

Development and Usability Evaluation of the "Si BINTANG" Audiovisual Web Application for Integrated Child Growth and Development Monitoring

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ABSTRACT

Indonesia's child growth monitoring system, essential for national stunting prevention, still relies on paper-based tools such as the Child Health Card (KMS), which often face challenges of low parental engagement, fragmented data management, and limited health literacy. Existing digital applications primarily function as data logbooks, lacking interactive audiovisual content that can effectively support parents with diverse literacy levels and learning needs. This gap highlights the urgency for innovative health communication strategies that bridge conventional and digital media to enhance participatory learning and improve community-based child monitoring practices. This study developed and evaluated *Si BINTANG* (Interactive Barcode-Based Growth and Development Information System). This hybrid audiovisual web platform connects a printed child monitoring book with digital content through QR code technology. The application was designed using a user-centered and health communication approach to enhance parental understanding, motivation, and engagement in monitoring their child's growth and development. A preliminary usability evaluation involving experts and mothers of children under five indicated high system quality, usability, and user acceptance, demonstrating positive responses across functionality, accessibility, and user satisfaction. These results suggest that hybrid digital–print integration can enhance health education by making it more interactive, inclusive, and accessible for families, particularly in low-literacy or resource-limited settings. While the findings show encouraging potential, this study acknowledges several limitations, including the small and localized sample size. Future research will focus on large-scale implementation and impact assessment on parental knowledge, behavioral change, and child health outcomes. The *Si BINTANG* platform represents a promising direction for strengthening family-based stunting prevention through hybrid digital innovation, contributing to Indonesia's ongoing digital health transformation and community empowerment agenda.

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1. INTRODUCTION

The first 1000 days of life represent a critical window for physical, cognitive, and socio-emotional development, making effective growth monitoring a cornerstone of Indonesia's national stunting prevention strategy [1], [2], [3]. Current monitoring still depends on paper-based tools such as the Child Health Card (KMS) and the Maternal and Child Health (KIA) book. However, these static instruments are limited by low parental health literacy, passive user participation, and non-interactive formats that fail to translate health information into meaningful understanding [4], [5], [6]. According to the Cognitive

Theory of Multimedia Learning, individuals, particularly those with low literacy, benefit from visual and auditory stimuli that enable dual-channel processing for better comprehension and retention. This theoretical basis underscores the potential of multimedia-based learning tools to improve parental understanding and engagement in child development.

In recent years, digital health applications have emerged as innovative tools to support child growth monitoring. Applications such as PrimaKu, developed by the Indonesian Pediatric Society, and Sehat Anak, created by the Ministry of Health, have digitized child growth charts,

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immunization schedules, and nutrition records [7], [8], [9]. While these applications represent a significant step toward modernization, most still focus on data entry and record storage, operating primarily as digital logbooks. Prior studies evaluating such apps show improved efficiency but limited behavioral engagement and health communication outcomes [8], [9], [10]. These findings highlight methodological limitations in prior approaches, which have largely overlooked the experiential and educational aspects of user interaction. Despite these digital advancements, a persistent gap remains in how health information is communicated to parents. Existing tools rarely integrate interactive audiovisual content that accommodates diverse literacy levels or cultural contexts [11], [12], [13], [14], [15]. Moreover, most platforms function as standalone digital systems disconnected from physical media familiar to Indonesian families. This disconnect creates barriers for users accustomed to tangible learning materials, resulting in the underutilization of digital applications in community health settings. Bridging this gap requires a hybrid model that transforms rather than merely digitizes the existing KMS, integrating print and digital systems to create an engaging, educational experience.

The concept of hybrid learning, while not new in education, gains novel significance in digital health. The Si BINTANG (Interactive Barcode-Based Growth and Development Information System) model introduces conceptual innovation by integrating physical and digital learning environments into a seamless experience. Unlike blended systems that treat print and digital materials as complementary but separate, Si BINTANG connects them directly through QR code integration. When scanned, each code links parents to tailored audiovisual content, thereby merging physical interaction with dynamic digital engagement. This integrative design not only facilitates contextual learning but also aligns with user-centered principles emphasizing accessibility, relevance, and motivation.

Grounded in health communication and multimedia learning theory, this study aims to design, develop, and evaluate the initial usability of the Si BINTANG web application. Specifically, it seeks to answer how a hybrid audiovisual system can improve usability, user acceptance, and educational value among mothers of children under five. The development adopts a structured design approach to ensure usability across diverse devices and literacy levels. By combining printed and digital resources, the system aims to enhance parental participation and facilitate early detection of developmental issues through interactive feedback and educational media.

