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Video-Mediated Drawing Interventions for Enhancing Spatial Cognition among Young Children

Prayitno, Zulfi Hendri, Nurul Arifiyanti, Amir Syamsudin, Denny Wahyu Triawa, Rachmalia Sinta Andika Putri, Widya Dwi Hardiyanti
Universitas Negeri Yogyakarta, Sleman, Indonesia

ABSTRACT

Visual–spatial skills are foundational cognitive competencies that support young children's academic achievement, particularly in mathematics and reading comprehension. However, their integration into early childhood instructional practice remains limited. This study examined the effectiveness of a video-guided drawing intervention in enhancing preschool children's visual–spatial ability. A preexperimental one-group pretest–posttest design was used with 65 children aged 5–6 years. Teachers received structured training to ensure consistent implementation of the intervention. Visual–spatial ability was measured using a validated drawing rubric to assess object form accuracy, compositional organization, and color application. Data were analyzed using normality and homogeneity tests followed by a paired-samples t-test ($\alpha = 0.05$). The results indicated a significant improvement in visual–spatial abilities following the intervention (mean difference = −1.600, SD = 1.235), $t(64) = -10.446$, $p < 0.001$, with a 95% confidence interval of −1.906 to −1.294, indicating a large effect size. These findings suggest that video-guided drawing is an effective strategy for enhancing visual–spatial skills and support the integration of interactive video-based approaches in early childhood curricula.

Keywords: early childhood education, preschool children, video-guided intervention, visual-spatial abilities

INTRODUCTION

Visual–spatial skills are fundamental cognitive competencies that enable young children to succeed both academically and in everyday life (Fung et al., 2020). These skills encompass the ability to perceive, analyze, and mentally manipulate visual information in space, such as shapes, directions, distances, and spatial relationships. Studies consistently indicate that strong visual–spatial abilities in early childhood are positively associated with later academic achievement, particularly in mathematics, science, and reading comprehension (Wang et al., 2021). Given their foundational role, early childhood education programs worldwide have been increasing their efforts to enhance spatial cognitive development during the preschool years, when neuroplasticity is at its peak. Despite this growing emphasis, variations remain in the types, intensity, and theoretical grounding of spatial interventions implemented in educational settings. Therefore, critically examining the range of intervention approaches that have demonstrated empirical effectiveness, as well as the theoretical frameworks that inform their design and implementation, is essential.

Meta-analytical evidence has demonstrated that early spatial skills training yields substantial positive outcomes, with average effect sizes reaching 0.96 for experimental groups compared with control conditions, suggesting that diverse training strategies can significantly enhance young children's spatial ability (Yang et al., 2020). Various methods have been employed in interventions, including hands-on exploration, visual prompts, gestural spatial training, and game-based learning approaches (Ardoin & Bowers, 2020; Lahav & Wolfson, 2023; Milkova & Pekarkova, 2023). Traditional spatial training methods have predominantly relied on physical manipulatives and hands-on experiences, which have demonstrated significant effectiveness in enhancing learners' spatial reasoning skills by engaging in multisensory learning pathways and supporting the transition from concrete to abstract thinking (Bansil, 2024; Byrne et al., 2023). However, despite their proven efficacy, implementation challenges in early childhood education settings include resource limitations, varying levels of program standardization across institutions, and barriers such as insufficient duration and inadequate consideration of learner diversity in curriculum design (Bufasi et al., 2024; Faustino, Kaur, & Bussey, 2024). Recent advances in technology have expanded the opportunities for standardized spatial training delivery (Modi, Gupta, & Rahmatullah, 2024). Empirical studies indicate that both physical manipulatives and virtual manipulatives can effectively enhance spatial ability, whereas technology-enhanced interventions provide scalable and accessible alternatives to address persistent implementation constraints across diverse educational contexts (Justo et al., 2022; Karakuş, 2017; Prayitno et al., 2024).

This study addresses a significant research gap by investigating the effectiveness of a novel video-guided drawing intervention for improving preschoolers' visual-spatial abilities. Drawing activities have been recognized as valuable tools for assessing and developing spatial cognition in young children, as they require the translation of three-dimensional spatial concepts into two-dimensional representations while engaging in fine motor skills and creative expression (Berti et al., 2022; Straffon et al., 2024). The video-guided approach combines the benefits of standardized instructional delivery with engaging in artistic expression, potentially offering a scalable and effective method for spatial skill development that addresses persistent implementation challenges in early childhood settings (Brame, 2016; Huang et al., 2025). This format ensures a consistent presentation of spatial concepts and drawing techniques while allowing children to practice spatial reasoning through hands-on creative activities, leveraging principles of effective educational video design that emphasize visual demonstration and guided practice (Prayitno et al., 2024). By employing a randomized controlled experimental design, this study provides robust evidence regarding the causal impact of video-guided drawing instruction on spatial cognitive development, addressing methodological gaps in previous research that relied primarily on observational or quasiexperimental approaches (Zhang et al., 2020).

