasible in terms of design and appearance but also proven effective in facilitating the four key dimensions of science literacy: content, competence, knowledge, and attitude. Expert validation results indicated that all assessed aspects achieved an average correlation score (r) of 0.87, categorized as high. Meanwhile, the feasibility test conducted with students yielded an average score of 87.55%, placing the product in the "feasible" category. *NanoQuest* effectively integrates visual and contextual learning principles with a science literacy approach by presenting interactive content and real-world phenomenon-based assessments. This strengthens the role of multimedia as a bridge between microscopic scientific concepts and real-life contexts, enhancing students' conceptual understanding and scientific thinking.

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