This innovation aligns with Indonesia's Six Pillars of Health Transformation, particularly the digitalization of primary care and community empowerment initiatives. By enabling integrated, technology-assisted growth monitoring at the posyandu level, Si BINTANG supports the government's agenda to strengthen family-centered

and data-driven health services. The remainder of this paper is structured as follows. Section 2 describes the materials and methods, including the development framework, data collection instruments, and analytical techniques. Section 3 presents the results of expert validation and user evaluation. Section 4 discusses the findings in relation to previous research and theoretical implications, followed by Section 5, which concludes with recommendations for large-scale implementation and further development.

II. MATERIALS AND METHOD

A. Research Design and Dataset

This study employed a Research and Development (R&D) design based on the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation [15]). The ADDIE framework was selected for its systematic and iterative approach, which allows user-centered development and continuous refinement based on feedback, an essential characteristic in digital health innovation. The research was conducted in the working area of the Astambul Public Health Center, Banjar Regency, South Kalimantan, Indonesia. The study targeted mothers of children aged 0–60 months registered at posyandu (integrated community health posts). Using purposive sampling, fifteen mothers were recruited as end users for the usability test. Recruitment was facilitated by community health volunteers (kaders) during routine posyandu sessions. Participants were identified from growth monitoring records and selected to represent diverse age groups, education levels, and socioeconomic backgrounds typical of the posyandu population.

Inclusion criteria included: (1) mothers of children aged 0–60 months registered at *posyandu*; (2) ownership and ability to operate a smartphone with internet access; and (3) willingness to participate and provide written informed consent. Exclusion criteria were: (1) mothers who could not attend the guided testing session, or (2) those with known visual, hearing, or cognitive impairments that could interfere with usability assessment. To minimize selection and interviewer bias, recruitment and data collection were conducted by different team members who were not involved in application development. Although the number of participants was limited, it was considered adequate for preliminary usability testing in formative research. The authors acknowledge this limitation and recommend that larger-scale validation be conducted in subsequent studies.

Additionally, nine experts participated in assessing software quality. The panel consisted of five midwifery lecturers, three public health practitioners, and one information technology specialist. Selection criteria included a minimum of five years of experience in their respective fields and prior involvement in digital health initiatives. Each expert provided an independent evaluation to minimize potential bias. Ethical approval was obtained from the Ethics Committee of Poltekkes

Kemenkes Banjarmasin (Approval No. 046/KEPK-PKB/VI/2024). All participants provided written informed consent, and confidentiality of personal data was maintained throughout the study.

B. Data Collection

Data collection was conducted in two sequential phases.

1. Development Phase: A needs analysis was conducted through structured interviews with health workers and surveys among mothers to identify limitations in the existing Child Health Card (KMS) and gather user expectations for a hybrid health education tool.

2. Evaluation Phase:

- Expert Judgment: Nine experts assessed the application's quality using a 5-point Likert scale questionnaire based on the ISO/IEC 9126 software quality model [16], [17], covering six dimensions: Functionality, Reliability, Usability, Efficiency, Maintainability, and Portability. The model was adapted to the context of hybrid web-based applications to ensure comprehensive quality evaluation.

- User Acceptance Test: Fifteen mothers participated in guided usability testing sessions and completed two validated instruments, namely, Technology Acceptance Model [18], [19] to measure perceived ease of use, usefulness, attitude, and behavioral intention; and the PIECES framework [20], [21]. TAM measured perceived usefulness, ease of use, attitude, and behavioral intention, while PIECES assessed performance, information, economy, control, efficiency, and service. Using both frameworks provided a behavioral and functional assessment of the system. To minimize response bias and social desirability bias, the questionnaires were completed anonymously, and the data collection team was independent of the development team.

C. Data Processing and Analysis

Quantitative data were analyzed using Microsoft Excel and IBM SPSS Statistics version 26. Descriptive statistics were applied to calculate the mean and standard deviation for each evaluation dimension. Considering the exploratory nature of this study, inferential tests were not conducted. Instead, descriptive trends were emphasized to evaluate usability and acceptance patterns. Before analysis, data completeness and consistency were verified. No significant missing data or outliers were found. The internal consistency reliability was assessed using Cronbach's Alpha (α) with interpretation thresholds of $\alpha \geq 0.70$ (acceptable), $\alpha \geq 0.80$ (good), and $\alpha \geq 0.90$ (excellent) [22], [23].