The primary objective was to evaluate the effectiveness of a structured video-guided drawing intervention on visual-spatial abilities among preschool children. On the basis of established evidence that spatial skills are particularly malleable during early childhood, we specifically hypothesized that children receiving video-guided drawing interventions would demonstrate significantly greater improvements in visual-spatial abilities (Uttal et al., 2013; Yang et al., 2020). We also explored whether intervention effects varied by child characteristics such as sex and baseline spatial ability levels given documented individual differences in spatial skill development and training responsiveness (Bogomolova et al., 2020; Rocha et al., 2022).

LITERATURE REVIEW

Social Cognitive Theory in Observational Learning

The social cognitive theory proposed by Albert Bandura emphasizes that learning occurs through the observation and imitation of models (observational learning) (Hernández-Campos, et al., 2026). Individuals tend to imitate what they observe, both directly and indirectly, allowing them to acquire contextual and meaningful understanding beyond theoretical knowledge. In the context of early childhood, learning is gained not only through direct experience but also through observing the behavior of others (Kaplan, Monroy, & Yu, 2026), including via media such as videos. Through videos, children can indirectly learn how to complete tasks by paying attention, showing interest, and attempting to understand the actions demonstrated by the model (Foti, et al., 2026).

Bandura explained that this process involves four main stages: attention, retention, reproduction, and motivation (Lee & Hemphill, 2026). Children first focus on the model presented in the video, then store the observed information in memory, reproduce it through actions such as drawing, and are ultimately driven by motivation to repeat or improve their performance. Therefore, the use of video as a medium for drawing instruction enables children to imitate visual steps systematically, supporting the development of spatial skills and visual–motor coordination. Additionally, videos allow children to observe detailed drawing techniques, while engaging elements such as colors and sound helps them sustain their attention for longer periods.

Spatial Cognition in Early Childhood

Spatial cognition in early childhood plays a crucial role in supporting overall cognitive development (Odiri & Blessing, 2026). This ability enables children to understand spatial relationships such as position, shape, size, and direction. Children with well-developed spatial cognition possess a foundational basis for logical thinking, problem-solving skills, and readiness for learning mathematics and science (Bourha, 2026). In addition, spatial cognition contributes to the development of creativity and visualization ability. Activities such as drawing, assembling, and constructing are examples of tasks that require spatial cognition. Therefore, early stimulation of spatial cognition is essential for supporting children's future academic development and life skills.

The development of spatial cognition is influenced by various factors, including learning experiences, the environment, social interaction, and the use of instructional media (Franchak, Ford, Fausey, & Luna, 2026; Stieger, Volsa, Lewetz, & Willinger, 2026). One increasingly relevant factor is the use of visual media, such as video, which can provide concrete and dynamic representations of spatial concepts. Through video, children can observe shapes, movements, and spatial relationships more clearly and engagingly, thereby facilitating comprehension and the internalization of concepts. The use of visual media can also increase children's attention and learning motivation and support learning through observation and imitation, ultimately contributing to the optimal development of spatial ability.

Video-Mediated Learning in Early Childhood Education

Video-mediated learning is an instructional approach that uses video as the primary medium to deliver information, provide demonstrations, and facilitate children's learning experiences. In the context of early childhood education, videos serve to present concrete, engaging, and easily understandable representations for young learners (Muftah, 2023). The use of video can increase children's attention, motivation, and engagement in the learning process (Cao, Wang, Li, & Tong, 2023). Furthermore, video enables children to learn through observation, imitate demonstrated steps, and transform abstract concepts into more tangible and meaningful understanding.

Numerous studies have shown that the use of video in early childhood education has a positive effect on learning outcomes. Previous research has indicated that video can improve cognitive abilities, including conceptual understanding and memory, and support the development of social skills through behavioral modeling (Ginting, et al., 2024). In addition, video has been found to be effective at enhancing creativity and problem-solving skills, particularly when it is combined with hands-on activities such as drawing or play (Mariam, Harmawati, & Sa'diah, 2024). Other studies also highlight that video-based learning helps children understand processes in a systematic and repetitive manner, thereby reinforcing learning through observation and imitation (Navarrete, 2023). Therefore, video represents a promising and relevant instructional medium in early childhood education.

RESEARCH METHOD

Research Design

This study employed a preexperimental one-group pretest–posttest design to evaluate the effectiveness of the video-guided drawing intervention on preschool children's visual–spatial abilities. This design was selected because of practical and ethical considerations commonly encountered in early childhood educational settings, where separating participants into treatment and control groups within the same classroom environment may disrupt regular learning activities. In addition, withholding potentially beneficial instructional experiences from some children may raise ethical concerns. This design allows researchers to examine changes in participants' performance before and after the intervention while maintaining ecological validity within natural classroom contexts (Creswell, 2018). However, the absence of a control group may introduce threats to internal validity, such as maturation, testing effects, and external influences. Therefore, the findings should be interpreted cautiously, and future research is encouraged to employ more rigorous experimental designs. The research design can be represented as follows:

$O_1 \rightarrow X \rightarrow O_2$.

where:

O_1 = Pretest measurement (children's drawing performance before video intervention)

X = Treatment (video-guided drawing intervention)

O_2 = Posttest measurement (children's drawing performance after video intervention)

Participants

The study involved 65 preschool children aged 5–6 years who were recruited from private schools in Yogyakarta. Participants were selected using a purposive sampling technique on the basis of the following inclusion criteria: (1) age range of 5–6 years, (2) typical developmental milestones, (3) no identified visual or motor impairments, (4) regular attendance at preschool, and (5) parental consent for participation.

