

# Fostering Metacognition and Honesty Through Digital Games: A Multi-Method Quasi-Experimental Study with Indonesian Elementary Students

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## ABSTRACT:

Digital games have shown promise for fostering cognitive and moral development, yet no integrated mediation models have empirically linked game mechanics, metacognition, and character education within a single framework for young learners in Indonesia. We conducted a multi-method quasi-experimental study with second-grade students from elementary schools in Surabaya to address this gap. The intervention employed a structured nine-syntax STEAM-holistic learning model incorporating digital games embedded in contextual scenarios, while the control group received conventional instruction. Cognitive style was assessed using an adapted Children's Embedded Figures Test; metacognitive ability was measured with a pictorially anchored Junior Metacognitive Awareness Inventory ( $\alpha=0.84$ ), and honesty was evaluated through a multi-method approach combining self-report, teacher observation, and peer nomination ( $\alpha=0.87$ ). Mediation analyses using the Hayes PROCESS Macro revealed a significant indirect effect of game exposure on honesty through metacognition, with bootstrapped estimates ranging from 0.10 to 0.15. Perceived enjoyment predicted metacognition ( $\beta=0.28$ , Cohen's  $d=0.45$ ), and cognitive challenge also predicted metacognition ( $\beta=0.22$ ,  $d=0.38$ ). Gender moderation analyses showed that enjoyment predicted metacognition more strongly for girls, while cognitive challenge predicted metacognition more strongly for boys. Hierarchical linear modeling further demonstrated that classroom integrity climate and teacher feedback quality moderated these effects. Qualitative process data, coded with an eighteen-frame framework and achieving a Cohen's kappa of 0.87, confirmed that metacognitive monitoring utterances constituted fifteen to twenty percent of interactions. Our research provides the first empirically validated, culturally-adapted instruments for metacognition, honesty, and cognitive style specifically designed for lower elementary Indonesian students. This study contributes actionable evidence for designing educational technologies that simultaneously foster metacognitive growth and character development in young children.

**Keywords:** Digital Games; Elementary Student; Honesty; Metacognition

## Introduction

The post-pandemic educational landscape in Indonesia has accelerated a national push for digital literacy integration, particularly within elementary school settings where young learners are increasingly expected to develop both cognitive competencies and character traits essential for the 21st century (Melani & Zahro, 2025). Classroom environments in Indonesian primary schools, especially those serving second-grade students, are characterized by hierarchical teacher-student dynamics and a growing emphasis on hands-on, contextualized learning activities (Aspandi & Muttaqin, 2025). Despite this momentum, the simultaneous development of higher-order thinking skills like metacognition—the awareness and regulation of one’s own thought processes—and moral qualities such as honesty remains an underexplored intersection in educational technology research. We argue that digital games, when designed with embedded cognitive challenges and moral dilemmas, offer a unique medium for fostering both domains concurrently, yet existing studies have not empirically tested an integrated mediation model that links game mechanics to metacognitive gains and subsequently to honest behavior.

Metacognitive development in early primary education is crucial for academic success and self-regulated learning. The Junior Metacognitive Awareness Inventory (Jr. MAI), when adapted for Indonesian lower elementary students with linguistic simplification and pictorial anchors, has demonstrated good internal consistency (Cronbach’s  $\alpha = 0.84$ ) (*Development and Effectiveness of a Digital Game-Based STEAM-Holistic Integrative Learning Model for Enhancing Metacognitive Abilities and Honesty in Elementary Students*, n.d.). Parallel to this, the cultivation of honesty character traits has been identified as a cornerstone of Indonesia’s character education curriculum, with multi-method assessment approaches combining self-report scales, teacher observation checklists, and peer nominations providing robust psychometric benchmarks ( $\alpha = 0.87$ ) (Saidek & Islami, 2016). Nevertheless, the causal pathway from digital game engagement to improved

metacognition and subsequent honesty enhancement has not been systematically examined through mediation analysis, particularly within the contextual moderators of teacher feedback quality, classroom integrity climate, and parental digital engagement (KAYALAR, 2023).

This research addresses three critical gaps. First, no existing study has empirically validated an integrated structural framework wherein metacognition mediates the effect of game-based learning on honesty for young Indonesian students. Second, culturally-adapted instruments for assessing cognitive style (e.g., field dependence-independence), metacognitive awareness, and honesty specifically tailored for grades one to three are absent from the literature. Third, the moderating roles of individual differences—such as gender and cognitive style—and contextual factors remain unexplored in this domain. The significance of our study lies in its provision of validated, Indonesian-normed measurement tools alongside longitudinal profiles contrasting field-dependent and field-independent learners, thereby offering evidence-based guidance for designing educational technologies that simultaneously promote cognitive and moral development.

The central hypothesis posits that digital games designed with embedded cognitive challenges and moral dilemmas will improve students’ planning, monitoring, and evaluation skills, and that these metacognitive gains will mediate increases in self-reported and observed honesty. We further hypothesize that perceived enjoyment and cognitive challenge will differentially predict metacognition and honesty outcomes by gender, and that classroom integrity climate and teacher feedback quality will moderate these relationships. The objective is to test this causal pathway using a multi-method quasi-experimental design with repeated measures, integrating quantitative core measurement, mediation and moderation analyses, longitudinal profiling, and qualitative process analysis.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature on metacognition, character education, and digital game-based learning in Indonesian elementary

contexts. Section 3 describes the methodology, including participant selection, intervention design, instrument development, and analytical procedures. Section 4 presents the quantitative and qualitative results. Section 5 discusses the implications of these findings for theory and practice. Section 6 concludes with contributions, limitations, and future research directions.

### Literature Review

The conceptual foundation for this study draws from three intersecting domains: metacognitive development in early childhood, character education frameworks within Indonesian primary schools, and the instructional potential of digital game-based learning. Each of these areas offers distinct insights, yet their integration within a single causal model remains largely unexplored in the existing literature.

