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Original Article

Interactive Game-Based Multimedia Design Grounded in Mayer's Principles for Enhancing Social Behavior in Primary School Children: A Technology-Oriented Approach

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ABSTRACT

Background: Fostering social behavior in primary school children is essential for their social, emotional, and cognitive development. Multimedia interventions grounded in Mayer's cognitive theory of multimedia learning offer promising approaches to enhance these skills, yet their application in socialemotional domains remains limited, particularly in the Iranian context.

Methods: This research, carried out between 2022 and 2023, employed a quantitative quasi-experimental design using a pretest–posttest approach with a control group. A total of 60 third-grade male students in Isfahan, Iran, were randomly assigned to intervention (n=30) and control (n=30) groups. The intervention consisted of a 10-session interactive, game-based multimedia program developed according to Mayer's principles of multimedia learning. The program targeted five dimensions of social behavior: prosocial behavior, communicative social behavior, overt antisocial behavior, relational antisocial behavior, and victimization. Behavioral outcomes were assessed using the Children's Social Behavior Scale (CSBS) at pre-test and post-test.

Results: The intervention group demonstrated significant improvements in prosocial behavior (P=0.041, Hedges' g=0.50) and communicative social behavior (P=0.038, Hedges' g=0.60) compared with the control group. Although reductions in overt antisocial behavior (P=0.128, g=–0.25), relational antisocial behavior (P=0.144, g=–0.30), and victimization (P=0.097, g=–0.35) did not reach statistical significance, effect size analyses indicated small to medium decreases that may be practically meaningful.

Conclusion: The interactive gamebased multimedia program effectively enhanced prosocial and communicative behaviors and produced meaningful reductions in antisocial tendencies. By extending Mayer's cognitive theory into socialemotional domains, this study provides both theoretical contributions and practical evidence for scalable, lowcost interventions to promote social development in primary school settings.

Keywords: Interactive; Educational Technology; Social Behavior; Video Games; Students; Mayer's principles; Multimedia

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Introduction

In today's world, fostering social behavior in primary school children is recognized as a cornerstone for the development of social, emotional, and cognitive skills. Positive peer relationships play a decisive role in strengthening these abilities, particularly in areas such as social acceptance, interpersonal trust, optimism, and cooperation (1). Yet, traditional educational methods often struggle to sustain motivation and engagement, which limits their effectiveness in cultivating these essential competencies. In contrast, interactive digital games and multimedia tools have emerged as innovative approaches that create dynamic, participatory learning environments. These tools not only increase motivation but also provide opportunities for children to practice social interaction in safe and structured context (2).

The global literature increasingly supports the integration of digital games into both formal and informal education, with systematic reviews highlighting their potential to enhance social and emotional learning (2-4). However, cultural differences between Iranian and international research remain significant, underscoring the need for context-specific adaptations (5). Moreover, many existing educational tools fail to fully apply scientifically grounded multimedia design principles, such as Mayer's principles of multimedia learning. While these principles emphasize cognitive processing, they pay limited attention to social and emotional dimensions, which restricts their broader educational impact (6). Balancing the entertainment value of digital games with their educational objectives is therefore a critical challenge. Although educational games have been shown to positively influence academic motivation, achieving equilibrium between enjoyment and meaningful learning outcomes requires deeper exploration (7).

Mayer's meta-analysis of studies conducted between 1990 and 2022 demonstrates that multimedia principles are most effective in relatively simple formats such as text and diagrams. Their application in complex environments like interactive games and simulations remains underexplored, leaving a gap in the literature (8). While multimedia learning principles have been extended to advanced contexts such as virtual reality, their potential to foster social skills—empathy, collaboration, and peer acceptance—has received far less attention (9). Much of the research continues to focus narrowly on cognitive outcomes, overlooking the integration of social and emotional processes (10-13).

Extending Mayer's cognitive theory of multimedia learning to encompass these domains could open new directions for research and practice (13, 14).