Research Procedures

Prior to implementation, classroom teachers underwent comprehensive training on video-guided drawing instruction methodology. The training also incorporated strategies for establishing classroom environments (Arifiyanti et al., 2025). The 4-hour training session covered (1) the theoretical foundations of video-guided learning in early childhood, (2) proper video presentation techniques, (3) facilitating children's drawing activities, (4) maintaining engagement during instruction, and (5) standardized assessment procedures. Teachers practiced the intervention protocol using sample videos and received feedback to ensure implementation fidelity.

Data collection procedures

Pretest Phase: Children were asked to create drawings related to the designated topic without any video guidance. This baseline measurement assessed children's initial visual-spatial abilities using standardized drawing prompts. The pretest was administered one week before the intervention to establish baseline performance levels.

Intervention Phase: The teachers implemented the video-guided drawing intervention in their regular classroom settings [duration]. Each session involved (1) a brief introduction to the drawing topic, (2) viewing of the instructional video (approximately 15 minutes), (3) guided drawing activity following video demonstration, and (4) brief reflection and sharing time.

Posttest Phase: Following the intervention period, the children completed identical drawing tasks to those administered during the pretest, using the same materials and conditions. The posttest was conducted within one week of intervention completion to capture the immediate effects of the video-guided instruction.

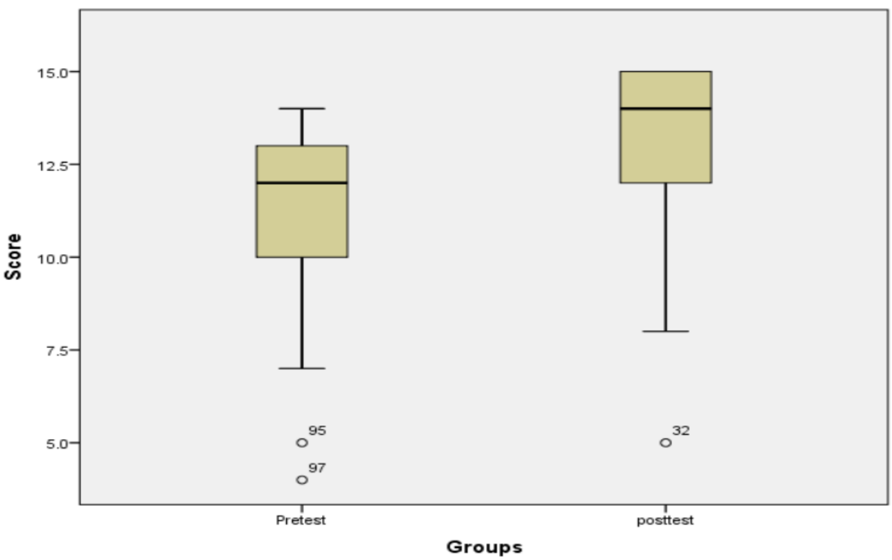
Research Instruments

The study utilized a validated drawing assessment rubric adapted from Gil-Ruiz, Martínez-Vérez, Toro, & Marulanda (2025) and Simon, Biró, & Kárpáti (2022) to evaluate children's visual-spatial abilities through their artistic productions. The instrument assessed three primary dimensions: (1) object form: line quality, shape recognition, and detail inclusion; (2) composition: spatial relationships and proportional balance; and (3) color usage: color application and variety. Each item was scored on a 3-point Likert scale (1 = not evident, 2 = somewhat evident, 3 = clearly evident), yielding total scores ranging from 7–21 points. Higher scores indicated superior visual-spatial abilities, as demonstrated through drawing performance. The instrument demonstrated strong psychometric properties in pilot testing, with a Cronbach's alpha coefficient of 0.87 indicating high internal consistency. Interrater reliability was established through independent scoring of 20% of the drawings by two trained evaluators.

Data Analysis

Prior to conducting the main data analysis, prerequisite tests were performed to ensure that the data met the required statistical assumptions. The normality test was conducted using the Kolmogorov–Smirnov and Shapiro–Wilk tests on both the pretest and posttest data of the visual spatial variable, with a significance level of $\alpha = 0.05$ (Figure 1).

