



Development of an Android-Based Digital Pop-up Book for Molecular Gastronomy Learning in Vocational Schools

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Abstract

The learning process in Basic Culinary subjects, particularly on Molecular Gastronomy material, is still limited by the use of less interactive learning media, resulting in low student engagement and learning outcomes. This study aimed to develop an Android-based Digital Pop-up Book learning media and to determine its feasibility, practicality, and effectiveness for Grade X Culinary students at SMK Mataram Semarang. The research employed a Research and Development (R&D) approach using the Four-D (4D) model, consisting of Define, Design, Develop, and Disseminate stages. The research subjects included 40 students divided into an experimental class and a control class. Data were collected through expert validation sheets, teacher and student practicality questionnaires, and pre-test and post-test instruments. The findings indicated that the developed learning media was highly feasible based on material and media expert validation, highly practical according to student responses, and effective in improving students' learning outcomes. The experimental class achieved an average N-Gain score of 55.28% (moderate category), while the control class obtained 13.58% (low category). These findings demonstrate that the Android-based Digital Pop-up Book is an effective, practical, and feasible learning medium for enhancing students' understanding of Molecular Gastronomy.

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INTRODUCTION

The rapid development of digital technology has significantly influenced the education sector, particularly in the implementation of technology-based learning media. Learning media play an essential role in facilitating the teaching and learning process by improving students' motivation, engagement, and understanding of learning materials. The integration of interactive digital media is expected to create meaningful learning experiences that support the development of students' knowledge and skills in accordance with the demands of twenty-first-century education (Abdulrahman et al., 2020; Bond et al., 2021; Haleem et al., 2022; Handoyo et al., 2025; Novaliendry et al., 2021). However, the utilization of digital learning media in vocational education remains limited, especially in subjects requiring conceptual understanding and visualization, such as Molecular Gastronomy.

Basic Culinary is one of the fundamental subjects in vocational culinary education that equips students with essential knowledge and practical competencies. One of its learning topics, Molecular Gastronomy, introduces scientific principles applied in modern culinary techniques, including spherification, gelification, foaming, emulsification, and sous vide. These concepts are relatively abstract and difficult for students to understand through conventional teaching methods or static presentation media alone (Abdulrahman et al., 2020; Mayer, 2021). Consequently, students often experience difficulties in comprehending the learning materials, resulting in low learning motivation and unsatisfactory learning outcomes. (Prihartini et al., 2021)

Previous studies have demonstrated that interactive digital learning media contribute positively to students' learning achievement. Previous studies have reported that Digital Pop-up Books can improve students' learning interest through attractive visual presentations and interactive multimedia features (Amalia & Nurharini, 2025; Ansori et al., 2024; Wahyuni et al., 2024). Likewise, previous studies have found that digital learning media provide greater

flexibility for independent learning because they can be accessed anytime and anywhere through mobile devices (Huruun'ien KI, Efendi A, 2019; Padmo et al., 2019). Furthermore, (Haleem et al., 2022; Prihartini et al., 2021). Explained that the integration of multimedia elements, including animations, videos, quizzes, and interactive navigation, significantly enhances students' participation during the learning process. Nevertheless, most previous studies focused on elementary education or general science subjects, while research investigating Android-based Digital Pop-up Books for vocational culinary education, particularly Molecular Gastronomy, remains limited.

The present study addresses this research gap by developing an Android-based Digital Pop-up Book specifically designed for the Molecular Gastronomy topic in the Basic Culinary subject for Grade X students at SMK Mataram Semarang. The developed media combines interactive illustrations, instructional videos, audio narration, learning materials, and evaluation quizzes within a single Android application, enabling students to learn independently and interactively (Wahyudianto et al., 2025). This innovation is expected to provide a more engaging learning environment while assisting teachers in delivering abstract concepts more effectively.

Therefore, this study aims to develop an Android-based Digital Pop-up Book learning media and evaluate its feasibility, practicality, and effectiveness in improving students' learning outcomes in Molecular Gastronomy. The findings of this research are expected to contribute both theoretically to the development of technology-enhanced learning media in vocational education and practically by providing an innovative instructional medium that supports effective teaching and learning in culinary vocational schools.