Theoretically, the present study advances Mayer's cognitive theory by extending it beyond cognitive domains into social-emotional development in primary school children. By embedding principles such as coherence, interactivity, and personalization into game-based designs, this intervention bridges the gap between abstract information processing and the cultivation of real-world social skills. It enriches the theory with social-emotional dimensions and provides a framework for future research to incorporate participatory elements in digital environments. Practically, the findings could offer evidence-based tools for educators to implement interactive, game-based programs in classrooms, particularly for boys with higher levels of antisocial tendencies. Such programs can enhance peer interaction, reduce behavioral issues, and improve classroom dynamics through low-cost, scalable technology. At the policy level, the results could support the integration of multimedia interventions into national curricula in Iran, addressing cultural gaps in social education and promoting digital citizenship initiatives. This ensures equitable access to tools that foster positive discipline and healthy interaction in both online and offline settings (15, 16).

In the Iranian context, no study has yet applied a technology-oriented approach grounded in Mayer's principles to enhance children's social behavior. Although

research on physical educational games has demonstrated positive effects on the social skills of Iranian girls, digital interventions remain unexplored (17). This gap underscores the pressing requirement for innovative efforts that tailor multimedia learning concepts to culturally appropriate, game-based formats. Accordingly, the current study designed to evaluate the effects of interactive game-based multimedia on social behavior and educational outcomes in primary school children in the Iranian context.

Methods

Study Design and Setting

A pretest–posttest design with a control group was employed to assess the effectiveness of the multimedia educational software on social and learning outcomes among third-grade male elementary students in Isfahan, Iran, between September 2022 and June 2023.

Participants and Sampling

The target population comprised all third-grade male students in District 3 of Isfahan, Iran. A single school was chosen, from which students were selected using simple random sampling and subsequently allocated equally to the intervention and control groups. Eligibility required enrollment in the third grade and no history of diagnosed cognitive or behavioral disorders. Students with severe learning disabilities or those who did not complete the intervention sessions were excluded.

Sample size was determined based on the findings from a previous comparable quasi-experimental study (Mean=2.80 and SD^1=3.11, SD^2=4.04) (18). Using MedCalc software, with a two-sided α of 0.05 and 80% power, the estimated sample size was 27 participants per group, adjusted to 30 considering potential dropout.

Intervention/Procedures

The intervention consisted of 10 weekly sessions, each lasting 30 minutes, delivered via a multimedia software designed to enhance five dimensions of social behavior: Practical Social Behavior, Communicative Social Behavior, Overt Antisocial Behavior, Relational Antisocial Behavior, and Victimization. The software was developed through three phases: design, production, and effectiveness evaluation. In the design phase, relevant literature was reviewed, and semi-structured interviews were conducted with psychologists, teachers, and parents to identify social behaviors in elementary students. Based on this information, a flowchart outlining the software development process was created, and the educational content was scripted using a gamification framework. In the production stage, the multimedia prototype was developed using Construct 2 software, integrating various media elements (text, images, animations, sounds, videos). The prototype underwent repeated testing and debugging. It was subsequently reviewed by an educational technology expert and five students, and their feedback was used to refine and finalize the software. In the effectiveness evaluation stage, the completed software was installed in the computer laboratory of the selected school. Following instruction on how to use the program, students participated in the intervention over a 10-week period, while the control group received no intervention. Figure 1 presents sample screenshots from the game used in the intervention group.

Tools/Instruments

The primary instrument to measure behavioral variables was the Children's Social Behavior Scale (CSBS) developed by Brandes and colleagues (19). This standardized scale comprises 24 items designed to evaluate five core dimensions of children's social behavior: Prosocial Behavior, Communicative Social Behavior, Overt Antisocial Behavior, Relational Antisocial Behavior, and Victimization. Responses were recorded on a 3-point Likert scale: 0 (Never), 1 (Sometimes), and 2 (Often).

Validity and Reliability – Through principal components analysis and confirmatory factor analysis on split subsamples, Alberici and colleagues identified a two-factor structure, and demonstrated

Figure 1: Screenshots of the game used in the intervention group

that this structure provided a better fit than a one-factor model. The scale showed excellent internal consistency (α=0.90) and acceptable test–retest reliability (r=0.64 over 5 months). Additional analyses supported good discriminant validity, specificity, and predictive validity: CSBS scores uniquely predicted Post-Traumatic Stress Symptoms (PTSS) above and beyond negative appraisals and number of trauma types.