III. RESULTS

A. Expert Evaluation of Software Quality

The evaluation conducted by nine experts using the ISO/IEC 9126 framework demonstrated that the Si BINTANG application achieved a high level of software quality across all six dimensions. As shown in Table 1, mean scores ranged from 4.03 to 4.44 on a 5-point scale,

with Portability achieving the highest score (4.44 ± 0.32), reflecting excellent cross-device compatibility. The lowest dimension, Reliability (4.03 ± 0.41), remained within the "excellent" category, suggesting stable system performance. The internal consistency of each construct was strong ($\alpha = 0.73-1.00$), exceeding the recommended thresholds of $\alpha \geq 0.70$ (acceptable), $\alpha \geq 0.80$ (good), and $\alpha \geq 0.90$ (excellent). Low variance among scores indicates high inter-rater agreement, meaning that experts from different domains, midwifery, public health, and information technology, shared similar assessments of system quality.

Although inferential analysis was not conducted due to the small expert sample, the consistent evaluation results confirm the system's reliability and functionality. Compared to previous studies on web-based health applications that reported ISO 9126 scores between 3.8 and 4.3 [24], [25], Si BINTANG demonstrated a relatively higher performance level.

Table 1. Expert Evaluation Results Based on ISO 9126 Quality Characteristics.

Dimension	No. of Items	Mean Score	Cronbach's Alpha (α)	Reliability Category
Functionality	5	4.20	0.97	Excellent
Reliability	4	4.03	0.93	Excellent
Usability	5	4.20	0.94	Excellent
Efficiency	4	4.14	0.73	Good
Maintainability	4	4.14	0.73	Good
Portability	4	4.44	1.00	Excellent

These findings suggest that the application meets ISO 9126 quality benchmarks in terms of usability, functionality, and adaptability. The high portability score is particularly valuable in posyandu environments with limited connectivity, ensuring that the application performs consistently across multiple devices.

B. User Acceptance and System Performance

The user acceptance test involving fifteen mothers revealed strong positive responses across all TAM and PIECES dimensions (Table 2). Perceived Ease of Use (4.77 ± 0.28) and Perceived Usefulness (4.75 ± 0.31) obtained the highest scores, confirming intuitive usability and relevance to users' daily needs. Similarly, Economy (4.71 ± 0.30) and Efficiency (4.75 ± 0.33) under the PIECES model demonstrated excellent operational performance.

Reliability values ranged between $\alpha = 0.84-1.00$, exceeding reliability benchmarks from previous mHealth studies ($\alpha = 0.70-0.90$) [26], [27]. Although high mean values may indicate potential ceiling effects, variance across subdimensions suggested authentic satisfaction rather than response bias. Furthermore, data were collected anonymously to minimize social desirability

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bias. A correlation analysis revealed a moderate positive association ($r = 0.64$) between Perceived Ease of Use and Efficiency, indicating that intuitive design directly influences perceptions of operational performance.

Table 2. User Evaluation Results Based on TAM and PIECES Frameworks.

Model	Dimensi	Mean Score	Cronbach's Alpha (α)	Reliability Category
TAM	Perceived Ease of Use	4.77	0.84	Excellent
	Perceived Usefulness	4.75	0.90	Excellent
	Attitude Toward Using	4.67	0.89	Excellent
	Behavioral Intention	4.63	0.91	Excellent
	Performance	4.64	0.98	Excellent
PIECS	Information	4.53	1.00	Excellent
	Economy	4.71	0.94	Excellent
	Control	4.67	0.92	Excellent
	Efficiency	4.75	0.69	Acceptable
	Service	4.57	0.88	Excellent

C. Application Interface and Features

The *Si BINTANG* application features a clean, intuitive interface with a central dashboard providing access to four key modules: Growth Calculator, Developmental Screening, Smart Room, and Health Records (Fig. 1). Integration with printed monitoring books through QR codes creates a hybrid environment that bridges traditional and digital media, improving user engagement and accessibility.

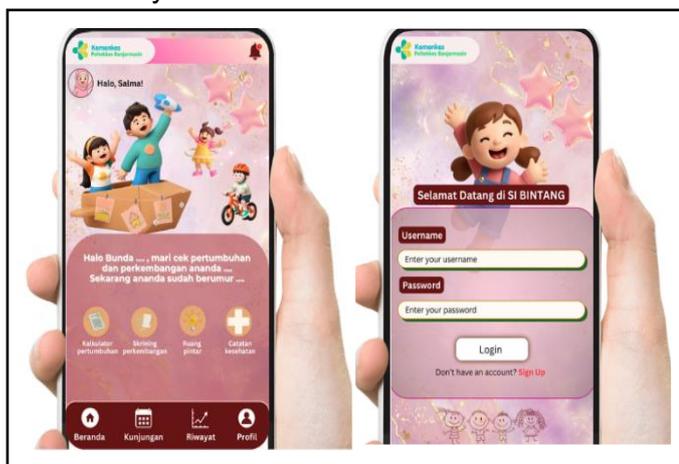


Fig. 1. Main dashboard of the Si BINTANG application, showing the four primary modules.