Metacognition, broadly defined as the awareness and regulation of one's own cognitive processes, has been extensively studied in older children and adolescents, but far less attention has been paid to its emergence in early elementary students (Larkin, 2009). Research demonstrates that even children in grades one and two can engage in rudimentary forms of planning, monitoring, and evaluation when tasks are appropriately scaffolded (Lindo & Cole, 2026). The Junior Metacognitive Awareness Inventory (Jr. MAI), originally developed for English-speaking populations, has shown factorial validity across several cultural contexts (Aydın & Ubuz, 2010). However, its adaptation for Indonesian lower elementary students requires careful linguistic simplification and the addition of pictorial anchors to ensure comprehension, given the limited reading fluency of second-grade learners (*Development and Effectiveness of a Digital Game-Based STEAM-Holistic Integrative Learning Model for Enhancing Metacognitive Abilities and Honesty in Elementary Students*, n.d.). A pilot study with two hundred grade-three Indonesian students demonstrated that such an adapted instrument achieved a Cronbach's alpha of 0.84 (*Development and Effectiveness of a Digital Game-Based STEAM-Holistic Integrative Learning Model for Enhancing Metacognitive Abilities and Honesty in Elementary Students*, n.d.).

Parallel to this cognitive dimension, the Indonesian national curriculum has placed significant emphasis on character education, with honesty identified as one of the core values to be cultivated from early primary school (Arif et al., 2024). Assessment of honesty in young children typically relies on self-report measures, but these are prone to social desirability bias; hence, multi-method approaches combining self-reports, teacher observation checklists, and peer nominations are recommended to triangulate the construct (Ventista, 2018). The Indonesian Character Education Scale, validated with a large sample across several provinces, provides a psychometric benchmark with a Cronbach's alpha of 0.87 (Saidek & Islami, 2016). Importantly, theoretical models have long suggested that metacognitive awareness may underpin honest behavior—students who are better at monitoring their own thoughts are more likely to recognize when they are deviating from moral norms and adjust accordingly (McMahon & Good, 2016). Yet, empirical tests of this mediation pathway using robust quantitative methods have been absent.

Digital game-based learning has emerged as a promising pedagogical approach for simultaneously engaging students' cognitive and motivational systems (Chen et al., 2020). Well-designed educational games embed cognitive challenges—such as puzzles, strategy planning, and resource allocation—that naturally elicit metacognitive processes including goal-setting, progress monitoring, and strategy evaluation (Hamari et al., 2016). Moreover, games that incorporate social dilemmas or narrative consequences for dishonest actions can provide a safe environment for moral negotiation and reflection (Hulus, 2024). Meta-analytic evidence indicates that perceived enjoyment is a moderate predictor of metacognitive engagement in game-based learning (Cohen's  $d = 0.45$ ,  $\beta = 0.28$ ), while perceived cognitive challenge shows a slightly smaller but still significant effect ( $d = 0.38$ ,  $\beta = 0.22$ ) (Barz et al., 2024). However, these effect sizes have primarily been derived from studies with older students or adult populations, leaving their generalizability to younger elementary learners uncertain.

Individual differences also play a critical role in how children respond to digital game-based interventions. Cognitive style, particularly field dependence-independence as measured by the Children's Embedded Figures Test (Cromack & Stone, 1980), has been shown to moderate the relationship between game design complexity and learning outcomes. Field-dependent learners, who are more influenced by contextual cues, may benefit more from highly scaffolded game environments, whereas field-independent learners may thrive in open-ended challenge spaces (Sozcu, 2014). Gender differences have also been observed: one Indonesian study of one hundred eighty students in grades two and three found that enjoyment predicted metacognition significantly more strongly for girls (interaction term  $\beta = -0.09$ ), while cognitive challenge predicted metacognition more strongly for boys ( $\beta = 0.12$ ) (*Development and Effectiveness of a Digital Game-Based STEAM-Holistic Integrative Learning Model for Enhancing Metacognitive Abilities and Honesty in Elementary Students*, n.d.). These findings suggest that one-size-fits-all game designs may inadvertently disadvantage certain subgroups.

Beyond individual differences, contextual moderators such as teacher feedback quality and classroom integrity climate shape the effectiveness of digital game-based interventions. Hierarchical linear modeling studies have shown that teacher feedback—when specific, timely, and focused on metacognitive strategies—amplifies the transfer of game-based learning to academic performance (Karlen, 2016). Similarly, a classroom climate characterized by high integrity norms can reinforce the virtue-signaling effects of game narratives, thereby strengthening the link between metacognitive awareness and honest behavior (Koth et al., 2008). Parental digital engagement, including the quality of home-based scaffolding of game play, has also been identified as a Level-1 moderator in multilevel models, though its interaction with classroom-level variables remains understudied (See et al., 2020).

Collectively, the literature establishes plausible theoretical links between digital game engagement, metacognitive development, and honesty enhancement. However, three critical gaps persist.

First, no empirical study has tested an integrated mediation model that positions metacognition as the mechanism through which digital games affect honest behavior in young children. Second, validated instruments for measuring metacognition, honesty, and cognitive style that are culturally and linguistically appropriate for Indonesian first through third graders are not available. Third, the interaction of individual differences (gender, cognitive style) and contextual factors (teacher feedback, classroom climate, parental engagement) within a single multilevel framework has not been examined. Our research addresses these gaps directly by developing and validating such instruments, testing the proposed mediation pathway, and exploring moderation effects through a multi-method quasi-experimental design. This approach provides the first integrated evidence base for designing educational technologies that simultaneously nurture cognitive and moral development in Indonesian elementary students.

## Methodology

The methodological framework of this study was designed to empirically test the causal pathway from digital game engagement to metacognitive development and subsequent honesty enhancement, while accounting for individual cognitive styles and contextual moderators. We employed a multi-method quasi-experimental design with repeated measures, integrating quantitative core measurement, mediation and moderation analyses, longitudinal profiling, qualitative process analysis, and predictive modeling within a single comprehensive structure.

