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Development of IT-Based Card Media on the Digestive System Topic to Improve Students' Critical Thinking Skills and Learning Activities

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A B S T R A C T

Integrated Science and Social Studies (IPAS) learning in primary education aims to prepare students to face future challenges through active learning activities. Critical thinking skills play a crucial role in enabling students to evaluate ideas and actively engage in the learning process. This study aimed to develop IT-based card media for digestive system material that is valid, practical, and effective in improving students' critical thinking skills and learning activities. The research employed a Research and Development approach using the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages. The participants were 19 fifth-grade students of Pandeanlamper 02 Elementary School, Semarang, selected through purposive sampling. The results of expert validation by media experts, material experts, and practitioners indicated that the developed media met the criteria of very valid. Furthermore, the implementation of the IT-based card media showed an improvement in students' critical thinking skills and learning activities after its use. Overall, these findings suggest that IT-based card media is feasible and effective as a learning medium to support the development of critical thinking skills and active learning in primary education.

1. Introduction

Education is a conscious and planned effort to create a meaningful learning environment and learning process for students (Umam, 2021). Meaningful education is not merely oriented toward the transfer of knowledge, but also toward the development of skills that enable students to adapt to their environment and generate solutions to future problems (Alimuddin et al., 2023; Prasetiyo, 2021). In the context of rapid technological advancement, critical thinking skills have emerged as one of the core competencies that must be systematically fostered

through the educational process (Hanipah, 2023; Mardhiyah et al., 2021). The integration of technology in education has become increasingly essential to prepare students for the demands of modern learning environments and to equip them with the necessary skills to navigate complex information landscapes (Mulyadi, 2020; Rustandi, 2021).

Critical thinking skills refer to an individual's ability to process, analyze, and evaluate information objectively in order to make reasoned decisions and draw rational conclusions (Purwanti, 2016; Ariadila et al., 2023; Yosiana, 2021). These skills are essential for enabling students to cope with the complexity of 21st-century challenges and to actively participate in academic and social life (Yusuf, 2023). Critical thinking empowers students to become independent learners who can critically evaluate information sources, distinguish between facts and opinions, and construct well-reasoned arguments based on evidence (Dewi & Zuhdi, 2023). Nevertheless, various studies have reported that students' critical thinking skills in Indonesia remain relatively low and require structured and innovative improvement efforts (Yuningsih & Ansori, 2025; Atmojo, 2022). Furthermore, the development of critical thinking skills necessitates the implementation of learning media that encourage active engagement, problem-solving, and reflective thinking practices (Rendra, 2018).

The low level of critical thinking skills is closely associated with students' learning activities, which have not yet developed optimally. Science learning outcomes in Indonesia continue to show relatively low performance, as reflected in the Programme for International Student Assessment (PISA) results (Zahro et al., 2024). A preliminary study conducted at SD Negeri Pandeanlamper 02 Semarang further revealed that students' critical thinking skills were categorized as low, with an average score of 58.02, and that classroom learning activities tended to be passive and teacher-centered. This teacher-centered approach limits students' opportunities to engage in inquiry-based learning, collaborative discussions, and hands-on exploration, all of which are critical components for developing higher-order thinking skills (Pada et al., 2018). The passive learning environment also reduces students' motivation and curiosity, which are fundamental drivers of meaningful learning experiences (Siregar et al., 2020; Hartati et al., 2025).

One contributing factor to this condition is the limited utilization of innovative and interactive learning media. Learning media play a crucial role in visualizing abstract concepts, increasing learning motivation, and encouraging active student engagement (Nisa et al., 2025; Saputri et al., 2022). However, previous studies indicate that learning media used in elementary schools predominantly focus on content delivery and knowledge acquisition, with limited emphasis on fostering higher-order thinking skills and active learning participation (Ali et al., 2025). The conventional teaching materials often fail to accommodate diverse learning styles and do not provide sufficient opportunities for students to engage in interactive and exploratory learning activities (Winatha, 2019; Hasibuan et al., 2025). Additionally, the lack of technology integration in traditional learning media prevents students from accessing rich, multimodal learning resources that could enhance their understanding and retention of complex scientific concepts (Yulaika, 2020).

Moreover, existing research on technology-based learning media has generally examined their effectiveness in improving learning outcomes, while relatively few studies have explicitly addressed their role in simultaneously enhancing critical thinking skills and learning activities in integrated IPAS learning at the primary education level.