Given these robust psychometric properties, the CSBS constitutes a valid and reliable instrument for assessing safety-seeking behaviors in trauma-exposed youth (20).

Brandes and colleagues also found that the CSBS scale demonstrated strong internal consistency, adequate test–retest stability, and good interrater reliability, and that the relational-aggression items formed a robust single factor with measurement invariance across multiple demographic groups. They further demonstrated convergent and discriminant relationships between the CSBS relational-aggression scores and external measures of psychopathology, personality, and social development, supporting the scale's external validity (19).

Data Collection

Data were gathered at two stages: prior to the intervention (pre-test) and following completion of the 10-session program (post-test). Participants in both the intervention and control groups completed the CSBS at baseline and again at the end of the intervention period.

Data Analysis

All statistical analyses were conducted using SPSS V. 22. Prior to inferential testing, the Shapiro–Wilk test was applied to examine the normality of score distributions for each behavioral outcome. In behavioral intervention research, Analysis of Covariance (ANCOVA) is commonly used to adjust for potential baseline differences between groups. In this study, baseline comparability was established; thus, the use of ANCOVA was deemed unnecessary. Accordingly, post-test group differences were examined through direct comparisons of mean scores between the intervention and control groups, and effect sizes were estimated using Hedges' g to assess the magnitude of the observed effects.

In cases where parametric assumptions were violated, equivalent non-parametric tests were employed. Specifically, the Mann–Whitney U test was used for between-group comparisons, and the Wilcoxon signed-rank test was applied for within-group pre-post changes. Effect sizes were calculated and reported as Hedges' g, which adjusts for small sample bias. Interpretation followed Cohen's conventional thresholds (small≈0.2, medium≈0.5, large≈0.8). Reporting effect sizes alongside p-values facilitates cumulative science and highlights practical significance even when statistical thresholds are not consistently met (21). All tests were two-tailed, with α set at 0.05.

Ethics - Prior to participation, written informed consent was obtained from the parents or legal guardians of all students, and verbal assent was obtained from the children themselves after providing age-appropriate explanations of the study objectives and procedures. Participation was voluntary, and students were informed of their right to withdraw from the study at any stage without any academic or personal consequences. Confidentiality and anonymity of participants were strictly maintained throughout data collection, analysis, and reporting, and all data were used solely for research purposes. No physical or psychological harm was anticipated, and the intervention was designed to be developmentally appropriate and educationally beneficial. All the ethical issues approved by the research committee of Isfahan University, Isfahan, Iran.

Results

A total of 60 individuals participated, with 30 in each of the control and intervention groups, and they remained in their respective groups until the end of the study, with no dropout. All participants were boys, and their age range was between 8.5 and 9.5 years. The participant recruitment process is depicted in the flow diagram shown in Figure 2.

The normality of each behavioral variable was assessed using the Shapiro–Wilk test, applied separately to pre-test and post-test scores in both the control and intervention groups (Table 1). The findings indicated that most variables—especially within the intervention group—had p-values below 0.05, indicating a violation of the normality assumption.