METHODS

This study employed a Research and Development (R&D) approach to develop an Android-based Digital Pop-up Book learning media for the Molecular Gastronomy topic in the

Basic Culinary subject. The research adopted the Four-D (4D) development model proposed, which consists of four stages: Define, Design, Develop, and Disseminate. This model was selected because it provides a systematic framework for developing educational products through needs analysis, product design, validation, revision, implementation, and dissemination.

The study was conducted at SMK Mataram Semarang during the second semester of the 2025/2026 academic year. The research subjects consisted of 40 tenth-grade Culinary students, divided into an experimental class (20 students) and a control class (20 students). The experimental class used the Android-based Digital Pop-up Book during learning activities, while the control class received instruction using the learning media commonly applied at the school. In addition, the product was validated by two material experts and two media experts, while practicality was assessed by two vocational culinary teachers and the students.

The development procedure followed the Four-D model. During the Define stage, curriculum analysis, learner characteristics, task analysis, concept analysis, and learning objective analysis were conducted to identify instructional needs related to the Molecular Gastronomy topic. The Design stage involved preparing learning materials, designing the application interface, developing storyboards, selecting multimedia components, and constructing assessment instruments. The learning media was created using Canva for graphic design, Smart Apps Creator for application development, and supporting software for editing images, videos, and audio. The resulting application included learning objectives, instructional materials, interactive illustrations, videos, narration, quizzes, navigation buttons, and user guidance.

During the Develop stage, the prototype underwent expert validation to evaluate content accuracy, instructional quality, visual appearance, navigation, and technical functionality. Suggestions provided by the validators were incorporated into product revisions before classroom implementation. The revised application was subsequently tested in the

experimental class to evaluate its practicality and effectiveness. Finally, the Disseminate stage involved introducing the finalized learning media to teachers and the school as an alternative instructional medium for Basic Culinary learning.

The research instruments consisted of interview guidelines, expert validation questionnaires, practicality questionnaires, and learning achievement tests. Expert validation instruments assessed content suitability, instructional quality, interface design, multimedia integration, and usability using a five-point Likert scale. Practicality questionnaires were completed by teachers and students after using the application. Learning effectiveness was measured using pre-test and post-test instruments administered to both experimental and control classes.

Data were analyzed using both descriptive and quantitative techniques. The feasibility and practicality of the developed media were analyzed using percentage scores calculated from the Likert-scale responses and interpreted according to predetermined feasibility criteria (Husain et al., 2025; Puspasari et al., 2025). Prior to hypothesis testing, data were examined for normality using the Shapiro–Wilk test and for homogeneity using Levene's test. The Shapiro–Wilk test was selected because it provides reliable results for small sample sizes, while Levene's test was used to assess the equality of variances before conducting parametric analyses (Mishra, 2023). The effectiveness of the developed media was determined by comparing students' pre-test and post-test scores using the N-Gain test, followed by an independent-samples t-test to examine differences in learning outcomes between the experimental and control groups at a significance level of 0.05. Statistical analyses were performed using IBM SPSS Statistics.

RESULTS AND DISCUSSION

Development of Android-Based Digital Pop-up Book Learning Media

This research produced an Android-based Digital Pop-up Book Learning Media for Molecular Gastronomy material in the Basic Culinary subject for Grade X students at SMK

Mataram Semarang. The development process employed the 4D development model (Define, Design, Develop, and Disseminate). This model was selected because it provides systematic procedures for developing educational products through structured stages according to users' needs.

The define stage was conducted through an analysis of learning needs, student characteristics, and problems encountered during the learning process of Basic Culinary subjects. The analysis results indicated that Molecular Gastronomy material has characteristics that require visualization, particularly in explaining food processing techniques and scientific processes that cannot be easily understood through theoretical explanations alone. Therefore, learning media that can present concepts through visual and interactive representations are needed.