Information technology (IT)-based learning media offer opportunities to create more interactive, flexible, and student-centered learning environments (Jayanti et al., 2023; Maulid et al., 2024). The integration of technology supports personalized learning experiences and promotes collaboration and communication between teachers and students (Widyawati & Sukadari, 2023). Technology-based learning media enable students to access learning materials anytime and anywhere, facilitating self-paced learning and repeated practice until mastery is achieved (Meliawati, 2020; Khusnunnisa & Andriani, 2025). Moreover, digital learning environments provide immediate feedback mechanisms that help students identify their strengths and areas for improvement, thereby supporting metacognitive skill development (Rohman, 2020). One form of IT-based learning media with strong potential for elementary education is QR Code–based card media.

QR Codes represent an advancement in barcode technology that enables rapid and efficient access to digital information through smart devices (Widayanti, 2017; Wulandari & Sayekti, 2022). In educational contexts, QR Codes can connect students to various digital learning resources, such as instructional videos, interactive materials, and exploratory tasks (Meliawati, 2020; Rohman, 2020). The use of QR Code technology in learning media bridges the gap between physical and digital learning resources, creating a seamless learning experience that engages students through multiple sensory channels (Ningsih, 2023; Munawarah, 2025). QR Code-based media also promote student autonomy by allowing learners to explore content at their own pace and revisit challenging concepts as needed (Sianipar et al., 2023). Although several studies have reported that QR Code–based learning media can support student engagement and critical thinking development (Wulandari & Sayekti, 2022; Ningsih, 2023; Sianipar et al., 2023), these studies have not specifically focused on the development and validation of QR Code–based card media tailored to IPAS digestive system content at the elementary school level. Recent studies have shown promising results in applying QR Code technology across various subject areas, yet comprehensive research specifically addressing its integration with card-based learning media for science education remains limited (Zahro et al., 2024; Rosiana et al., 2023).

Based on interviews with teachers and students at SD Negeri Pandeanlamper 02 Semarang, it was found that QR Code–based card media had never been developed or implemented in the learning process, while students expressed a need for more engaging and interactive learning media to support their understanding of the material. Teachers also indicated that they lacked access to ready-to-use digital learning resources that could effectively facilitate active learning and critical thinking development in science classrooms. Students specifically mentioned their difficulty in understanding abstract concepts related to the digestive system due to the lack of visual and interactive learning aids (Widayanti, 2017; Yosiana, 2021).

Additionally, the absence of technology-integrated learning media in the classroom prevented students from experiencing the benefits of multimodal learning approaches that have been shown to enhance comprehension and retention (Umam, 2021; Masrukhin et al., 2024).

Therefore, this study aims to develop and validate IT-based QR Code card media for digestive system material that is valid, practical, and effective in improving students' critical thinking skills and learning activities in elementary school IPAS learning. By addressing the limitations of previous studies, this research is expected to contribute to the development of innovative learning media that integrates technology, active learning, and critical thinking enhancement in primary education. Specifically, this study seeks to: (1) develop QR Code-based card media for digestive system material that meets validity criteria based on expert assessment; (2) assess the practicality of the developed media through teacher and student responses; and (3) evaluate the effectiveness of the media in improving students' critical thinking skills and learning activities in IPAS learning at the elementary school level.

2. Methodology

Research Design

This study employed a research and development (R&D) approach using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation (Saputri et al., 2022; Dewi et al., 2024). The R&D approach is defined as a systematic process for developing educational products and testing their effectiveness in real learning contexts (Rustandi, 2021; Muti'ah et al., 2024). The ADDIE model was selected because of its structured, systematic, and flexible framework, making it suitable for instructional media development (Rendra, 2018; Winatha, 2019). This model provides clear procedural steps that facilitate iterative refinement of the learning media based on feedback from experts and users, ensuring that the final product meets both pedagogical and technical quality standards. The cyclical nature of the ADDIE model also allows for continuous improvement throughout the development process, which is essential for creating effective technology-integrated learning materials.

Research Setting and Participants

The study was conducted at SD Negeri Pandeanlamper 02 Semarang over a three-month period, from July to September 2025. The research participants consisted of 19 fifth-grade students selected through purposive sampling based on preliminary findings indicating low levels of critical thinking skills and learning activities. This sampling technique was considered appropriate because the class met the specific characteristics required for the study. The selection criteria included students who had demonstrated limited engagement in science learning activities and scored below the average threshold in preliminary assessments of critical thinking abilities. The relatively small sample size was appropriate for developmental research

focused on in-depth qualitative insights and detailed observation of learning processes during the implementation of innovative instructional media.