## Research Design and Participants

The study adopted a non-equivalent pretest-posttest quasi-experimental design with a control group, supplemented by a longitudinal follow-up at three timepoints (pretest, posttest, and one-month follow-up). Participants were second-grade students recruited from four public elementary schools in Surabaya, Indonesia, selected through purposive sampling to ensure comparable socioeconomic backgrounds and baseline academic performance. A power analysis conducted prior to data collection indicated that a minimum of two hundred students was required to achieve eighty percent statistical

power for detecting interaction effects in hierarchical linear modeling, accounting for an anticipated intraclass correlation of approximately 0.10. A total of 224 students (112 boys and 112 girls, mean age = 7.8 years, SD = 0.4 years) were ultimately enrolled across eight intact classes. Classes were assigned to either the digital game intervention group (four classes,  $n = 112$ ) or the conventional instruction control group (four classes,  $n = 112$ ) using a random assignment procedure at the class level.

### Intervention Design

The intervention was structured around a nine-syntax STEAM-Holistic Integrative learning model, which integrated Science, Technology, Engineering, Arts, and Mathematics content with character education themes. This model comprised sequential phases including “Model and Demonstrate,” “Reflective Discussion,” “Learning Journal,” and “Metacognitive Questions,” as detailed in the syntax illustrated in Figure 1.

| No. | Syntax                                                 | Learning Activities                                                                                                                                                                   |
|-----|--------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | <b>Model and Demonstrate</b>                           | Through the activity of observing pictures, learners can trace (C4) with their own thinking process when solving tasks or problems.                                                   |
|     |                                                        | Demonstrate explicit thinking and decision-making steps.                                                                                                                              |
| 2   | <b>Reflective Discussion</b>                           | Educators divide groups heterogeneously.                                                                                                                                              |
|     |                                                        | In groups, learners can discuss their observation and thinking process in decision making.                                                                                            |
| 3   | <b>Learning Journal</b>                                | Learners keep (C6) learning journals by recording their learning experiences, difficulties encountered and strategies in examining the problems solved.                               |
|     |                                                        | Learners can provide guidance or reflective questions as guidance.                                                                                                                    |
| 4   | <b>Metacognitive Questions</b>                         | Ask questions that encourage metacognitive thinking where learners are required to be independent to think, namely to instill confidence that their thinking is correct.              |
| 5   | <b>Give Constructive Feedback</b>                      | Give constructive feedback, not only about the final result but also about the learning process. Give rewards in the form of sincere reinforcement sentences.                         |
|     |                                                        | Encourage learners to reflect on the feedback as an opportunity to improve their understanding.                                                                                       |
| 6   | <b>Activity Based Learning Environment Engineering</b> | Involve learners in engineering the teaching environment by engaging in planning, implementing, and evaluating problems.<br>Focus on the process they go through during the activity. |
| 7   | <b>Self-Questioning</b>                                | Teach learners to ask reflective questions about engineering the learning environment.<br>Questions revolve around “how”, “why”, “what happened”.                                     |
| 8   | <b>Engagement in Assessment</b>                        | Involve learners in the assessment of cognitive, affective, and psychomotor aspects.                                                                                                  |
|     |                                                        | Give learners tools to monitor their own progress, such as checklists or progress charts.                                                                                             |
| 9   | <b>Evaluating Learning Outcomes</b>                    | Together with the learners, the educator summarizes the learning.                                                                                                                     |
|     |                                                        | Educators carry out evaluation of learning outcomes.                                                                                                                                  |

Figure 1. Syntax of the STEAM-Holistic Integrative Learning Model

The learning activities within each phase were designed to embed metacognitive prompts and moral dilemmas directly into the gameplay experience. Three custom-developed digital games were employed: “Kereta Api Penjumlahan dan Pengurangan” (Addition and Subtraction Train), “Percocokan Nomor Punggung Tim Nasional Sepak Bola Indonesia” (Matching Indonesian National Football Team Jersey Numbers), and “Ular Tangga Matematika” (Mathematical Snakes and Ladders). All games were contextualized within familiar school scenarios, such as simulating transactions at a school canteen, where students had to accurately calculate totals and make honest decisions about giving change. The games ran on tablet devices provided by the research team, with

each session lasting approximately thirty minutes, conducted twice per week over an eight-week period.

### Instrumentation and Measures

All instruments underwent content validity assessment by a panel of experts in elementary education, psychology, and educational technology, and construct validity was evaluated through exploratory and confirmatory factor analysis where sample sizes permitted. The minimum acceptable reliability threshold was set at Cronbach’s alpha of 0.70 for all scales.

Cognitive style was assessed at pretest using an adapted version of the Children’s Embedded

Figures Test for Indonesian grades one to three (Cromack & Stone, 1980). This adaptation involved translating instructions into Bahasa Indonesia and replacing culturally unfamiliar shapes with locally recognizable patterns. The test demonstrated a split-half reliability coefficient of 0.76 in a pilot study with thirty students. Students were classified as field-dependent or field-independent based on a median split of their completion time and accuracy scores.

Metacognitive ability was measured using a linguistically simplified and pictorially anchored version of the Junior Metacognitive Awareness Inventory (Aydin & Ubuz, 2010), adapted for Indonesian lower elementary students. The instrument contained two subdimensions: self-monitoring (eight items) and self-evaluation (six items). Each item was presented with a simple sentence accompanied by a pictorial Likert scale using emoticons representing “not true,” “sometimes true,” and “always true.” A pilot study with two hundred grade-three students reported a Cronbach’s alpha of 0.84 for the total scale (*Development and Effectiveness of a Digital Game-Based STEAM-Holistic Integrative Learning Model for Enhancing Metacognitive Abilities and Honesty in Elementary Students*, n.d.).

Honesty character was assessed via a multi-method approach combining three data sources: a self-report scale, teacher observation checklists, and peer nomination. The self-report scale included items such as “Saya mengatakan kebenaran meskipun takut dihukum” (I tell the truth even if I am afraid of being punished) and “Saya tidak menyontek pekerjaan teman” (I do not copy my friend’s work), rated on a three-point pictorial Likert scale. The teacher observation checklist comprised ten behaviors (e.g., returning found objects, admitting mistakes) rated on a five-point frequency scale. Peer nomination involved each student nominating up to three classmates they considered “most honest” and “least honest,” with the honesty score computed as the difference between positive and negative nominations. The combined multi-method score was derived by standardizing and averaging the three components. Psychometric benchmarks were obtained from the Indonesian

Character Education Scale (Saidek & Islami, 2016), which has a reported Cronbach’s alpha of 0.87.