Figure 1: *Results of the Normality Test*



The homogeneity of variance test was subsequently conducted using Levene's test (Table 1). Following the prerequisite tests, a paired samples t-test was conducted to examine the effectiveness of the intervention on visual spatial ability. The paired samples t-test is appropriate for analyzing differences between pretest and posttest scores within the same group in a one-group experimental design (Anderson, 2010). This parametric test examines whether there is a statistically significant difference between two related means, specifically comparing participants' performance before and after the treatment intervention. The significance level was set at $\alpha = 0.05$, and a 95% confidence interval was calculated for the mean difference. Despite the violation of normality assumptions identified in the prerequisite tests, the paired samples t-test remained appropriate given the adequate sample size ($n = 65$), which allows the central limit theorem to apply, ensuring that the sampling distribution approaches normality for large samples (Kwak & Kim, 2017).

Despite these violations of both normality and homogeneity assumptions, a paired samples t-test was conducted, given the adequate sample size ($n = 65$) and the robustness of the t-test to assumption violations with large samples. The results revealed a mean difference of -1.154 between the pretest and posttest scores, with t-statistics of -0.393 and 64 degrees of freedom, respectively. The significance value (2-tailed) was 0.695, which exceeded the alpha level of 0.05, indicating that there was no statistically significant difference between the pretest and posttest visual spatial scores. The 95% confidence interval for the mean difference ranged from -0.935 to 0.628, which included zero, further supporting the conclusion of no significant effect. Although the central limit theorem allows for parametric testing with large samples despite assumption violations, the multiple violations observed suggest that future analyses might benefit from nonparametric alternatives such as the Wilcoxon signed-rank test to ensure more robust statistical conclusions.

Table 1: *Test of Homogeneity of Variance*

Levene Statistic	df1	df2	sig
1.158	1	128	.284

Table 2: *Paired Samples T-Test*

Pair	Comparison	Mean	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper	t	df	Sig. (2-tailed)
Pair 1	Pretest – Posttest	-1.600	1.235	0.153	-1.906	-1.294	-10.446	64	0.000

RESULTS

The paired samples t-test results supported the research hypothesis regarding the effectiveness of the video-guided drawing intervention. The analysis revealed a mean difference of –1.600 (SD = 1.235; SE = 0.153), with t values of –10.446 and 64 degrees of freedom (Table 2). The significance value of 0.000 ($p < 0.001$) indicates a highly significant difference between the pretest and posttest scores. The 95% confidence interval for the mean difference ranged from –1.906 to – 1.294, demonstrating that, at the population level, improvements in visual–spatial ability consistently occurred within a 1.294 to 1.906-point range. The negative sign of the mean difference shows that the posttest scores were consistently higher than the pretest scores, confirming a clear performance improvement following the intervention.

The intervention effect size of 1.600 points with a standard deviation of 1.235 indicates that gains in visual–spatial ability occurred relatively evenly across the majority of participants. The large t statistic (–10.446) reflects a substantial effect with excellent statistical power to detect existing differences. The relatively small standard error (0.153) demonstrates high precision in estimating the population mean, further strengthening the reliability of the findings. The combination of a strong correlation ($r = 0.703$) and a significant mean increase suggests that although the relative ranking among children remained stable, all participants experienced systematic improvements in visual–spatial ability after they participated in the video-guided drawing intervention.

Overall, these analytical results provide robust empirical evidence that video-guided drawing intervention effectively enhances preschool children's visual–spatial ability. The mean improvement of 1.600 points, together with the $p < 0.001$ significance level, demonstrates that the intervention has a practically and statistically meaningful positive effect. These findings support the research hypothesis that a video-guided drawing approach can serve as an effective strategy for developing visual–spatial abilities in preschool-aged children, producing consistent and reliable effects at the population level.

DISCUSSION AND CONCLUSIONS

The results of the paired samples t-test indicated a significant improvement in preschool children's visual-spatial abilities following the video-assisted drawing intervention. These findings align with the study by Prayitno et al. (2024), who developed an animation-based learning model for children aged 5–6 years. Their model was shown to be effective in stimulating children's drawing expression through structured animated stages, with model validity reaching over 90%, and the majority of children demonstrated notable progress. The effectiveness of the intervention can be explained through several developmental and learning theories.

According to Piaget's cognitive theory, children in the preoperational stage begin to develop the ability to mentally represent objects (Ghazi et al., 2014). The incorporation of video-based instruction in the present study enabled the children to observe the drawing process in a structured, sequential manner, thereby facilitating the formation of more coherent mental representations of the objects depicted.

Beyond statistical significance, the improvement in visual-spatial ability can be explained through cognitive mechanisms associated with multimodal learning. Video-based instruction simultaneously presents dynamic visual cues, temporal sequencing, and spatial transformations, which support more effective encoding and mental manipulation of visual information. Recent studies have indicated that dynamic visual media enhances spatial reasoning and mental imagery in early learners by reducing cognitive ambiguity during complex tasks such as drawing (Chikha et al., 2021; Gustina et al., 2025). Accordingly, video-assisted drawing extends beyond simple content delivery by actively scaffolding the development of core visual–spatial processes, including mental rotation, spatial visualization, and representational accuracy.