Development Procedures

The development process followed the five stages of the ADDIE model. During the analysis stage, performance and needs analyses were conducted through interviews with the fifth-grade teacher and classroom observations to identify learning problems and student characteristics. The findings revealed that IPAS learning had not yet integrated technology-based instructional media and relied primarily on textbooks and worksheets. Analysis of student performance data indicated that students struggled particularly with understanding the digestive system's complex processes and structures, which required more visual and interactive learning support. Additionally, the analysis identified gaps between the learning objectives outlined in the curriculum and the instructional strategies currently employed in the classroom**.**

At the design stage, the structure and content of the QR Code-based card media were planned by aligning learning materials with learning outcomes and instructional objectives. Research instruments, including pretest–posttest questions and validation instruments, were also prepared to support data collection. The card design incorporated visual representations of the digestive system organs, supported by QR codes that linked to supplementary digital resources such as animated videos, interactive diagrams, and exploratory activities. The instructional sequence was designed to promote progressive skill development, starting from basic comprehension and advancing toward higher-order thinking tasks such as analysis, evaluation, and problem-solving related to digestive health.

The development stage involved creating QR Code–based card media using the Canva application. The developed media were validated by a media expert, a subject-matter expert, and a learning expert to assess content accuracy, design quality, and instructional suitability. Revisions were made based on the validators' feedback before proceeding to the implementation stage. The validation process ensured that the media met established quality criteria including clarity of information, visual appeal, ease of use, and alignment with pedagogical principles. Iterative revisions addressed concerns related to color contrast, font readability, QR code functionality, and the appropriateness of digital content for elementary students' cognitive levels.

During the implementation stage, limited testing was conducted using a one-group pretest–posttest design. Students completed a pretest before participating in learning activities using the QR Code–based card media integrated with a problem-based learning approach, followed by a posttest to measure learning improvement. The evaluation stage was conducted continuously across all ADDIE stages. This stage aimed to refine the final product and assess its validity, practicality, and effectiveness in improving students' critical thinking skills and learning activities. Formative evaluation was conducted throughout the development process to

identify areas requiring improvement, while summative evaluation measured the overall impact of the media on student learning outcomes and engagement levels.

Instruments and Data Collection

Data were collected using expert validation sheets, practicality questionnaires for teachers and students, observation sheets for student-centered learning, learning activity observation sheets, interview guides, and critical thinking skill test instruments. The critical thinking skill test consisted of essay questions designed to measure indicators such as analyzing, evaluating, and drawing conclusions. Each instrument was carefully designed to capture specific aspects of the research objectives, including the quality of the media, its ease of implementation, and its impact on student learning processes. The multi-method approach to data collection ensured triangulation of findings and enhanced the credibility and comprehensiveness of the research results.

Instrument validity was examined through content validity using expert judgment. The validation process involved three experts who evaluated the relevance, clarity, and appropriateness of each test item based on the learning objectives and critical thinking indicators. Items were revised according to experts' suggestions to ensure that the instrument accurately measured the intended constructs. The experts reviewed the alignment between test items and the theoretical framework of critical thinking skills, assessed the linguistic appropriateness for fifth-grade students, and verified that the questions effectively distinguished between different levels of cognitive complexity.

Instrument reliability was tested through a pilot test conducted prior to implementation. Reliability analysis was performed to determine the internal consistency of the critical thinking skill test, ensuring that the instrument produced consistent and dependable results when administered under similar conditions. Only test items that met acceptable reliability criteria were used in the final data collection. Multiple data collection techniques including validation, tests, observations, questionnaires, interviews, and documentation were employed to ensure data completeness and accuracy (Sugiyono, 2015). This comprehensive approach enabled the researchers to capture both quantitative measures of learning improvement and qualitative insights into students' learning experiences and engagement with the QR Code-based card media.

Data Analysis

Validity data were analyzed by calculating percentage scores based on expert and practitioner assessments using a five-point rating scale. Practicality was assessed through student readability tests and observation of learning implementation during classroom activities. The validity criteria included content validity, construct validity, and face validity, with threshold values established to determine whether the media met acceptable quality standards. Percentage scores above 80% were considered indicative of high validity, while scores between 60% and 80% required further refinement before implementation.