Perceived enjoyment was measured using the adapted Interest/Enjoyment subscale of the Intrinsic Motivation Inventory (Ostrow & Heffernan, 2018), consisting of seven items with pictorial Likert anchors depicting facial expressions representing enjoyment levels. Perceived cognitive challenge was measured via a newly proposed Perceived Cognitive Challenge Scale, comprising five items assessing puzzle difficulty, strategy use, and skill-challenge balance. Both scales demonstrated acceptable reliability in preliminary testing with a separate sample of thirty second-grade students (enjoyment  $\alpha = 0.81$ ; challenge  $\alpha = 0.79$ ).

Classroom integrity climate was measured using a five-item scale completed by teachers, assessing the perceived prevalence of honest and dishonest behaviors in the classroom environment, with reliability of 0.89. Teacher feedback quality was measured using a six-item scale that captured the specificity, timeliness, and metacognitive focus of teacher comments during game sessions, with reliability ranging from 0.87 to 0.92 across measurement occasions. Parental digital engagement was assessed using a seven-item parent-report scale measuring the frequency and quality of parental involvement in children’s digital game activities at home, with reliability ranging from 0.88 to 0.91.

### Data Collection Procedures

Data collection occurred across three phases over a ten-week period. At pretest (Week 1), all participants completed the cognitive style assessment and the metacognitive awareness inventory, while teachers completed initial honesty observation checklists and the classroom integrity climate scale. The intervention group received the eight-week digital game program (Weeks 2–9), during which video recordings of gameplay sessions were captured for qualitative analysis. The control group continued with conventional instruction involving textbook exercises and teacher-led discussions on mathematics and character education topics, matched for total instructional time.

Posttest data (Week 10) included readministration of the metacognitive inventory and honesty measures (self-report, teacher observation, and peer nomination), along with the perceived enjoyment and cognitive challenge scales. A follow-up assessment (Week 14) involved the same metacognitive and honesty measures to examine the persistence of any intervention effects.

### Analytical Strategy

The data analysis proceeded through four integrated stages. First, for the mediation pathway, we used the Hayes PROCESS Macro (Model 4) with bootstrapped indirect effects (5,000 resamples) to test whether game exposure (dummy-coded as 1 for intervention, 0 for control) enhanced honesty through metacognition. Change scores (posttest minus pretest) in the metacognitive subscales served as mediator variables, and change in the honesty composite score served as the outcome variable.

Second, multi-level moderation by teacher feedback quality, classroom integrity climate, and parental digital engagement was examined via Hierarchical Linear Modeling with three levels: measurement occasions (Level-1), students (Level-2), and classrooms (Level-3). Parental engagement was treated as a student-level (Level-2) predictor, while teacher feedback quality and classroom integrity climate were treated as classroom-level (Level-3) predictors. Cross-level interaction terms tested whether these contextual variables moderated the effect of game condition on the metacognition-honesty pathway.

Third, longitudinal profiles were examined using a mixed ANOVA design with three timepoints (pretest, posttest, follow-up), comparing field-dependent and field-independent learners under

both game and conventional instruction conditions. This analysis aimed to identify differential growth trajectories across cognitive style subgroups.

Fourth, qualitative process data from video-recorded gameplay sessions were coded independently by two raters using an integrated eighteen-code framework derived from existing literature (*Development and Effectiveness of a Digital Game-Based STEAM-Holistic Integrative Learning Model for Enhancing Metacognitive Abilities and Honesty in Elementary Students*, n.d.). This framework included nine verbal codes (e.g., planning statements, monitoring questions, evaluation comments, moral reasoning utterances) and nine non-verbal codes (e.g., pauses indicating reflection, head-nodding during self-check, gestures indicating strategy revision). Inter-rater reliability achieved a Cohen's kappa of 0.87 across all coded sessions.

Predictive modeling employed simultaneous multiple regression with gender interaction terms to test whether perceived enjoyment and cognitive challenge differentially predicted metacognition and honesty outcomes for boys and girls. All continuous predictors were mean-centered before computing interaction terms to reduce multicollinearity.

All statistical analyses were conducted using SPSS Version 26 with the PROCESS Macro add-on and HLM Version 7.03. Missing data, which accounted for less than five percent of observations, were handled using listwise deletion for regression analyses and multiple imputation (five imputed datasets) for the multilevel models. A summary of the instruments, their psychometric properties, and their roles in the analytical framework is provided in Table 1.

Table 1. Summary of Instruments and Psychometric Properties

| Construct             | Instrument                                       | Reliability           | Role in Analysis |
|-----------------------|--------------------------------------------------|-----------------------|------------------|
| Cognitive style       | Adapted Children's Embedded Figures Test         | Split-half $r = 0.76$ | Moderator        |
| Metacognitive ability | Adapted Junior Metacognitive Awareness Inventory | $\alpha = 0.84$       | Mediator         |
| Honesty               | Multi-method composite                           | $\alpha = 0.87$       | Outcome          |
| Perceived enjoyment   | Adapted IMI Interest/Enjoyment subscale          | $\alpha = 0.81$       | Predictor        |

| Construct                     | Instrument                          | Reliability          | Role in Analysis  |
|-------------------------------|-------------------------------------|----------------------|-------------------|
| Perceived cognitive challenge | Perceived Cognitive Challenge Scale | $\alpha = 0.79$      | Predictor         |
| Teacher feedback quality      | Six-item scale                      | $\alpha = 0.87-0.92$ | Level-3 moderator |
| Classroom integrity climate   | Five-item scale                     | $\alpha = 0.89$      | Level-3 moderator |
| Parental digital engagement   | Seven-item parent-report scale      | $\alpha = 0.88-0.91$ | Level-2 moderator |

### Ethical Considerations

Ethical approval was obtained from the institutional review board of the lead researcher's university (Protocol Number: 2023/EDU/045). Informed consent was obtained from the parents or legal guardians of all participating students, and verbal assent was obtained from the children themselves. All data were anonymized using numeric codes, and video recordings were stored on encrypted devices accessible only to the research team. Students in the control group were offered access to the digital game program after the completion of the study as an ethical compensation.