Additionally, motivational theory suggests that active engagement in enjoyable activities can increase children's intrinsic motivation to learn (Guo Nyuhuan, 2024; Ryan & Deci, 2026). Engaging video content may increase cognitive involvement and encourage active participation in drawing tasks. Vygotsky's theory further emphasizes the importance of social interaction and environmental support in cognitive development, and videos can serve as supplementary scaffolding to guide children in understanding and completing drawing tasks (Daniels, 2026). Visual media such as video can provide step-by-step instructions and examples, making it easier for children to grasp new concepts or skills (Mayer, 2026; Tzuriel, 2021). In early childhood education contexts, video-assisted learning is particularly relevant because of preschool children's limited attention span and reliance on concrete representations. Recent research highlights that structured visual guidance helps young learners sustain focus and reduces task-related frustration during creative activities (Li, 2023; OECD, 2026). Therefore, the use of drawing videos aligns well with the developmental characteristics of preschool children, offering an age-appropriate instructional approach that supports both engagement and cognitive processing.

The intervention demonstrated consistent effects across participants, including children with lower initial abilities, who, while showing improvement, maintained their relative ranking. This pattern indicates that the intervention functioned as a general cognitive enhancer rather than a compensatory mechanism. Developmental studies suggest that while instructional support can increase overall performance, individual differences in visual-spatial ability tend to remain relatively stable over time (Koomson, 2025). Thus, video-assisted drawing appears effective at improving competence across ability levels without disrupting underlying developmental trajectories.

Further empirical analysis indicated that gains in visual–spatial skills were relatively uniform across participants, thereby supporting the reliability and potential generalizability of the findings. Comparisons with similar studies confirm the consistency of effects, such as research highlighting the effectiveness of animation models in enhancing children's drawing expression (Smith & Ye, 2025; Smith et al., 2023; Srivastava et al., 2025). These studies also note that animations can serve as an accessible and enjoyable learning tool while preserving children's unique drawing styles when transformed into animated forms (Smith & Ye, 2025). However, findings also suggest that overly complex animations, both spatially and temporally, may hinder children's understanding of broader structures, indicating that animation-based learning models should be adjusted according to the complexity of the material (Ploetzner & Fillisch, 2017). Overall, animation-supported approaches appear most effective when they are systematically aligned with learners' developmental characteristics and cognitive capacities.

These findings have important practical and research implications. Interactive videos may serve as an effective strategy for enhancing children's visual-spatial skills and can be integrated into early childhood curricula or creativity-oriented learning modules. Future research should explore the long-term effects of such interventions, investigate combinations with other learning media to maximize effectiveness, and adapt interventions for children with special needs or diverse cultural contexts to ensure broader inclusivity and impact.

Despite the promising results, several limitations should be considered. First, the study employed pretest–posttest measures in a single group, which makes it difficult to fully control for external factors that might influence outcomes, such as variations in parental involvement or children's prior drawing experience. Furthermore, the data obtained in this study may serve as preliminary evidence for future studies that include experimental designs with control groups. The present findings provide baseline empirical data that can guide the development of larger and more controlled investigations aimed at validating the effectiveness of video-guided drawing interventions in enhancing preschool children's visual–spatial abilities. Second, the sample was relatively homogeneous and drawn from a single region or type of educational institution, limiting the generalizability of the findings to preschool populations with different social, cultural, or geographic backgrounds.

This study provides strong empirical evidence that a video-assisted drawing intervention can significantly increase preschool children's visual spatial skills. The paired-samples t-test revealed meaningful and consistent gains across participants, confirming both statistical and practical significance. These results support and extend the literature on animation- and video-based learning, showing that step-by-step visual modeling effectively strengthens children's mental representations, engagement, and motivation to learn. The discussion also highlights theoretical underpinnings from Piaget's cognitive development, Vygotsky's scaffolding, and motivational theory, suggesting that structured multimedia experiences can foster cognitive growth in early childhood.

IMPLICATIONS

The findings imply that integrating interactive video into early childhood curricula is a feasible and impactful strategy for nurturing visual–spatial development while also offering a flexible model adaptable to diverse educational contexts. Moreover, the study acknowledges methodological limitations such as a single-group design and a relatively homogeneous sample, which warrant caution in generalizing the results. Future research should examine long-term effects, include more heterogeneous populations, and explore blended media approaches to broaden their applicability. Overall, the results of this study underscore that thoughtfully designed video-assisted drawing activities can serve as an effective and engaging pathway for supporting young children's creative and cognitive development.