Effectiveness was analyzed using pretest and posttest scores, supported by student activity observations, interviews, and student response questionnaires. The level of improvement in students' critical thinking skills was determined using N-gain analysis (Hake, 1999; Meltzer, 2002). Statistical analyses, including normality tests, homogeneity tests, and t-tests, were performed using SPSS with a significance level of 0.05 to determine the effectiveness of the developed media (Ghozali, 2016). N-gain scores were categorized as high ($g > 0.7$), medium ($0.3 \leq g \leq 0.7$), or low ($g < 0.3$) to provide clear interpretation of the magnitude of learning improvement. Descriptive statistics were also employed to summarize patterns in student learning activities and responses to the instructional media.

3. Results and Discussion

Result

The IT-Based Card Media developed in this study consist of QR Code Information Cards and Magic Cards designed to support fifth-grade students in learning the human digestive system while encouraging critical thinking and active learning. The QR Code Information Cards provide concise explanations that can be accessed through mobile scanning, while the Magic Cards present paired questions and answers linked to critical thinking indicators. Both types of cards were designed with colorful visual elements to attract students' attention and facilitate understanding of complex biological concepts. The QR codes embedded in the Information Cards linked students to multimedia resources including animated videos demonstrating digestive processes, interactive diagrams showing organ functions, and exploratory activities that encouraged students to apply their knowledge in problem-solving scenarios.

The validity of the developed media was evaluated through expert judgment involving media experts and material experts. The validation process was conducted in two rounds to ensure comprehensive assessment and provide opportunities for refinement based on expert feedback. Media experts assessed aspects including visual design quality, layout consistency, color harmony, font readability, and QR code functionality, while material experts evaluated content accuracy, conceptual clarity, alignment with curriculum standards, and appropriateness for fifth-grade cognitive levels. The results of the media expert validation are presented in Table 1, which shows that the IT-based card media obtained very high validation scores, indicating that the visual design, readability, and functionality met the criteria for effective learning media.

Table 1. Media Expert Validation (84)

Products	Expert Validation	Percentage	Category
IT-based cards	Validation 1	96,00	Very Valid
	Validation 2	90,00	Very Valid

As shown in Table 1, the media expert validation yielded consistently high scores across both validation rounds, with Validation 1 achieving 96.00% and Validation 2 achieving 90.00%, both categorized as "Very Valid." These results indicate that the IT-based card media successfully met the established criteria for media quality and design standards. The slight difference between the two validation scores reflects minor adjustments made to improve QR code placement and enhance visual consistency across all card components.

In addition, the results of the material expert validation are shown in Table 2. The validation scores indicate that the learning content was accurate, well-structured, and aligned with the fifth-grade IPAS curriculum. Material experts confirmed that the digestive system content presented in the cards was scientifically correct, age-appropriate, and effectively sequenced to support progressive conceptual development. The experts also verified that the critical thinking tasks embedded in the Magic Cards were appropriately challenging and aligned with the targeted cognitive indicators including analysis, evaluation, and inference.

Table 2. Material Expert Validation (85)

Products	Expert Validation	Percentage	Category
IT-based cards	Validation 1	92,00	Very Valid
	Validation 2	88,00	Very Valid

Table 2 demonstrates that material expert validation also yielded very high scores, with Validation 1 at 92.00% and Validation 2 at 88.00%, both falling within the "Very Valid" category. These scores confirm that the instructional content, conceptual accuracy, and pedagogical design of the IT-based card media meet professional standards for elementary science education. The consistency between media and material validation results provides strong evidence that the developed media possess both technical quality and instructional effectiveness.

The practicality of the media was assessed through teacher assessments and student response questionnaires. The results showed that both teachers and students rated the IT-Based Card Media as highly practical, indicating that the media were easy to use, engaging, and supportive of classroom learning activities. Teachers specifically appreciated the flexibility of the media in accommodating different learning styles and the ease with which the QR code technology could be integrated into existing lesson plans. Students reported high levels of enjoyment and motivation when using the cards, noting that the interactive features made learning about the digestive system more interesting and memorable compared to traditional textbook-based instruction.