The design stage involved designing an Android-based learning application using the concept of a digital pop-up book. The media was developed by integrating various multimedia components, including text, illustrations, animations, audio, learning videos, and interactive quizzes. The developed media consists of several main features, including the main page, usage instructions, learning objectives, Molecular Gastronomy materials, demonstration videos, learning evaluations, and developer information.



Figure 1. Display of Android-Based Digital Pop-up Book Learning Media

Based on Figure 1, the Android-based Digital Pop-up Book media was designed as an interactive learning resource that combines visual and digital elements. The integration of illustrations, videos, and interactive features supports students in understanding Molecular

Gastronomy concepts, particularly materials involving complex processes and procedures.

The develop stage was conducted through the development of the initial product, expert validation, and product revision. Validation was performed by material experts and media experts to ensure that the developed media met the criteria of content quality, presentation, interface design, and learning functionality. Suggestions from validators were used as a basis for improving the product before implementation.

The disseminate stage was carried out by implementing the developed media among Grade X Culinary students at SMK Mataram Semarang. This stage aimed to determine the practicality and effectiveness of the developed media in supporting the learning process.

The development of digital multimedia-based learning media demonstrates that technology integration can provide solutions for improving vocational learning quality. (Prihartini et al., 2021). Similar findings were reported by (Handoyo et al., 2025), who concluded that Android-based learning significantly improves vocational students' learning outcomes, learning motivation, and work readiness. reported that interactive multimedia development in vocational schools can produce valid, practical, and effective learning media to support students' learning outcomes. This indicates that multimedia-based learning is appropriate for vocational education, where students require both conceptual understanding and procedural skills.

Furthermore, the use of Android applications provides flexibility for students to access learning resources. Digital technology utilization in vocational education plays an important role in supporting adaptive learning environments because students can access digital learning resources independently (Habibi et al., 2023). Mobile learning environments also encourage self-directed learning and increase learner engagement because educational resources remain accessible beyond classroom settings (Huruun'ien KI , Efendi A, 2019)

Therefore, the development of Android-based Digital Pop-up Book media contributes to educational technology by providing an innovative learning resource that combines the

pop-up book concept with digital application technology. This media can serve as an alternative learning resource for vocational materials requiring visualization, demonstrations, and simulations.

Feasibility of Android-Based Digital Pop-up Book Learning Media

The feasibility test was conducted to determine whether the developed media met the criteria for use in learning activities. The assessment was carried out by material experts and media experts based on content quality, presentation, interface design, navigation, and media functionality.

Table 1. Feasibility Validation Results of Android-Based Digital Pop-up Book Learning Media

Validator	Percentage	Category
Material Expert	87%	Very Feasible
Media Expert	85%	Very Feasible

The validation results indicate that the developed media fulfilled the feasibility criteria as a learning medium. This finding demonstrates that the learning content, presentation structure, and interface design were appropriate for supporting the learning objectives of Molecular Gastronomy.

The feasibility of learning media is an essential aspect because educational media should not only have an attractive appearance but also effectively support students in achieving learning competencies. (Arsyad 2019) stated that effective learning media should clarify learning messages, attract students' attention, and support the achievement of learning objectives.

The findings of this study indicate that Android-based digital media can overcome limitations in delivering Molecular Gastronomy materials. Through visual and multimedia presentations, students can obtain clearer representations of concepts and food processing techniques that are difficult to observe directly.

Practicality of Android-Based Digital Pop-up Book Learning Media

The practicality test was conducted to determine the ease of use of the developed media based on teacher and student responses after implementation in the learning process.

Table 2. Practicality Test Results of Learning Media

No	Aspek	Average	Deskription
1	Format	93%	Highly practical
2	Relevance	89%	Highly practical
3	Interest	92%	Highly practical
4	Satisfaction	87%	Highly practical
5	Confidence	93%	Highly practical
Overall Average		91%	Highly practical

The practicality results indicate that the developed media can be easily used in learning activities. This practicality is supported by the simple interface design, clear navigation system, and learning features that are appropriate for students' needs.