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REFERENCES

Anderson, C. J. (2010). The Corsini encyclopedia of psychology. In *The Corsini Encyclopedia of Psychology* (pp. 1–3). Wiley. https://doi.org/10.1002/9780470479216.corpsy0161

Ardoin, N. M., & Bowers, A. W. (2020). Early childhood environmental education: A systematic review of the research literature. *Educational Research Review*, *31*, 100353. https://doi.org/10.1016/j.edurev.2020.100353

Arifiyanti, N., Dwiningrum, S. I. A., & Syamsudin, A. (2025). Strategies of indonesian kindergarten teachers for developing children's prosocial behavior. *Journal of Education Culture and Society*, *16*(1), 57–75. https://doi.org/10.15503/jecs2025.2.57.75

Bansil, A. G. , & Y. E. V. (2024). Educational intervention involving physical manipulatives to enhance spatial reasoning skills of Grade 7 learners. *Journal of Positive School Psychology*, *6*(3), 1–9.
Berti, S., Cigala, A., & Sharmahd, N. (2022). Draw.in.g.: A tool to explore children's representation of the preschool educational environment. *Frontiers in Psychology*.
Bogomolova, K., van der Ham, I. J. M., Dankbaar, M. E. W., van den Broek, W. W., Hovius, S. E. R., van der Hage, J. A., & Hierck, B. P. (2020). The effect of stereoscopic augmented reality visualization on learning anatomy and the modifying effect of visual-spatial abilities: A double-center randomized controlled trial. *Anatomical Sciences Education*, *13*(5), 558–567. https://doi.org/10.1002/ase.1941
Bourha, D., Hatzigianni, M., Sidiropoulou, T., & Vitoulis, M. (2026). From Blocks to Bots: The STEM Potential of Technology-Enhanced Toys in Early Childhood Education. *Behavioral Sciences*, 16. https://doi.org/10.3390/bs16010161.
Brame, C. J. (2016). Effective educational videos: principles and guidelines for maximizing student learning from video content. *CBE—Life Sciences Education*, *15*(4), es6. https://doi.org/10.1187/cbe.16-03-0125
Bufasi, E., Lin, T. J., Benedicic, U., Westerhof, M., Mishra, R., Namsone, D., Dudareva, I., Sorby, S., Gumaelius, L., Klapwijk, R. M., Spandaw, J., Bowe, B., O'Kane, C., Duffy, G., Pagkratidou, M., & Buckley, J. (2024). Addressing the complexity of spatial teaching: a narrative review of barriers and enablers. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1306189
Byrne, E. M., Jensen, H., Thomsen, B. S., & Ramchandani, P. G. (2023). Educational interventions involving physical manipulatives for improving children's learning and development: A scoping review. *Review of Education*, *11*(2). https://doi.org/10.1002/rev3.3400
Cao, X., Wang, F., Li, H., & Tong, Y. (2023). Characters' realism, not familiarity, improved Chinese children's learning from video. *Journal of Children and Media*, 17, 409 - 425. https://doi.org/10.1080/17482798.2023.2227290.
Chikha, A., Khacharem, A., Trabelsi, K., & Bragazzi, N. L. (2021). The effect of spatial ability in learning from static and dynamic visualizations: A moderation analysis in 6-year-old children. *Frontiers in Psychology*, *12*, 583968. https://doi.org/10.3389/fpsyg.2021.583968
Creswell, J. W. , & C. J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). *Sage Publications*.
Daniels, H. (2026). *Vygotsky in the digital age: Social interaction, scaffolding, and technology-enhanced learning*. Routledge.

Faustino, A., Kaur, G., & Bussey, M. (2024). Instructional technologies of education in East African countries: An overview. *Journal of Interdisciplinary Studies in Education*, *13*(S1). https://doi.org/10.32674/arn6je58

Foti, F., La Rosa, V., Pullano, L., Iaquinta, T., & Commodari, E. (2026). The Role of the Different Components of Attention on Observational Learning in Early Primary School Children: New Insights and Educational Implications. *Brain Sciences*. https://doi.org/10.3390/brainsci16020237.

Franchak, J., Ford, J., Fausey, C., & Luna, A. (2026). Infants' Daily Routines Shape Opportunities for Perceptual-Motor Exploration.. *Developmental science*, 29 2, e70119 . https://doi.org/10.1111/desc.70119.

Fung, W. K., Chung, K. K. H., & Lam, C. B. (2020). Mathematics, executive functioning, and visual–spatial skills in Chinese kindergarten children: Examining the bidirectionality. *Journal of Experimental Child Psychology*, *199*, 104923. https://doi.org/10.1016/j.jecp.2020.104923

Ghazi, S., Khan, U., Shahzada, G., & Ullah, K. (2014). Formal operational stage of Piaget's cognitive development theory: An implication in learning mathematics. . *Journal of Educational Research*, *17*, 71–81.

Gil-Ruiz, P., Martínez-Vérez, V., Toro, W., & Marulanda, W. (2025). Children's Drawing and Graphic Development: An Empirical Study of the Developmental Stages According to Lowenfeld. *Education Sciences*. https://doi.org/10.3390/educsci15060681.

Ginting, D., Woods, R., Barella, Y., Limanta, L., Madkur, A., & How, H. (2024). The Effects of Digital Storytelling on the Retention and Transferability of Student Knowledge. *SAGE Open*, 14. https://doi.org/10.1177/21582440241271267.

