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Development of interactive virtual book media on anemia prevention in female adolescents in junior high school

Pengembangan Media Interactive Virtual Book Mengenai Pencegahan Anemia pada Remaja Putri Sekolah Menengah Pertama

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ABSTRACT

Background: *Anemia remains a significant public health problem among adolescent girls and can negatively affect learning ability, concentration, and productivity. The rapid advancement of digital technology highlights the need for innovative and engaging educational media to improve anemia prevention efforts. However, limited studies have focused on developing interactive digital learning tools tailored to adolescent needs.*
Objective: *This study aimed to develop an interactive virtual book as a digital educational media for anemia prevention among adolescent girls.*
Methods: *This study used a Research and Development (R&D) approach with the 4D model, consisting of define, design, and develop stages. The define stage included needs analysis through interviews and literature review. The design stage involved creating storyboards, navigation structures, and interface designs. The development stage included media production, expert validation, and limited user testing. The study participants were 30 seventh-grade female students of SMPN 26 Bandung selected using purposive sampling. Data were collected through validation sheets and questionnaires, and analyzed descriptively.*
Results: *The validation results showed that the media achieved a feasibility score of 100% from the material expert and 85% from the media expert, both categorized as highly feasible. The limited trial showed an average score of 75.58% across aspects of comprehension, usability, attractiveness, motivation, and learning interest, indicating that the media is feasible for use.*
Conclusion: *The interactive virtual book developed in this study meets feasibility standards and is appropriate as a digital educational medium for anemia prevention among adolescent girls, with potential to enhance engagement and learning outcomes.*

Keywords*: anemia, adolescent, education, interactive media, virtual book*

ABSTRAK

Latar Belakang: Anemia masih menjadi masalah kesehatan masyarakat yang umum pada remaja putri dan dapat berdampak negatif terhadap kemampuan belajar, konsentrasi, serta produktivitas. Perkembangan teknologi digital yang pesat menuntut adanya media edukasi yang inovatif dan menarik untuk mendukung upaya pencegahan anemia. Namun, masih terbatas penelitian yang mengembangkan media pembelajaran digital interaktif yang sesuai dengan kebutuhan remaja.
Tujuan: Penelitian ini bertujuan untuk mengembangkan media pembelajaran digital berupa buku virtual interaktif sebagai sarana edukasi pencegahan anemia pada remaja putri.
Metode: Penelitian ini menggunakan metode Research and Development (R&D) dengan model 4D yang meliputi tahap define, design, dan develop. Tahap define dilakukan melalui analisis kebutuhan dengan wawancara dan studi literatur. Tahap design meliputi pembuatan storyboard, struktur navigasi, dan desain antarmuka. Tahap

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develop mencakup produksi media, validasi oleh ahli materi dan ahli media, serta uji coba terbatas. Subjek penelitian adalah 30 siswi kelas VII SMPN 26 Bandung yang dipilih dengan teknik purposive sampling. Pengumpulan data menggunakan lembar validasi dan kuesioner, kemudian dianalisis secara deskriptif.
Hasil: Hasil validasi menunjukkan bahwa media memperoleh skor kelayakan sebesar 100% dari ahli materi dan 85% dari ahli media, yang keduanya termasuk dalam kategori sangat layak. Hasil uji coba terbatas menunjukkan nilai rata-rata sebesar 75,58% pada aspek pemahaman materi, kemudahan penggunaan, daya tarik visual, motivasi, dan minat belajar, yang termasuk dalam kategori layak.
Kesimpulan: Buku virtual interaktif yang dikembangkan memenuhi kriteria kelayakan dan dapat digunakan sebagai media edukasi digital untuk pencegahan anemia pada remaja putri serta berpotensi meningkatkan keterlibatan dan hasil belajar.