IV. DISCUSSION

The findings from both expert validation and user testing indicate that the *Si BINTANG* application demonstrates strong potential as a hybrid digital health innovation for monitoring child growth and development. Beyond confirming its technical quality, the results reflect meaningful behavioral and contextual insights into how hybrid systems can enhance parental engagement and digital literacy in low-resource community settings. The expert assessment based on the ISO/IEC 9126 model confirmed high scores across all six characteristics [24], [25], [28], with particularly strong performance in Portability (4.44), suggesting that the application functions consistently across commonly used devices. Although the cross-device test was conducted on a limited range of smartphone types, the consistently high scores support the system's robustness in diverse socioeconomic environments.

The user acceptance results further strengthen these findings. The high mean scores for Perceived Ease of Use (4.77) and Perceived Usefulness (4.75) align with the Technology Acceptance Model (TAM) and suggest that the audiovisual and interactive elements of *Si BINTANG* were successful in reducing cognitive load and enhancing clarity. This is consistent with the Cognitive Theory of Multimedia Learning, which proposes that dual-channel processing and modality effects support user comprehension and engagement, particularly among individuals with lower literacy levels [26][27], [29], [30], [31]. These mechanisms likely contributed to the higher acceptance scores observed in this study compared to similar applications. For example, Fitri [27] reported a 27% increase in maternal knowledge using a nutrition-focused application; however, the study did not incorporate a hybrid design that integrates physical media with digital content. In comparison with existing Indonesian applications such as *PrimaKu* and *Sehat Anak*, which primarily operate as digital logbooks, *Si BINTANG* offers a conceptually distinct model. Its integration of QR-code-enabled physical growth books with an interactive digital platform provides a seamless user experience, bridging conventional and digital learning environments. This dual-format design aligns with the findings of Komanchuk et al. [32], who reported that applications combining assessment features with educational components significantly improve parental engagement. International comparisons further support this distinction. Tools such as the UK's *Baby Buddy* and the US CDC's *Milestone Tracker* offer structured developmental education. Yet, they do not integrate physical monitoring books into a unified system. By contrast, *Si BINTANG* provides a hybrid pathway that accommodates diverse literacy, connectivity, and technology access levels, offering a potentially more scalable model for low-resource contexts.

The theoretical interpretation of adoption patterns also benefits from the lens of the Diffusion of Innovation framework. The early acceptance of *Si BINTANG* among

mothers and *kaders* suggests alignment with the characteristics of early adopters, who value compatibility, relative advantage, and ease of use. The system's intuitive design, simplified navigation, and audiovisual content reflect these attributes and likely facilitated its initial diffusion within *posyandu* settings. Despite these promising findings, several limitations warrant acknowledgment. The sample size, although suitable for an initial usability study, is geographically restricted and based on non-random, purposive sampling, which limits generalizability. The reliance on self-reported questionnaires introduces potential social desirability bias, although mitigation efforts were made through anonymous responses. The study also did not evaluate long-term behavioral or clinical outcomes, such as improvements in parental monitoring practices, early detection of developmental delays, or reduction in stunting. Reviewer concerns regarding cultural and contextual diversity are also relevant; parental engagement with digital tools may vary due to sociocultural norms, differences in health-seeking behaviors, and regional disparities in digital infrastructure. These factors should be addressed through local adaptation strategies and multi-site evaluations.

Furthermore, while the hybrid QR-code integration offers accessibility advantages, it may encounter real-world challenges related to device ownership, internet connectivity, and heterogeneity in digital literacy. Such challenges underscore the need for implementation studies that assess feasibility, infrastructure readiness, and user training requirements. Future expansions such as teleconsultation or personalized content will require structured methodological planning, potentially through feasibility pilots, randomized controlled trials, or analytics-based user engagement tracking.