Practicality is an important aspect of educational product development because a valid product must also be applicable in real learning situations. (Nieveen 1999) explained that a developed product can be considered practical when it is easy to use and suitable for actual educational contexts.

The use of Android-based media also provides advantages because students can access learning materials more flexibly. The media can be used not only during classroom activities but also as an independent learning resource outside the classroom.

The findings suggest that Android-based Digital Pop-up Book media has potential applications in other vocational learning contexts, particularly subjects requiring conceptual visualization and procedural understanding.

1. Effectiveness of Android-Based Digital Pop-up Book Learning Media

The effectiveness test was conducted to determine the impact of using Android-based

Digital Pop-up Book media on students' learning outcomes. The analysis was carried out by comparing the learning outcomes of the experimental and control classes through pre-test, post-test, and N-Gain analysis.

Table 3. Comparison of Students' Learning Outcomes

Class	Pre-test	Post-test
Experimental Class	56.80	82.60
Control Class	56.60	64.80

Table 4. N-Gain Test Results

Class	N-Gain Score	Category
Experimental Class	55.28%	Moderate
Control Class	13.58%	Low

The results indicate that the implementation of Android-based Digital Pop-up Book learning media contributed positively to students' learning improvement. The difference in learning improvement between the experimental and control classes demonstrates that interactive digital media provides better support for students' understanding of Molecular Gastronomy materials.

The effectiveness of the media can be explained by the integration of various multimedia elements, including visual illustrations, instructional videos, textual explanations, and interactive evaluations. These elements provide students with multiple learning representations, allowing them to construct knowledge more effectively. The use of interactive multimedia in learning has been shown to improve students' engagement, motivation, and understanding because digital media enables learners to actively interact with learning content rather than only receive information (Haleem et al., 2022).

Furthermore, the utilization of technology-based learning media supports a more flexible and student-centered learning environment. Digital learning resources that combine visual, audio, and interactive components can improve learning experiences by providing opportunities for students to explore materials independently and receive immediate feedback during the learning process (Bond et al., 2021). Therefore, the

interactive features in the Android-based Digital Pop-up Book, such as learning videos and quizzes, contribute to creating a more meaningful learning experience.

The findings of this study are also consistent with recent research emphasizing that digital learning media plays an important role in vocational education because students require learning resources that can visualize practical processes and support skill development. The integration of digital technology in vocational learning can enhance students' learning experiences by connecting theoretical knowledge with practical applications (Mishra et al., 2023).

Overall, this research contributes to the field of educational technology, particularly vocational education, by developing an Android-based learning medium that integrates digital technology with interactive learning principles. The developed media provides an innovative solution for learning materials that require visualization of processes and procedures, especially in culinary education.

Furthermore, the developed Digital Pop-up Book media has the potential to be adapted for other vocational subjects with similar characteristics, particularly subjects that require demonstrations, simulations, and procedural understanding.

CONCLUSION

This study concludes that the development of an Android-based Digital Pop-up Book for the *Molecular Gastronomy* topic in the Basic Culinary subject successfully produced a learning medium that is feasible, practical, and effective in supporting the learning process in accordance with the research objectives. The developed media addresses the limitations of conventional instruction by presenting learning materials in an interactive, visual, and easily accessible format, thereby enhancing students' understanding, engagement, and learning outcomes, particularly for abstract concepts. The findings indicate that integrating digital technology with the Digital Pop-up Book concept offers an innovative alternative for vocational learning media, especially for subjects requiring the visualization

of processes and procedures. These findings strengthen previous evidence that Android-based interactive multimedia is capable of creating more flexible, student-centered, and technology-supported vocational learning environments (Handoyo et al., 2025; Novaliendry et al., 2021). This study contributes to the advancement of educational technology by developing an Android-based learning medium that integrates interactive multimedia principles with the characteristics of vocational education, thereby enriching the body of knowledge on technology-enhanced learning and providing a valuable reference for the development of digital learning media in other voc.

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