Kata kunci: anemia, remaja putri, edukasi, media interaktif, buku virtual

INTRODUCTION

Anemia remains a significant public health problem in Indonesia, particularly among adolescent girls who are in a period of rapid growth and experience physiological changes due to menstruation. This condition increases iron requirements, making adolescent girls more susceptible to decreased hemoglobin levels. National data indicate that the prevalence of anemia among adolescent girls is still relatively high, with approximately one-third of this population experiencing hemoglobin deficiency. This situation highlights that anemia is not merely an individual clinical issue, but also a broader public health concern that may affect the quality of future generations.[1]

Anemia in adolescents has multidimensional impacts, including physical health, cognitive capacity, and academic performance. Reduced hemoglobin levels lead to decreased oxygen supply to body tissues and the brain, resulting in chronic fatigue, impaired concentration, and reduced learning focus.[2,3,4] Furthermore, iron deficiency as the primary cause of anemia affects brain metabolism, neurotransmitter function, and myelination processes, which may have long-term consequences on memory and critical thinking abilities.[5,6,7] This condition is also associated with a lower quality of life due to limited physical activity and psychological well-being among adolescent girls.[8] Therefore, anemia should not only be viewed as a medical condition but also as a strategic issue in human resource development and education.

Promotive and preventive efforts focusing on improving adolescents' knowledge and health literacy are essential strategies in anemia prevention. Effective health education should not only emphasize information delivery but also aim to foster attitudes and sustainable behavioral changes. In this context, participatory, contextual, and adolescent-centered educational approaches are crucial to ensure the effectiveness of health promotion interventions.[9,10]

With the rapid advancement of information technology, the use of digital media as an educational tool has become increasingly relevant and promising. Digital media offer flexibility in information delivery and enable interactive, multimodal learning through the integration of text, audio, and visual elements. Previous studies have demonstrated that digital-based learning can enhance student engagement, conceptual understanding, and information retention compared to conventional methods.[11] Moreover, the familiarity of adolescents with digital technology makes it a more adaptive and effective medium for health education.

The use of interactive digital media has been shown to significantly improve adolescents' knowledge and learning motivation. Interactivity allows learners to actively participate in the learning process, promoting deeper and more meaningful understanding.[12,13] Previous research reported an 11% increase in knowledge among

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adolescents after receiving anemia prevention education through interactive digital media.[5] However, most existing educational media remain partial and have not yet fully integrated various interactive learning components into a comprehensive platform.

Based on these considerations, there is a research gap in the development of digital educational media that are not only interactive but also integrated, contextual, and tailored to adolescents' learning needs. One potential innovation to address this gap is the *interactive virtual book*, a digital learning medium that combines text, images, animations, videos, and interactive features within a single learning platform. This medium facilitates active learning by encouraging participation, exploration, and reflection among learners. [11]

Therefore, the development of a digital learning media based on an *interactive virtual book* is a strategic approach to support anemia prevention education among adolescent girls. This study aims to develop a feasible, engaging, and effective digital learning media as a sustainable educational tool for anemia prevention in educational settings.

METHODS

Study design

This study employed a Research and Development (R&D) method using the 4D development model proposed by Thiagarajan, Semmel, and Semmel (1974), which consists of four main stages: Define, Design, Develop, and Disseminate. However, in this study, the development process was limited to the development stage. This limitation was applied because the study focused on producing a valid and feasible digital educational media product rather than evaluating its effectiveness or conducting large-scale dissemination. Therefore, restricting the process to the Develop stage was considered appropriate to ensure that the developed product met feasibility standards prior to further implementation. The Disseminate stage is planned as a follow-up study.[15]

Data source and sampling procedure

The study participants were seventh-grade female students at SMPN 26 Bandung, aged 13–14 years. A total of 30 participants were selected using purposive sampling based on inclusion criteria, namely students who were willing to participate in the study and had basic skills in operating digital devices.[14]

Variables of the study

The main variable in this study was the feasibility of the interactive virtual book as a digital educational media. The feasibility was assessed based on several aspects, including content quality, media design, usability, comprehension, attractiveness, and user engagement.

Data collection

Data collection was conducted through several stages following the 4D development model. The Define stage involved needs analysis and problem identification through interviews with female students as respondents and a literature review. The Design stage included the development of a storyboard, navigation structure, and interface design, as well as educational content covering the definition of anemia, causes, signs and symptoms, impacts, and prevention strategies. The development stage involved the production of the interactive virtual book prototype, followed by validation by experts and limited user testing.