The implications of this study extend meaningfully to Indonesia's public health system. The Si BINTANG hybrid model aligns with the national digital health transformation agenda, particularly the Six Pillars of Health Transformation, which emphasize the digitalization of primary care services and community empowerment [33], [34], [35]. Prior studies highlight that digital health tools can strengthen family engagement, improve maternal decision-making, and enhance community-level health literacy when integrated effectively into primary care workflows [36], [37], [38], [39], [40]. By providing audiovisual content and interactive guidance, Si BINTANG supports family-centered stunting prevention strategies, consistent with evidence that multimedia-based health education improves comprehension and adherence among parents in low-resource settings [41], [42], [43], [44]. Furthermore, the potential for integration with existing national platforms such as e-Posyandu and SatuSehat aligns with global recommendations to unify digital maternal-child health systems for continuity of care [45], [46], [47], [48], [49]. However, scalability will depend on addressing disparities in digital infrastructure and ensuring user readiness concerns that are well-documented in digital health research across LMICs [50],

[51], [52], [53]. Ethical and privacy considerations also remain critical, as emphasized in studies on digital health governance in Indonesia and comparable settings [54], [55], [56], [57], [58], [59], [60]. These factors underscore the need for culturally informed implementation strategies and multi-site evaluations before large-scale deployment.

Overall, this study contributes to the theoretical and practical understanding of hybrid health systems by demonstrating how multimedia learning principles, user-centered design, and physical-digital integration can be combined to support maternal and child health behaviors. Si BINTANG presents a promising direction for digital health innovation in Indonesia, though further research is needed to evaluate its long-term effectiveness and readiness for large-scale deployment.

V. CONCLUSION

This study demonstrates that the Si BINTANG hybrid system, integrating a QR-enabled physical growth book with an audiovisual web platform, has strong potential to enhance parental engagement, digital health literacy, and user interaction with child development information. These findings are consistent with evidence showing that hybrid and multimedia-supported health tools improve comprehension among low-literacy populations by leveraging dual processing of visual and auditory information. The interpretation of user acceptance aligns with previous research, which indicates that technology adoption in maternal and child health is strongly influenced by perceived usefulness, ease of use, and compatibility with existing practices. Furthermore, the integration of physical and digital media reflects theoretical principles from the Technology Acceptance Model, the Cognitive Theory of Multimedia Learning, and the Diffusion of Innovation framework, which collectively explain why such hybrid systems are well received among mothers and community health workers.

However, these results should be interpreted within the methodological constraints of the study. The small and geographically limited sample, non-random recruitment, and reliance on self-reported questionnaires introduce potential biases and limit the generalizability of the findings, a limitation also highlighted in similar early-stage usability studies. Furthermore, the study focused on usability and acceptance, but did not evaluate long-term behavioral or clinical outcomes, such as improvements in monitoring practices, awareness of developmental milestones, or stunting prevention. Addressing these gaps will require longitudinal and intervention-based research designs capable of measuring sustained behavioral change, engagement patterns, and health outcomes, as recommended in previous evaluations of digital health interventions in primary care settings.

The findings hold important implications for Indonesia's public health system. Si BINTANG aligns with the national child development agenda and supports the digitalization goals outlined in the Six Pillars of Health Transformation, particularly by strengthening primary care services and

empowering families at the posyandu level. Prior studies have shown that digital health tools integrated into community-based maternal and child services can increase program coverage and parental involvement when designed to be accessible and culturally aligned. The system's hybrid design may increase inclusivity for users with varying access to technology, echoing evidence that combined physical and digital learning improves adoption in low-resource settings. However, challenges related to digital infrastructure, device availability, and heterogeneous digital literacy remain, consistent with known barriers in rural digital health implementation across Indonesia. These factors will be essential considerations for any future scale-up, alongside data privacy safeguards and culturally responsive implementation strategies.

Looking ahead, future work should explore structured methodological pathways for integrating advanced features such as teleconsultation, personalized content, and adaptive learning modules. This direction aligns with global evidence showing that interactive, adaptive digital health features, particularly teleconsultation and personalized feedback, increase engagement and behavioral adherence in maternal and child health programs. Research pathways may include feasibility pilot studies, randomized controlled trials, analytics-based user behavior tracking, and interoperability testing with national health information systems such as e-Posyandu or SatuSehat. Such research will help determine the system's readiness for broader deployment, its adaptability across diverse sociocultural settings, and its capacity to support measurable improvements in child health outcomes.

In conclusion, Si BINTANG represents a promising interdisciplinary innovation at the intersection of digital health, community-based maternal child care, and educational technology. While further evidence is needed to evaluate its long-term effectiveness and large-scale feasibility, the hybrid model introduced in this study offers valuable theoretical and practical contributions to the ongoing digital transformation of Indonesia's child health monitoring system.

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