Guo Nyuhuan. (2024). Beyond rewards and punishments: enhancing children's intrinsic motivation through self-determination theory. *World Journal of Advanced Research and Reviews*, *21*(2), 1576–1583. https://doi.org/10.30574/wjarr.2024.21.2.0457

Gustina, D., Mariana, N., & Wiryanto, W. (2025). Augmented reality-based ethnomathematics learning media to enhance spatial ability in 3D geometry for fifth grade elementary students. *Journal of Innovation and Research in Primary Education*, *4*(2), 1229. https://doi.org/10.56916/jirpe.v4i2.1229

Hernández-Campos, M., Hilliger, I., Prado-Calderón, J., Martínez-Abad, F., & García-Peñalvo, F. (2026). Factors associated with 21st-century learning outcomes in higher education: A learning analytics model grounded in social cognitive theory. *Computers in Human Behavior Reports*. https://doi.org/10.1016/j.chbr.2026.100981

Huang, L., Leung, S. K. Y., Li, J. W., & Wu, Z. (2025). How does comprehensive art education facilitate children's creativity? A mixed-methods study in China. *Early Education and Development*, *36*(2), 460–476. https://doi.org/10.1080/10409289.2024.2404822

Justo, E., Delgado, A., Llorente-Cejudo, C., Aguilar, R., & Cabero-Almenara, J. (2022). The effectiveness of physical and virtual manipulatives on learning and motivation in structural engineering. *Journal of Engineering Education*, *111*(4), 813–851. https://doi.org/10.1002/jee.20482

Kaplan, B., Monroy, C., & Yu, C. (2026). Seizing Learning Opportunities in Everyday Life: Infants Are Attentive During Non-Child-Directed Activity. *Developmental Science*, 29. https://doi.org/10.1111/desc.70141.

Karakuş, F. (2017). *The* effects of dynamic geometry software and physical manipulatives on preservice primary teachers' van Hiele levels and spatial abilities. *Turkish Journal of Computer and Mathematics Education, . 5*(2), 102–123.

Koomson, D. (2025). The effect of metacognitive strategies on spatial visualization performance in geometry. *European Journal of Education Studies*, *12*(10), 6226. https://doi.org/10.46827/ejes.v12i10.6226

Lahav, O., & Wolfson, A. (2023). Enhancing spatial skills of young children with special needs using the Osmo Tangram based on tangible technology versus a Tangram card game. *Virtual Reality*, *27*(1), 451–463. https://doi.org/10.1007/s10055-022-00665-z

Lee, Y., & Hemphill, M. (2026). Implementing Mediational Observational Learning Techniques for Social Emotional Learning in Specific Physical Education Content. *Journal of Teaching in Physical Education*. https://doi.org/10.1123/jtpe.2024-0212.

Li, J. (2023). The Use of Color in Illustration. *Communications in Humanities Research*, *16*(1), 6–11. https://doi.org/10.54254/2753-7064/16/20230021

Mariam, D., Harmawati, H., & Sa'diah, T. (2024). Effect of Animated Video Media on Creative Thinking in Elementary School IPAS (Natural and Social Sciences) Learning. *Journal of Education Method and Learning Strategy*. https://doi.org/10.59653/jemls.v2i03.1128.

Mayer, R. E. (2026). *Multimedia learning and instructional design in contemporary education* (3, Ed.). Cambridge University Press.

Milkova, E., & Pekarkova, S. (2023). Spatial skills malleability of preschool children. *Interactive Learning Environments*, *31*(5), 3244–3256. https://doi.org/10.1080/10494820.2021.1922462

Modi, S., Gupta, T., & Rahmatullah, M. . (2024). Digital storytelling as a tool for global citizenship and sustainability: Enhancing cross-cultural understanding in education. *Journal of Interdisciplinary Studies in Education*, *13*(S1). https://doi.org/10.32674/s817ax14

Muftah, M. (2023). Implementing Animated Videos to Enhance Vocabulary Comprehension among Early Childhood EFL Learners. *Mextesol Journal*. https://doi.org/10.61871/mj.v47n4-9.

Navarrete, E., Nehring, A., Schanze, S., Ewerth, R., & Hoppe, A. (2023). A Closer Look into Recent Video-based Learning Research: A Comprehensive Review of Video Characteristics, Tools, Technologies, and Learning Effectiveness. *International Journal of Artificial Intelligence in Education*, 35, 1631 - 1694. https://doi.org/10.1007/s40593-025-00481-x.

Odiri, O., & Blessing, O. (2026). Early Intervention as the Foundation for Early Childhood Math Learning. *Asian Journal of Early Childhood and Elementary Education*. https://doi.org/10.58578/ajecee.v6i1.8855.

OECD. (2026). *Learning and teaching in the digital era: Evidence from early childhood education*. OECD Publishing.