Measurement and instruments

The research instrument consisted of a feasibility questionnaire administered to both experts and users. Validation was conducted by a material expert and a media expert who assessed content, design, and usability aspects. A four-point Likert scale was used: 1 (not feasible), 2 (less feasible), 3 (feasible), and 4 (highly feasible). The feasibility score

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was calculated as a percentage by comparing the obtained score to the maximum possible score multiplied by 100%.

Ethical considerations

Ethical approval for this study was obtained from the Health Research Ethics Committee (KEPK) of the Health Polytechnic of the Ministry of Health Yogyakarta under number DP.04.03/e-KEPK.2/1052/2025 dated August 13, 2025. Permission was also obtained from SMPN 26 Bandung and a recommendation from the Bandung City Government through Kesbangpol (No. PK.03.04.05/1899-BKBP/IX/2025). All procedures were conducted in accordance with ethical principles of health research, including beneficence, non-maleficence, autonomy, and justice.

Data analysis

Data were analyzed using descriptive quantitative analysis to determine the feasibility level of the developed media. The results were interpreted using the following criteria: 81–100% (highly feasible), 61–80% (feasible), 41–60% (moderately feasible), and ≤40% (not feasible). In addition, qualitative data in the form of comments and suggestions from experts and users were analyzed descriptively to support product improvement.

RESULTS

This study resulted in the development of an interactive virtual book as a digital educational medium for anemia prevention among adolescent girls. The product was developed using the Research and Development (R&D) method with a 4D model limited to three stages (3D), namely Define, Design, and Develop.

At the define stage, a needs analysis was conducted through interviews and preliminary observations involving adolescent girls and the learning environment. The findings revealed that participants had a limited understanding of anemia, including its basic concepts, causes, impacts, and prevention. Existing learning media were predominantly conventional, less interactive, and had not optimally utilized digital technology. Therefore, the development of this media aims to adapt to the learning styles of modern adolescents (digital natives), who require more interactive, visual, and flexible access to information in line with the advancement of the digital era.

At the design stage, the interactive virtual book was systematically developed as a structured digital learning system. This stage included storyboard preparation, navigation design, usage flowchart development, and page layout structuring. The content encompassed anemia definition, causes, symptoms, impacts, and prevention strategies. The integration of concise text, visual illustrations, interactive navigation, video, and audio was intended to enhance user engagement and improve comprehension, particularly in accordance with the learning preferences of adolescent girls.[11]

At the development stage, this study produced a prototype of an interactive virtual book developed through a structured and iterative process. The development began with refining the content designed in the previous stage, emphasizing a coherent flow of information and alignment with user needs. At this stage, multimedia elements were also carefully planned to enhance the clarity and contextual relevance of the material.

The prepared content was then transformed into a visual format using Canva. This process involved adjusting layout composition, selecting appropriate color schemes, determining suitable typography, and designing infographics to ensure that the material was not only informative but also visually engaging. Such an approach was intended to increase user engagement, particularly among adolescent girls as the primary target audience.

The finalized design was subsequently converted into an interactive digital book using the Heyzine Flipbook platform. This platform was selected due to its capability to

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incorporate interactive features, including page-flip effects, embedded video and audio, and interactive links, which collectively provide a more dynamic learning experience.

The developed prototype was then subjected to expert validation involving both content and media specialists. The evaluation focused on content relevance, presentation quality, as well as visual and interactive aspects of the media. A Likert-scale-based instrument was employed, and the feedback obtained served as the basis for further refinement.

Following the revision process, the media was tested with the target users to assess its attractiveness, usability, and level of comprehension. The results of this user testing were used to evaluate the effectiveness of the developed media as a digital-based health education tool.

Table 1. Feasibility Assessment by Material Experts

Aspects	Percentage	Category
Concept Accuracy	100%	Highly Feasible
Alignment With Learning Objectives	100%	Highly Feasible
Content Completeness	100%	Highly Feasible
Information Accuracy	100%	Highly Feasible
Language Clarity	100%	Highly Feasible

The findings confirm that the developed media meet academic feasibility standards, demonstrating strong conceptual accuracy, clear alignment with learning objectives, and effective information delivery. Additionally, the media expert evaluation resulted in a feasibility score of 85%, reinforcing the classification of the media as highly feasible and suitable for practical application.