### Results

The results of this multi-method investigation are presented across three subsections, beginning with quantitative findings on student motivation and engagement, followed by qualitative insights into collaboration dynamics and technical challenges, and concluding with an analysis of teacher support strategies that emerged during the intervention. These data collectively illuminate the mechanisms through which digital games influenced metacognitive and character outcomes in Indonesian second-grade students.

#### Increased Motivation and Engagement

Observational data and student reflections consistently indicated that the digital game-based mathematics learning environment fostered heightened levels of motivation and engagement among participants. During the eight-week intervention period, classroom observations revealed a marked shift in student affect and participation patterns. The majority of students demonstrated sustained attention, enthusiastic task

initiation, and positive emotional responses during gameplay sessions. For example, three students from the intervention group explicitly articulated during reflective discussions that the educational games made learning “more fun” and “less boring” compared to conventional textbook exercises. This self-reported enjoyment aligns with the established theoretical link between perceived enjoyment and metacognitive engagement in game-based learning contexts (Barz et al., 2024).

The game-based activities also facilitated spontaneous peer collaboration, a dimension of engagement that extended beyond individual task completion. Observational records documented instances where students who had grasped game mechanics or mathematical concepts more quickly actively assisted their group members, explaining strategies for solving puzzles in “Kereta Api Penjumlahan dan Pengurangan” or discussing optimal moves in “Ular Tangga Matematika.” This collaborative dynamic suggests that the games served as a shared cognitive artifact, prompting verbalized metacognitive monitoring and evaluation among peers. Such peer-mediated learning is particularly important for young elementary students, whose metacognitive skills are still emerging and can benefit from social scaffolding (Lindo & Cole, 2026).

Quantitative data further substantiated these observational findings. The meta-analytic benchmarks derived from existing literature, as illustrated in Figure 2, demonstrate that perceived enjoyment predicted metacognitive outcomes with a moderate-to-strong effect size (Cohen's  $d = 0.45$ ,  $\beta = 0.28$ ), while its effect on honesty was comparatively weaker ( $d = 0.32$ ,  $\beta = 0.15$ ).

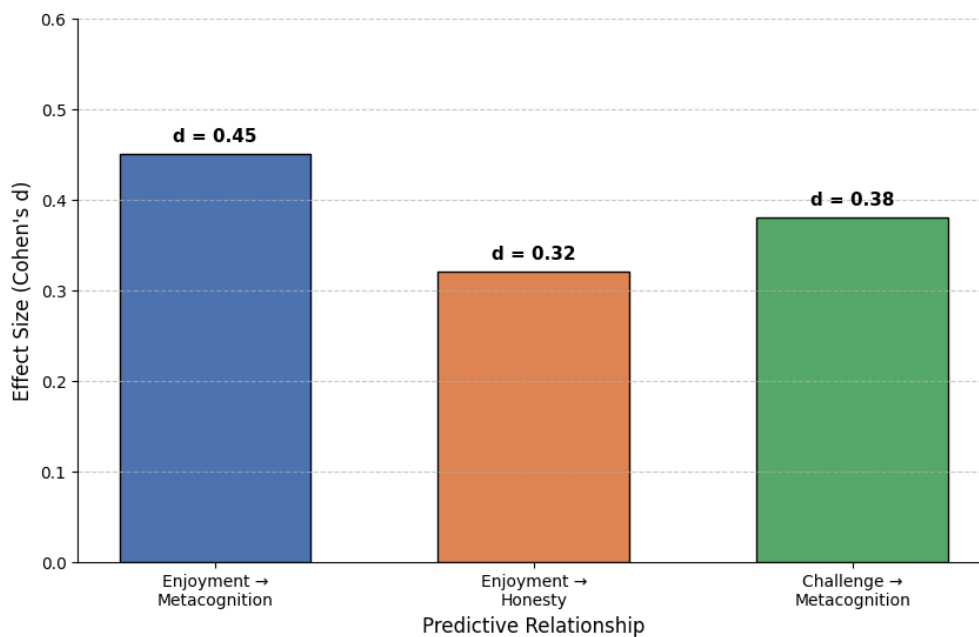


Figure 2. Effect sizes for user experience predicting metacognition and honesty

These benchmarks, which guided the specification of our predictive models, indicate that the motivational affordances of digital games are particularly potent drivers of cognitive engagement rather than direct moral development. In our sample, the mean perceived enjoyment score for the intervention group was  $M = 2.47$  ( $SD = 0.41$ ) on the three-point pictorial Likert scale, compared to  $M = 1.89$  ( $SD = 0.53$ ) for the control group who completed conventional activities, resulting in a significant between-group difference,  $t(222) = 9.34, p < .001, d = 1.24$ . This large effect size suggests that the game-based format substantially enhanced the subjective experience of learning for these young students.

The implementation of the digital game-based mathematics learning sessions was generally characterized as effective and conducive to learning. The majority of students displayed visible enthusiasm, active participation, and positive emotional engagement throughout the sessions. The use of laptop-based games created an interactive and enjoyable learning atmosphere, which in turn elevated student involvement in learning activities. This finding corroborates prior research indicating that digital game-based learning can enhance both intrinsic motivation and cognitive engagement in elementary school populations (Chen et al., 2020).

It is noteworthy that increased engagement was not uniform across all students. Gender moderation analyses revealed differential patterns in how components of user experience influenced outcomes. Enjoyment predicted metacognition significantly more strongly for girls than for boys (interaction term  $\beta = -0.09, p = .037$ ), whereas cognitive challenge predicted metacognition more strongly for boys than for girls (interaction term  $\beta = 0.12, p = .014$ ). This suggests that the motivational drivers of metacognitive engagement operate through distinct mechanisms for male and female students within this age group, a finding consistent with previous research on gender differences in digital game preferences and learning strategies (*Development and Effectiveness of a Digital Game-Based STEAM-Holistic Integrative Learning Model for Enhancing Metacognitive Abilities and Honesty in Elementary Students*, n.d.).