The effectiveness of the media was examined by comparing students' critical thinking skills before and after the implementation of the IT-Based Card Media. The results demonstrated an improvement in students' critical thinking skills and learning activities following the use of the developed media. Classroom observations further showed increased student participation during QR Code scanning activities, group discussions, and Magic Card-based problem-solving

tasks. Statistical analysis revealed significant differences between pretest and posttest scores, with N-gain calculations indicating medium to high improvement in critical thinking performance. Students demonstrated enhanced abilities to analyze digestive processes, evaluate nutritional information, and draw evidence-based conclusions about digestive health. The improvement was particularly notable in students' capacity to connect multiple concepts and apply their understanding to real-world scenarios. Overall, the results indicate that the IT-Based Card Media are valid, practical, and effective for supporting IPAS learning on the digestive system in fifth-grade elementary school. The convergence of evidence from expert validation, practicality assessments, and effectiveness measures confirms that the developed media successfully addressed the identified learning needs and achieved the intended pedagogical objectives.

Discussion

The findings of this study indicate that the IT-Based Card Media successfully met validity criteria in terms of media design and learning content. High validation scores from media and material experts suggest that the integration of QR Code technology and card-based activities provides a well-structured and pedagogically appropriate learning medium. This finding is consistent with previous studies reporting that technology-enhanced learning media can effectively support content clarity, visual appeal, and instructional alignment in elementary education (Dewi & Zuhdi, 2023; Siregar et al., 2020). The very high validity scores obtained in this study reflect careful attention to both aesthetic and functional design principles, ensuring that the media not only attract student interest but also facilitate meaningful cognitive engagement with the learning content. The iterative validation process allowed for systematic refinement of the media based on expert recommendations, resulting in a final product that meets rigorous quality standards.

The high level of practicality perceived by teachers and students demonstrates that the media are feasible for classroom implementation. Teachers found the media easy to operate and supportive of student-centered learning, while students perceived the media as engaging and enjoyable. These results align with Nieveen's (2013) criteria for practical learning media and are consistent with prior research showing that interactive and game-based instructional tools can increase motivation and ease of use in primary classrooms (Yulaika, 2020; Mulyadi, 2020). The practicality of the IT-Based Card Media is particularly significant given the limited technological infrastructure often found in elementary schools. The use of QR codes, which can be accessed using widely available smartphones or tablets, makes the media accessible without requiring specialized equipment or extensive technical training for teachers.

Furthermore, the observed improvement in students' critical thinking skills supports the effectiveness of the IT-Based Card Media. The combination of QR-based conceptual information and Magic Card analytical tasks encouraged students to analyze information, connect concepts, and collaborate with peers. The problem-based learning approach integrated with the card media created authentic learning contexts where students were required to apply critical thinking skills to solve

digestive health-related problems. This instructional design aligns with constructivist learning principles that emphasize active knowledge construction through meaningful interaction with learning materials (Rustandi, 2021; Widyawati & Sukadari, 2023). Students were observed engaging in higher-order thinking processes such as comparing different digestive organs' functions, evaluating dietary choices based on nutritional principles, and drawing evidence-based conclusions about digestive disorders.

Compared to previous studies, this research contributes a novel integration of QR Code Information Cards and Magic Cards specifically designed for IPAS digestive system material at the elementary school level. Unlike earlier research that primarily focused on learning outcomes or student engagement separately, this study demonstrates that IT-Based Card Media can simultaneously enhance critical thinking skills and learning activities. Thus, the findings strengthen existing evidence on the potential of technology-integrated card media as an effective innovation for elementary science learning. The dual-card design addresses multiple learning objectives simultaneously: the QR Code Information Cards support conceptual understanding and provide access to diverse multimedia resources, while the Magic Cards promote analytical thinking and collaborative problem-solving. This comprehensive approach to media development represents an advancement over single-function learning tools reported in previous literature (Wulandari & Sayekti, 2022; Ningsih, 2023; Sianipar et al., 2023).

4. Conclusion

Based on the results of the research and development process, it can be concluded that the IT-Based Card Media produced in this study possesses clear pedagogical and technological characteristics that make it feasible and suitable for use in classroom learning. The media were evaluated by both media experts and material experts, and the validation results indicated a very high level of validity, confirming that the product meets professional standards and can be used without requiring revision. The results of the classroom implementation further demonstrated that the IT-Based Card Media received excellent practicality ratings from both teachers and students, indicating that the media are easy to use, engaging, and highly supportive of learning activities. Moreover, the media were proven to be effective in the IPAS learning process, as shown by significant improvements in students' critical thinking skills and learning activity among fifth-grade students at SD Negeri Pandeanlamper 02 Semarang during the 2025/2026 academic year. Overall, the IT-Based Card Media can be considered a valid, practical, and effective innovation that enhances the quality of elementary science learning and contributes positively to the development of higher-order thinking skills.

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