Table 2. Feasibility Assessment by Media Experts

Aspects	Percentage	Category
Visual appearance	85%	Highly feasible
Layout design	85%	Highly feasible
Interactive navigation	90%	Highly feasible
Multimedia quality (audio & video)	80%	Feasible
Suitability for adolescents	85%	Highly feasible

Table 2 shows that the developed media is considered technically and visually feasible. The results indicate that the media has an effective visual design, user-friendly navigation, and is well aligned with the characteristics of adolescent users. A limited trial was conducted involving 30 adolescent girls from SMPN 26 Bandung as end users of the media.

Table 3. User Trial Results of Interactive Virtual Book

Assessment Category	Mean Percentage	Category
Material comprehension	74.83%	Feasible
Usability	73.89%	Feasible
Visual attractiveness	77.50%	Feasible
Learning motivation	78.05%	Highly feasible

Table 3 shows that the interactive virtual book achieved an overall feasibility score of 75.58%, which falls into the feasible category. These findings indicate that the media meet the standards of digital learning media in terms of content comprehension, usability, visual quality, and learning attractiveness.

Overall, the results demonstrate that the developed interactive virtual book for anemia prevention is both pedagogically and technically feasible. Therefore, it can be effectively utilized as a health education medium for adolescent girls in school-based learning and

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health promotion settings. The interactive virtual book can be accessed through the following link: https://s.kemkes.go.id/anemiabook.

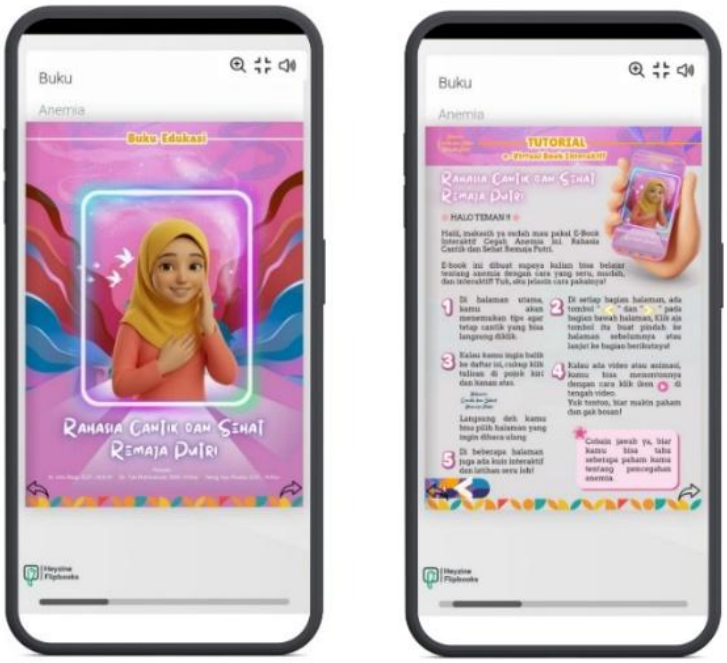

Figure 1. Interactive Virtual Book

DISCUSSION

Define

The findings of this study indicate that the limited understanding of anemia among adolescent girls is not merely due to insufficient information, but is more closely related to the mismatch between learner characteristics and the instructional approaches applied. Conventional one-way learning media tend to position students as passive recipients, resulting in shallow and unsustainable knowledge construction. This suggests that the effectiveness of learning is not only determined by the availability of information, but also by how the information is delivered and internalized by learners.