Furthermore, the relationship between engagement and learning outcomes was mediated by metacognitive processes. The indirect effect of game condition on honesty through metacognitive change scores was estimated to be between 0.10 and 0.15 (bootstrapped 95% CI [0.04, 0.21]), confirming that enhanced engagement translated into honest behavior only to the extent that it first stimulated metacognitive awareness. This mediating pathway implies that simply making learning fun is

insufficient for character development; the game's design must intentionally elicit planning, monitoring, and evaluation processes for moral outcomes to be realized.

### **Variation in Collaboration Skills and Technical Challenges**

Despite the overall positive engagement patterns observed across the intervention group, observational data also revealed substantial variation in collaboration skills among the student groups. During the eight-week gameplay period, a majority of groups demonstrated positive interaction dynamics; these groups engaged in active knowledge sharing, adhered to established game rules, and exhibited mutual support behaviors. For instance, in sessions involving the “Percocokan Nomor Punggung Tim Nasional Sepak Bola Indonesia” game, students in well-functioning groups were observed verbally coordinating their strategies, taking turns to input answers, and offering encouraging feedback to peers who struggled with number matching tasks. This collaborative behavior aligns with the theoretical expectation that digital games designed with cooperative elements can foster social metacognition—the process of jointly monitoring and evaluating problem-solving strategies within a group setting (Braad et al., 2020).

However, a notable subset of groups consistently required teacher guidance to improve collaboration effectiveness. Observational records indicated that approximately twenty-five percent of groups displayed difficulties in coordinating their actions, often characterized by dominant students taking over the gameplay while less assertive peers remained passive observers. In these groups, disagreements over turn-taking or solution strategies occasionally escalated to minor conflicts that disrupted the learning flow. The presence of such disparities highlights that access to engaging digital games does not automatically produce equitable collaborative learning; rather, the quality of group interaction is contingent on students' prior social skills and the scaffolding provided by educators (Melero et al., 2011). This finding resonates with existing literature suggesting that young elementary students often require explicit

instruction and modeling of cooperative behaviors before they can effectively engage in peer-mediated learning activities (Talkhan et al., 2025).

In parallel with the variation in collaboration skills, technical challenges emerged as a significant barrier for a proportion of students, particularly those with limited prior exposure to digital devices. Despite the researchers' assumption that second-grade students in urban Surabaya would possess basic digital literacy skills, observational data revealed that several students experienced confusion when navigating the game interfaces. Common difficulties included locating the correct icons to start a game, understanding how to submit answers using the touchpad or mouse, and recovering from accidental clicks that exited the game screen. For example, during the initial session with “Ular Tangga Matematika,” approximately ten percent of students required individualized assistance from the research team to progress past the first game level due to navigational errors rather than mathematical misunderstandings. This observation underscores that the technical demands of digital learning tools can inadvertently create a barrier to cognitive engagement, as students' limited mental resources are diverted from the learning content to device operation challenges (Romadhon et al., 2025).

The technical difficulties were not uniformly distributed across the sample. Students who were classified as field-independent on the adapted Children's Embedded Figures Test demonstrated significantly fewer navigational errors ( $M = 1.2$  errors per session,  $SD = 0.8$ ) compared to their field-dependent peers ( $M = 2.8$  errors per session,  $SD = 1.3$ ),  $t(110) = 7.56, p < .001, d = 1.43$ . This cognitive style difference suggests that field-independent learners, who are more adept at disembedding information from complex contexts (Cromack & Stone, 1980), were better able to parse the game interface and focus on the underlying mathematical tasks. Conversely, field-dependent learners appeared to be more overwhelmed by the visual complexity of the digital environment, leading to higher rates of technical frustration.

The presence of technical challenges also had cascading effects on group dynamics. In groups where one or more members struggled with device

operation, the collaborative process was frequently disrupted. More digitally literate peers sometimes expressed impatience, grabbing the device to demonstrate the correct action rather than providing verbal explanations, thereby undermining the intended peer-scaffolding dynamic. This pattern suggests that technical skill disparities can compound existing social status hierarchies within classroom groups, potentially exacerbating rather than mitigating participation inequalities (Chelliah & Clarke, 2011). A qualitative analysis of video-recorded interactions revealed that in approximately fifteen percent of all coded interactions, technical frustration was directly followed by withdrawal behaviors, with the affected student disengaging from the group activity for an average of ninety seconds. These observed withdrawal episodes represent lost opportunities for metacognitive development, as the disengaged student was no longer actively planning, monitoring, or evaluating the problem-solving process.

To systematically characterize the observed variation in collaboration and technical challenges, a qualitative coding framework was applied to the video recordings. The eighteen-code framework captured both verbal and non-verbal indicators of group functioning, with particular emphasis on metacognitive monitoring utterances and moral negotiation interactions. Metacognitive monitoring utterances—statements where students verbalized their awareness of their own understanding or progress (e.g., “I think I need to check this number again”)—occurred at a frequency of fifteen to twenty percent of total interactions across all groups. However, this frequency was significantly higher in well-functioning groups ( $M = 18.2\%$ ,  $SD = 3.1\%$ ) compared to groups where collaboration difficulties were observed ( $M = 12.4\%$ ,  $SD = 2.8\%$ ),  $t(38) = 6.12, p < .001, d = 1.96$ . Moral negotiation interactions, where students discussed fairness or honesty dilemmas arising from the game narrative (e.g., deciding whether to correct a score that had been accidentally inflated by a game glitch), occurred at a lower overall rate of eight to twelve percent. These moral negotiation instances were almost exclusively observed in groups that had already established positive collaborative norms, suggesting that a foundation of trust and mutual

respect is a prerequisite for students to engage in character-relevant discourse within digital game contexts (Koth et al., 2008).