Ploetzner, R., & Fillisch, B. (2017). Not the silver bullet: Learner-generated drawings make it difficult to understand broader spatiotemporal structures in complex animations. *Learning and Instruction*, *47*, 13–24. https://doi.org/10.1016/j.learninstruc.2016.10.002

Prayitno, P., Harun, H., Syamsudin, A., Purwoko, R. Y., & Setiana, D. S. (2024). Animation-based learning model to stimulate drawing work in children aged 5-6 years. *Journal of Pedagogical Research*. https://doi.org/10.33902/JPR.202427516

Rocha, K., Grogan, K., & Ramsey, R. (2022). What makes online teaching spatial? Examining the interactions among teachers' spatial skills, spatial anxiety, and spatial pedagogy. *Frontiers in Education*, *7*.

Ryan, R. M., & Deci, E. L. (2026). Self-determination theory and intrinsic motivation in digital learning environments. *Journal of Educational Psychology*, *118*(4), 557–576.

Simon, T., Biró, I., & Kárpáti, A. (2022). Developmental Assessment of Visual Communication Skills in Primary Education. *Journal of Intelligence*, 10. https://doi.org/10.3390/jintelligence10030045.

Smith, H. , H. N., & Ye, Y. (2025). *Animating childlike drawings with 2.5D character rigs.* .

Smith, H. J., Zheng, Q., Li, Y., Jain, S., & Hodgins, J. K. (2023). A Method for Animating Children's Drawings of the Human Figure. *ACM Transactions on Graphics*, *42*(3), 1–15. https://doi.org/10.1145/3592788

Srivastava, A., Smith, H., Nguyen-Phuoc, T., & Ye, Y. (2025). *ChildlikeSHAPES: Semantic hierarchical region parsing for animating figure drawings.* .

Stieger, S., Volsa, S., Lewetz, D., & Willinger, D. (2026). Spatial Cognition in the Field: A New Approach Using the Smartphone's Compass Sensors and Navigation Apps. *Journal of Intelligence*. https://doi.org/10.3390/jintelligence14010014.

Straffon, L. M., Hoff, E., & Core, C. (2024). Exploring the role of parental support and cultural learning context in children's representational drawing development. . *Early Childhood Research Quarterly*, (67), 56–68.

Tzuriel, D. (2021). *The Socio-Cultural Theory of Vygotsky* (pp. 53–66). https://doi.org/10.1007/978-3-030-75692-5_3

Uttal, D. H., Meadow, N. G., Tipton, E., Hand, L. L., Alden, A. R., Warren, C., & Newcombe, N. S. (2013). The malleability of spatial skills: A meta-analysis of training studies. *Psychological Bulletin*, *139*(2), 352–402. https://doi.org/10.1037/a0028446

Wang, S., Hu, B., & Zhang, X. (2021). Kindergarteners' spatial skills and their reading and math achievement in second grade. . *Early Childhood Research Quarterly*, *57*, 289-300.

Yang, W., Liu, H., Chen, N., Xu, P., & Lin, X. (2020). Is Early Spatial Skills Training Effective? A Meta-Analysis. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01938

Zhang, X., Chen, C., Yang, T., & Xu, X. (2020). Spatial Skills Associated With Block-Building Complexity in Preschoolers. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.563493

Prayitno, Prayitno is a lecturer at the Faculty of Education, Universitas Negeri Yogyakarta (UNY), whose work focuses on creativity skills through play-based and art-based learning and innovation in learning models. Email: prayprayitno576@uny.ac.id

Hendri, Zulfi, is a professor at the Faculty of Languages and Arts, Universitas Negeri Yogyakarta (UNY). His research focuses on art education and creative pedagogy, the development of teaching materials that integrate local potential and digital approaches, and the integration of character education and cultural values in visual arts. Email: zulfi_hendri@uny.ac.id

Arifiyanti, Nurul, is a lecturer at the Faculty of Education, Universitas Negeri Yogyakarta (UNY), whose work focuses on early childhood development, particularly motor, social-emotional, and prosocial skills, as well as innovation in learning and technology integration. Email: nurularifiyanti@uny.ac.id

Syamsudin, Amir is a lecturer at the Faculty of Education, Universitas Negeri Yogyakarta (UNY), whose work focuses on the development of religious and moral values in early childhood education. Email: amirsyamsudin@uny.ac.id

Triawan, Denny Wahyu, is a lecturer at the Faculty of Languages and Arts, Universitas Negeri Yogyakarta (UNY), whose work focuses on art education, particularly visual arts learning, cultural art studies, and the integration of technology in teaching practices. Email: dennywahyutriawan@uny.ac.id

Putri, Rachmalia Sinta Andika, is a student in the Early Childhood Education Teacher Education Program, Faculty of Education, Universitas Negeri Yogyakarta (UNY), with an academic interest in early childhood learning and development. Email: rachmaliasinta.2022@student.uny.ac.id

Hardiyanti, Widya Dwi, is a Master's Student in the Department of Early Childhood Education, Faculty of Education, Universitas Negeri Yogyakarta (UNY), with an academic interest in early childhood learning and development. Email: widyadwi.2024@student.uny.ac.id