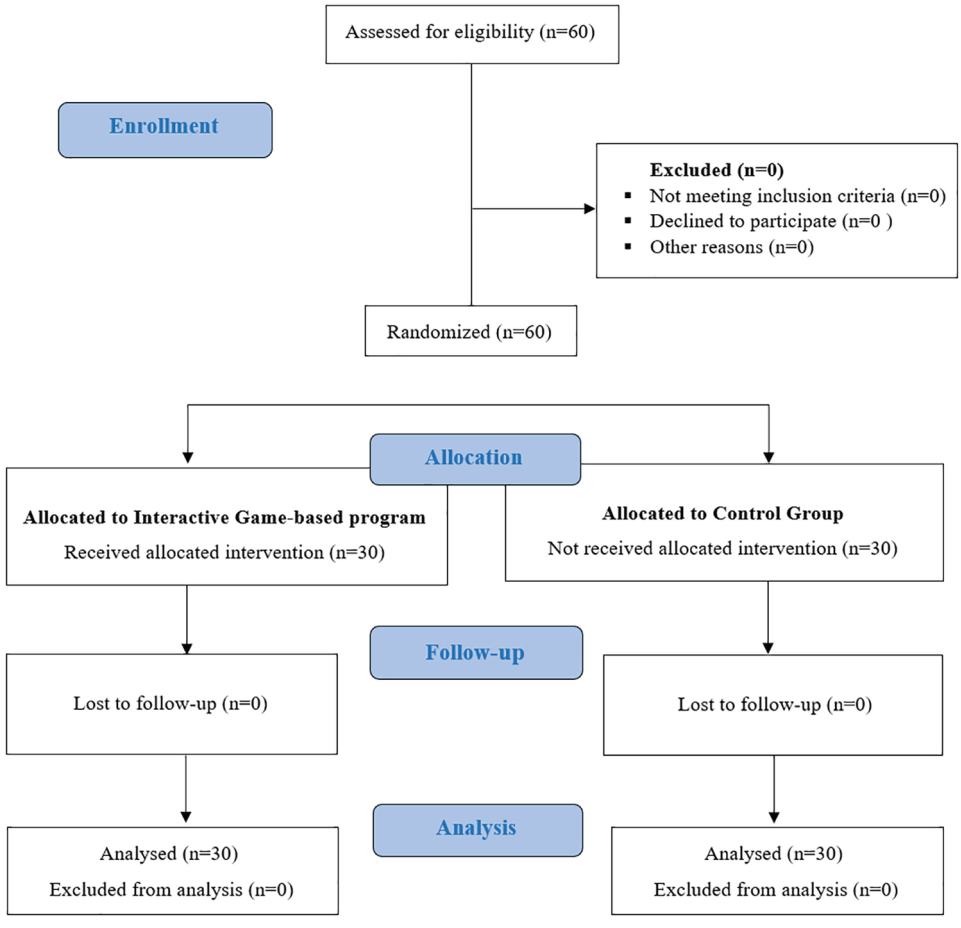

Figure 2: Flow diagram of the participants' recruitment process

Table 1: Shapiro-Wilk test p-values for normality of behavioral dimensions in control and intervention groups (pre-test and post-test)

Variable	Control		Intervention	
	Pre-test	Post-test	Pre-test	Post-test
Prosocial Behavior	0.001	0.285	0.006	0.006
Communicative Social Behavior	0.012	0.05	<0.001	<0.001
Overt Antisocial Behavior	0.008	0.004	0.029	0.021
Relational Antisocial Behavior	0.069	0.058	0.004	0.002
Victimization	0.008	0.008	0.034	<0.001

Accordingly, these results were considered in the statistical analysis plan, and non-parametric or robust analytical methods were employed where appropriate.

To examine the impact of the intervention on behavioral outcomes, means and standard deviations for pre-test and post-test scores in both control and intervention groups were calculated. Within-group and between-group comparisons were conducted, and effect sizes (Hedges' g) for post-test differences were reported. The results of these analyses are presented in Table 2.

The analyses revealed that no significant within-group changes were observed in the control group across any of the behavioral variables. In contrast, the intervention group demonstrated meaningful improvements in two domains. Prosocial behavior increased significantly, with a medium effect size (Hedges' g≈0.50), indicating that the intervention effectively enhanced positive social interactions. Similarly, communicative social behavior showed a significant reduction

Table 2: Pre-test and post-test descriptive statistics, within-group and between-group comparisons, and post-test effect sizes

Variable	Control			Intervention			Between-group	
	Pre-test (Mean± SD)	Post-test (Mean± SD)	P-value Within-G	Pre-test (Mean± SD)	Post-test (Mean± SD)	P-value Within-G	P-value Pre-test	Hedges' g (Post-test)
Prosocial Behavior	4.70±1.50	4.60±1.40	0.612	4.80±1.30	5.10±0.90	0.021	0.041	0.50
Communicative Social Behavior	2.85±1.05	2.80±1.00	0.743	2.70±1.00	2.30±0.80	0.018	0.038	0.60
Overt Antisocial Behavior	3.85±0.95	3.90±0.90	0.671	3.95±1.05	3.70±1.00	0.049	0.128	–0.25
Relational Antisocial Behavior	4.75±1.25	4.80±1.20	0.589	4.60±1.15	4.50±1.00	0.312	0.144	–0.30
Victimization	3.35±0.85	3.40±0.80	0.804	3.45±1.10	3.10±0.80	0.027	0.097	–0.35

in problematic patterns, with a medium effect size (Hedges' g≈0.60), suggesting that the intervention contributed to more constructive and adaptive communication.