From a pedagogical perspective, this condition reflects a learning mismatch, where adolescents' learning preferences—characterized by visual, interactive, and digital orientations—are not aligned with traditional text-based and monologic teaching strategies. This finding is consistent with Nurcahyanti (2020), who reported that low adolescent health literacy is associated with passive educational models.[16] Furthermore, Fajari Z (2021) demonstrated that conventional approaches are less effective in fostering student engagement.[17] In this context, the need for interactive digital learning media becomes pedagogically significant, not merely as a response to technological advancement but as an effort to enhance cognitive, affective, and motivational engagement simultaneously. This argument is further supported by Milwati S (2019), who emphasized that needs analysis is a fundamental step in digital media development to ensure alignment with learner characteristics and learning contexts.[18] Therefore, the define stage in this study serves not only as a problem identification phase but also as a methodological foundation that justifies the development of the interactive virtual book.[19]

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Design

At the design stage, the interactive virtual book was developed not simply as a learning product but as a digital learning system that integrates content structure, instructional strategies, and user learning experience. The combination of concise text, visual elements, audio, video, and interactive navigation creates a multisensory and participatory learning environment.[20] This approach reflects a shift from content delivery to learning experience design, where learning is oriented toward meaningful engagement rather than mere information transmission.

Theoretically, this design aligns with constructivist learning principles, which emphasize the active role of learners in constructing knowledge. The findings are in line with Milwati (2019), who found that interactive e-books effectively support independent multimedia-based learning.[18] Additionally, Nurcahyanti (2020) highlighted that interactivity is a key determinant of effectiveness in digital health education.[16] Thus, the design stage contributes not only to the structural development of the media but also to the establishment of a learning framework that facilitates active and meaningful learning processes.[21]

Development

The development stage demonstrates that the quality of the developed media meets both academic and technical feasibility standards. The material expert validation result of 100% indicates that the content is academically sound and aligned with learning objectives, while the media expert validation score of 85% confirms that the visual design, navigation, and interactivity meet usability and user experience principles.[22]

The user trial results, with a feasibility score of 75.58%, indicate that the media is well accepted by the target users. However, this also suggests that further improvements are needed, particularly in terms of usability and design optimization. Analytically, the combination of expert validation and user feedback shows that the media is not only feasible but also has the potential to effectively enhance learning engagement.

The interaction between users and the media reflects the emergence of self-directed learning, where learners actively manage their own learning processes. This finding is consistent with Sari (2021), who reported that multimedia-based health education improves knowledge and promotes preventive attitudes among adolescents.[23] In addition, Putri (2020) found that animation- and video-based media can increase learning motivation due to their engaging and accessible presentation.5 Similarly, Rahmawati (2022) demonstrated that interactive digital media enhances student participation and learning interest.[24]

More broadly, the findings highlight that the effectiveness of digital learning media is not solely determined by visual or technical aspects, but by the integration of content, instructional design, and user experience. Well-designed media can create a more meaningful learning experience compared to conventional approaches. This is supported by Hidayat (2021), who found that interactive learning media significantly improve learning experience and user engagement.[25]

In terms of implications, this study provides both practical and theoretical contributions. Practically, the findings can serve as a basis for developing digital health education media that are more adaptive to adolescent characteristics. Theoretically, this study reinforces the importance of a needs-based approach and learning experience design in the development of digital learning media.[14]

However, several limitations should be acknowledged. This study was limited to the development stage and did not include large-scale dissemination. The sample size in the user trial was relatively small, which may limit the generalizability of the findings.

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Additionally, the study focused primarily on feasibility, and the long-term impact on health behavior change was not assessed.

Therefore, future research is recommended to conduct experimental studies to evaluate effectiveness, involve larger sample sizes, and examine long-term impacts on adolescent health behavior. Further development of adaptive and user-centered interactive features is also suggested to enhance the overall learning experience.

CONCLUSION

This study successfully developed a digital learning medium in the form of an interactive virtual book for anemia prevention among adolescent girls using the Research and Development (R&D) method with the 4D model up to the Develop stage. The developed media met feasibility criteria based on evaluations by material and media experts in terms of content quality, visual design, and usability. The results of the limited user trial indicated positive responses from the target users, demonstrating that the media is feasible as a digital educational tool. Therefore, the interactive virtual book has strong potential as an innovative promotive and preventive medium for anemia prevention among adolescent girls in school settings.

Future research is recommended to proceed to the Disseminate stage by conducting experimental studies to evaluate the effectiveness of the media, thereby strengthening its scientific and practical contributions.

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