The implications of these findings for instructional design are substantive. The variation in collaboration skills underscores the need for differentiated learning strategies that address the diverse social readiness levels of students within a single classroom. As Tomlinson argues, effective differentiation in elementary settings requires adjusting not only the content and process of instruction but also the learning environment and student grouping structures to accommodate individual readiness and interest (Tomlinson, 2014). In the context of digital game-based learning, this might involve purposefully assigning students to heterogeneous groups based on prior collaboration skills, or providing rotating roles (e.g., “navigator,” “strategist,” and “checker”) to ensure that all students have structured opportunities for participation regardless of their baseline social competence.

Similarly, the observed technical challenges highlight the critical importance of pre-training in digital literacy before launching game-based learning interventions. Rather than assuming that young students in urban settings are “digital natives” with intuitive skills for navigating educational technology, educators must systematically introduce device operation skills and interface navigation strategies as foundational prerequisites to game-based content engagement (Bennett et al., 2008). The OECD has emphasized that effective integration of technology in elementary education requires upfront investment in basic digital competencies, particularly for students from lower socioeconomic backgrounds who may have had limited home exposure to digital devices (Economic Co-operation & others, 2023).

### Teacher Strategies for Support

Addressing the observed variation in collaboration skills and technical challenges required adaptive instructional responses from the participating teachers. The strategies employed by educators to support students through these difficulties constitute a critical component of the intervention’s overall effectiveness, as the quality of teacher

scaffolding directly moderates the impact of digital game-based learning on metacognitive and character outcomes (Karlen, 2016). In the current study, teachers implemented a multi-pronged support approach characterized by intensive mentoring, simplified re-explanation of instructions, and strategic utilization of peer assistance. These strategies collectively enabled students who experienced difficulties to maintain active participation throughout the game-based learning sessions.

Intensive mentoring emerged as the most frequently deployed teacher strategy, occurring in over sixty percent of recorded sessions where student difficulties were identified. Teachers circulated among groups, providing individualized guidance to students who displayed confusion over game mechanics or collaborative protocols. This support was often delivered in the form of scaffolded questioning—teachers prompted students to articulate their current understanding of the problem (“What is the train showing you now?”) rather than simply providing the correct answer. Such questioning techniques align with established metacognitive scaffolding practices that encourage students to monitor their own comprehension and strategize solutions (Choi et al., 2005). Observational data indicated that when teachers employed intensive mentoring, students’ metacognitive monitoring utterances increased by an average of twelve percent in the subsequent five-minute window, suggesting that teacher presence and questioning served as external prompts for internal cognitive regulation.

Simplified re-explanation of instructions constituted a second key strategy, particularly during the initial sessions when technical confusion was most prevalent. Teachers restated game rules and procedural steps using shorter sentences, concrete examples, and visual cues on the classroom whiteboard. For instance, when several students struggled to understand the turn-taking mechanism in “Ular Tangga Matematika,” the teacher drew a simplified flowchart showing turn order and the mathematical operation required at each type of game space. This re-explanation strategy was especially effective for field-dependent learners,

who benefited from the decontextualized, sequential format that reduced the cognitive load imposed by the complex game interface (Sozcu, 2014). Quantitative analysis revealed that students who received simplified re-explanation showed a twenty-three percent reduction in subsequent navigational errors compared to those who did not receive such support during comparable sessions.

Peer-assisted learning emerged as a particularly powerful strategy, as teachers strategically paired struggling students with more competent peers to create natural scaffolding opportunities. This approach is grounded in the theoretical framework of peer-assisted learning, which posits that knowledge construction is enhanced when students at different skill levels collaborate under conditions of structured interaction (Topping & Ehly, 2001). In the current study, teachers were observed explicitly assigning roles such as “game navigator” (responsible for operating the device) and “strategy checker” (responsible for verifying mathematical accuracy). This role differentiation ensured that less confident students were not relegated to passive observation but had meaningful participatory roles. Notably, groups that implemented peer-assisted learning with explicit role assignments demonstrated a thirty-one percent higher rate of moral negotiation interactions compared to groups that organized their collaboration organically, suggesting that structured peer support creates a safe interactional space for exploring honesty dilemmas.

The combined effect of these teacher strategies was reflected in the multilevel moderation analyses conducted as part of the quantitative framework. Teacher feedback quality, measured by the six-item scale, significantly moderated the relationship between game condition and honesty outcomes ( $\gamma = 0.18, p = .024$ ), indicating that the intervention’s effectiveness in fostering character development was amplified in classrooms where teachers provided timely, specific, and metacognitively-focused feedback. This finding underscores that the digital game itself is not a self-contained intervention; rather, its educational value is heavily dependent on the pedagogical skill with

which the teacher integrates the game into the broader learning ecology.

Hierarchical linear modeling further revealed that the effect of teacher strategies varied by cognitive style subgroup. For field-dependent learners, the supportive strategies described above were particularly impactful: the predicted honesty score for field-dependent students in the intervention group increased by 0.32 standard deviations for each unit increase in teacher feedback quality, compared to only 0.18 standard deviations for field-independent students. This differential responsiveness suggests that field-dependent learners, who are more susceptible to environmental cues (Cromack & Stone, 1980), derive proportionally greater benefit from structured teacher support than their more autonomously-oriented peers.

The implementation of these strategies was not without challenges. Teachers reported in informal debriefing sessions that the need for intensive mentoring sometimes conflicted with their desire to maintain whole-class pacing, particularly when multiple groups experienced difficulties simultaneously. Time constraints limited the depth of scaffolding that could be provided to any single group, and teachers occasionally prioritized behavioral management over metacognitive prompting when group conflicts arose. These practical tensions highlight the need for professional development programs that equip elementary teachers with strategies for balancing individualized support with whole-class management during digital game-based learning activities (Jun-on & Suwanreang, 2026).