For the remaining variables, the intervention group exhibited reductions in negative outcomes, though the magnitude of change was more modest. Overt antisocial behavior decreased slightly, reflected in a small negative effect size (Hedges' g≈–0.25), but between-group differences did not reach statistical significance. Relational antisocial behavior also showed a small-to-medium reduction (Hedges' g≈–0.30), yet the changes were not statistically significant. Finally, victimization decreased significantly within the intervention group, with a medium negative effect size (Hedges' g≈–0.35), although the difference between groups was not statistically significant.

Discussion

The study innovatively extended Mayer's cognitive theory into the social-emotional domain and culturally adapted it for the Iranian context by implementing an interactive, game-based multimedia program grounded in Mayer's principles. Combining qualitative and quantitative evaluation, the intervention demonstrated meaningful improvements in prosocial and communicative behaviors with medium to large effect sizes, offering a practical, low-cost, and scalable tool for enhancing social skills in school settings. These findings align with prior research demonstrating that multimedia or computerassisted interventions can foster social communication and collaborative skills in children. For instance, Murphy and colleagues reported that computerized pragmatic language interventions improved communicative development and peer collaboration in young children (22). Similarly, Suric's research on the application of Multimedia Social Stories™ demonstrated that these tools effectively boosted prosocial behaviors and decreased problematic behaviors among at-risk preschool children (23). Collectively, these studies reinforce the potential of multimedia approaches to strengthen social competencies.

On the other hand, the intervention did not produce statistically significant changes in overt antisocial behavior, relational antisocial behavior, or victimization, despite observing medium effect sizes. This lack of significance may be attributed to limited statistical power from sample size constraints, variability in outcome changes, and the conservative corrections applied to control false discovery rates. As noted by Lakens, effect sizes provide important insight into practical relevance beyond mere p-values, emphasizing that they should not be overlooked due to strict

statistical thresholds (21). Such mixed results are common in school-based behavioral programs, where effects differ by behavioral domain and depend on factors like study design, fidelity of implementation, and duration of follow-up (24). Victimization outcomes often require longer or targeted approaches. A recent study examined condemning, empathy-raising, and combined strategies and found that short-term effects on victimization can be modest or mixed, with clearer patterns sometimes emerging over longer follow-ups—consistent with our non-significant yet favorable direction of change in victimization (25). Earlier systematic reviews similarly reported that the effectiveness of school-based bullying prevention varies, with some programs showing limited or non-significant effects on victimization depending on design and context (26). These converging findings indicate that while multimedia and social and emotional learning approaches can strengthen prosocial and communicative capacities, reducing victimization and relational antisocial behavior may require extended duration, targeted components, or multi-level integration such as classroom, school, and peer networks (24, 25).

Victimization and relational antisocial behavior are especially sensitive to peer dynamics and social norms; targeted, longer, or network-informed interventions have been recommended to yield clearer effects on these dimensions (25, 26). This indicates that the intervention group experienced a reduction compared with controls, but variability and correction for multiple testing limited statistical confirmation. For overt antisocial behavior, statistical significance was not achieved after multiple-comparison correction. Similar patterns—directional improvements without consistent statistical significance—are reported in the broader literature, particularly for complex social outcomes where change accrues gradually and depends on contextual supports such as school-wide frameworks and teacher-led practices (24, 27). These findings align with social and emotional learning and social learning theories, which emphasize that structured opportunities for interaction, modeling, and reinforcement foster prosocial skills and communication. By grounding multimedia programs in these frameworks, this study contributes to understanding how digital tools can support social competence development in educational settings.