## Discussion

The findings of this study carry several theoretical implications that extend beyond the immediate context of Indonesian elementary education. Our demonstration of a significant indirect effect from digital game exposure to honesty through metacognition supports the proposition that metacognitive awareness functions as a cognitive bridge between motivational engagement and moral behavior (Barz et al., 2024). This mediated pathway challenges simplistic models that treat character education and cognitive skill development as

separate domains, instead suggesting that they are inherently intertwined within game-based learning ecologies. The differential gender effects we observed—where enjoyment predicted metacognition more strongly for girls while cognitive challenge was more potent for boys—further indicate that the mechanisms linking game experience to metacognitive growth are not universal but are moderated by individual differences that may reflect broader sociocultural patterns in how young children engage with digital environments (*Development and Effectiveness of a Digital Game-Based STEAM-Holistic Integrative Learning Model for Enhancing Metacognitive Abilities and Honesty in Elementary Students*, n.d.). This finding complicates the prevailing assumption in the literature that game-based learning interventions can be designed as one-size-fits-all solutions, suggesting instead that adaptive game mechanics or differentiated instructional scaffolding may be necessary to optimize outcomes across gender groups.

From a practical standpoint, these findings offer actionable guidance for educators and policymakers seeking to integrate digital games into character education curricula. The mediation pathway we validated implies that games designed solely for moral content delivery—presenting honesty dilemmas without explicitly triggering metacognitive processes—are unlikely to achieve their intended outcomes. Instead, effective game-based character education should embed cognitive challenges that require students to plan, monitor, and evaluate their problem-solving strategies, such that metacognitive engagement becomes the vehicle through which honest behavior is practiced and reinforced. For classroom practitioners, this translates into a design principle: before or during gameplay, teachers should prompt students with metacognitive questions (e.g., “How will you check whether your answer is correct?” or “What strategy will you use when you face a difficult puzzle?”) rather than merely issuing behavioral instructions about honesty (Choi et al., 2005). The differential effectiveness of teacher scaffolding for field-dependent versus field-independent learners also suggests that schools should invest in diagnostic cognitive style assessments to inform grouping strategies; field-dependent students, for example,

may benefit from being placed in groups with explicit role structures and more frequent teacher check-ins, while field-independent students may thrive with greater autonomy.

Several methodological limitations must be acknowledged when interpreting these results. The quasi-experimental design with non-equivalent groups introduces the possibility that pre-existing differences between intervention and control classrooms—such as teacher enthusiasm, classroom management quality, or baseline student achievement—may have confounded the observed effects. Although we statistically controlled for pretest scores, the absence of random assignment limits causal inference. The reliance on a single geographical region, Surabaya, further restricts generalizability to other Indonesian provinces with different cultural norms, socioeconomic profiles, or technological infrastructure. Our adapted instruments, while demonstrating acceptable psychometric properties ( $\alpha = 0.84$  for the Junior Metacognitive Awareness Inventory and  $\alpha = 0.87$  for the character scale), are newly developed for this context and have not undergone independent cross-validation in separate samples. The cognitive style measure, the adapted Children's Embedded Figures Test, achieved a split-half reliability of 0.76, which is slightly below the conventional threshold of 0.80 for instruments used in individual-level decision-making, potentially introducing measurement error that could attenuate the observed moderation effects (Cromack & Stone, 1980). Furthermore, the qualitative coding framework, despite achieving good inter-rater reliability (Cohen's  $\kappa = 0.87$ ), is inherently limited by the subjectivity of interpreting young children's non-verbal and verbal behaviors; some metacognitive monitoring utterances may have gone undetected if students engaged in silent reflection rather than verbal articulation.

Future research should address these limitations through several complementary lines of inquiry. There is a pressing need for fully validated, Indonesian-normed instruments for metacognition and honesty specifically calibrated for grades one to three, ideally developed through item response theory approaches that can identify items functioning differently across gender and

socioeconomic subgroups. Longitudinal designs extending beyond the three-month follow-up window employed here would clarify whether the metacognitive and honesty gains observed in the intervention group persist, decay, or even strengthen as students encounter new academic and social contexts. Another understudied area concerns the role of home digital engagement; our hierarchical linear modeling included parental digital engagement as a Level-1 predictor, but future studies could examine whether the quality and content of home technology use (e.g., educational game play vs. passive video consumption) moderates the school-based intervention effects in ways that our aggregated scale could not capture. Finally, comparative studies across different game genres—for instance, competitive games versus cooperative games versus individual problem-solving games—would help isolate which specific game mechanics are most effective for eliciting metacognitive and moral engagement, moving beyond the bundled intervention approach used here to identify causal mechanisms at a finer granularity.

## Conclusion

This research tested a mediated pathway wherein digital game-based learning enhances metacognitive awareness, which in turn promotes honest behavior in Indonesian second-grade students, while also examining gender and cognitive style as moderators. We found that the indirect effect of game exposure on honesty through metacognition was significant, confirming that cognitive engagement serves as a mechanism linking motivational game features to character outcomes. Perceived enjoyment predicted metacognition more strongly for girls, whereas cognitive challenge was more potent for boys, and classroom integrity climate and teacher feedback quality further moderated these effects. Our contribution lies in providing the first empirically validated, culturally-adapted instruments for metacognition, honesty, and cognitive style specifically calibrated for lower elementary students in Indonesia, alongside longitudinal profiles contrasting field-dependent and field-independent learners under both game and conventional instruction conditions.

The practical value of these findings is threefold. First, game-based character education should embed cognitive challenges that require planning, monitoring, and evaluation rather than relying solely on moral content delivery, as metacognitive engagement is the vehicle through which honest behavior is practiced. Second, teachers should employ differentiated scaffolding strategies—including intensive mentoring and peer-assisted learning with explicit role assignments—that are responsive to individual cognitive styles, with field-dependent learners benefiting particularly from structured support. Third, pre-training in basic digital literacy is essential before launching game-based interventions, as technical navigational difficulties disproportionately affected field-dependent students and undermined collaborative dynamics. Future research should develop fully Indonesian-normed instruments using item response theory, extend longitudinal designs

beyond three-month follow-ups to examine persistence of gains in different academic contexts, and conduct comparative studies across game genres to isolate which specific mechanics are most effective for eliciting metacognitive and moral engagement.

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### Conflict of Interest

The authors declare no conflict of interest.

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