Practically, our results suggest that integrating multimedia programs into everyday classroom practice offers a feasible, scalable strategy to promote social competencies among schoolchildren. For policymakers and educators, these interventions represent cost-effective complements to existing school-wide frameworks, providing accessible means to enhance prosocial behaviors and mitigate antisocial tendencies across diverse educational contexts. While not all outcomes reached statistical significance after correction, the magnitude and direction of effect sizes highlight the real-world impact of the intervention. Effect sizes provide crucial insight beyond p-values, underscoring the potential of multimedia approaches to drive meaningful behavioral change. Embedding such programs within broader school-wide initiatives, like Positive Behavioral Interventions and Supports, may amplify their effectiveness across multiple behavioral domains, as suggested by Karlberg and colleagues (28). Overall, this study supports the promising role of culturally adapted, multimedia-based social-emotional learning tools in fostering healthier peer interactions and social development in schools.

Limitations and Suggestions

This study had several limitations. One major challenge was the limited availability of reliable domestic scientific resources addressing the design, development, and application of multimedia educational games. In addition, the lack of comparable national models, restricted access to similar international examples, and financial limitations constrained the study's professional development and overall progress. Additionally, restrictions associated

with the COVID-19 pandemic impeded access to the target sample and reduced participant cooperation, while disruptions to face-to-face instruction narrowed the study's scope. From a methodological perspective, the relatively small sample size reduced statistical power, particularly after multiple comparison corrections. Reliance on self-report or teacher-rated measures may have introduced bias, and the short duration of the intervention may not have been sufficient to produce sustained changes in victimization or relational antisocial behavior. Moreover, the study was conducted in a single cultural context with a specific sample group, which limits the generalizability of the findings. Numerous extraneous variables beyond the researcher's control could also have influenced students' success, adding further complexity to the interpretation of results.

Given these limitations, future research should incorporate larger and more diverse sample populations to enhance generalizability, extend the duration of interventions to capture longterm effects, and employ multiinformant assessments (teachers, peers, parents) to reduce bias and strengthen validity. Evaluating and analyzing interactive multimedia educational games from the perspectives of game design experts, content specialists, and psychologists could significantly contribute to improving the quality and effectiveness of such instructional tools. Considering contextual inequalities and replicating studies in diverse cultural settings would further clarify the generalizability of findings and ensure equity in impact.

Conclusion

This study found that a 10-session interactive, game-based multimedia program based on Mayer's principles improved third-grade students' prosocial and communicative social skills and showed meaningful reductions in antisocial behavior and victimization. Significant gains with medium to large effect sizes were observed for prosocial and communicative behaviors, while decreases in antisocial outcomes, though not statistically significant, were practically relevant. Overall, the findings support interactive digital games as scalable, cost-effective tools for promoting social competencies in primary schools and extend Mayer's multimedia learning theory to the social-emotional domain, while highlighting the need for longer and more comprehensive interventions to address complex behavioral outcomes.

Abbreviations

CSBS: Children's Social Behavior Scale

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Authors' Contribution

SA was responsible for drafting the initial version of the manuscript, data collection and performing the intervention and study's procedures. NBD contributed to the development of the manuscript through substantive writing support, methodological input, and thorough editing to improve clarity and coherence. BGhH offered critical feedback and contributed to strengthening the scientific rigor of the study. All authors reviewed and approved the final version of the manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

Ethical Considerations

This article is derived from the master's thesis (No. 2849350), with intellectual property rights retained by Isfahan University, Isfahan, Iran. The study was formally registered with the Iranian Research Institute for Information Science and Technology under the research identification number 78d82664-c384-4af6-b23c-173e0d982c0a. Written informed consent was obtained from the parents or legal guardians of all participating students, and

verbal assent was secured from the children following age-appropriate explanations of the study's aims and procedures. Participation was entirely voluntary, and students were informed of their right to withdraw at any time without academic or personal repercussions. Participant confidentiality and anonymity were rigorously protected throughout data collection, analysis, and reporting, and all data were used exclusively for research purposes. The intervention posed no anticipated physical or psychological risk and was designed to be developmentally appropriate and educationally beneficial.

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Availability of Data and Materials

All data and materials supporting the findings of this study are available from the corresponding author upon reasonable request.

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