

Enhancing the emotion regulation of preschool children through the EmoPlay Pals App: Evidence from China

Meng Yao, Melissa Ng Lee Yen Abdullah ^{*} 

Educational Studies, Universiti Sains Malaysia, Penang, Malaysia

ARTICLE INFO

Keywords:
Digital app
Emotion regulation
Preschool children
Quasi-experimental study

ABSTRACT

Although interest in technology-assisted interventions is increasing, studies involving preschool-aged children remain limited. This gap is especially evident in the lack of empirical work on culturally adapted digital tools that help young children manage their emotions. In the Chinese context, most existing approaches continue to rely on traditional materials such as picture books, and only a small number of studies have examined interactive applications grounded in psychological theory. To address this gap, the present study examined the effectiveness of the *EmoPlay Pals* App, an interactive Mandarin-language application designed with familiar cultural contexts, everyday preschool routines, and age-appropriate role models for Chinese children. A quasi-experimental pre-test–post-test design with a delayed post-test was used. The sample consisted of 100 preschool children aged 4–5 years from two kindergartens in Chengdu, China, randomly assigned to either the experimental group ($n = 50$) or the control group ($n = 50$). Over eight weeks, the experimental group used the *EmoPlay Pals* App during classroom activities, while the control group continued with picture-book–based emotional learning activities. Emotion regulation was assessed at baseline, immediately after the intervention, and again three weeks later. Semi-structured interviews with teachers added further insight into classroom behaviours and children's use of the strategies taught. Repeated-measures ANOVA showed a significant group $\times$ time interaction, with the experimental group showing improvements that continued beyond the intervention period. Teachers echoed these patterns, reporting noticeable gains in attention, impulse control, and adaptability among the children who used the app. Overall, the findings show that a theory-informed, culturally grounded digital tool can meaningfully support preschool children's emotion-regulation development, pointing to its potential value in early childhood education.

1. Introduction

Emotion regulation is a complex and multidimensional process involving the conscious use of cognitive resources to perceive, recognise, understand, and manage emotions (Chambers et al., 2009). Early childhood is a critical developmental stage for acquiring emotion regulation skills, which are not only linked to children's mental health but also exert a profound and lasting influence on their social adaptation and future interpersonal relationships (Wyman et al., 2010). According to the latest Chinese 'Guidelines for Learning and Development of Children Aged 3–6' (Huang et al., 2022), the emotional development requirements for 4–5-year-old children specify that they should demonstrate emotional stability, the capacity to express positive emotions, and the ability to apply regulation strategies appropriately. However, a growing body of research indicates that the ability of

Chinese preschool children to regulate emotions remains insufficient (Xie et al., 2021). Moreover, China's highly structured education system places considerable pressure on students, including preschoolers, who are already expected to meet demanding academic standards imposed by both schools and families at a young age. These combined cultural and educational pressures create distinctive challenges for Chinese children in developing emotion regulation (Deng et al., 2022).

A large body of psychological research points to traits such as social difficulties, impulsive behaviour and inattention stemming from a lack of emotional regulation skills in young children (Spinelli et al., 2021). In the preschool stage, children are in a sensitive period of self-regulation development, and their executive brain functions, and emotion recognition and expression systems are not yet fully mature. The ability to regulate negative emotions and maintain positive emotions is, thus, crucial to their physical health, emotional health, and

^{*} Corresponding author at: School of Educational Studies, Universiti Sains Malaysia, Penang, Malaysia.
E-mail address: melissa@usm.my (M.N.L.Y. Abdullah).

cognitive development at this stage. Consequently, external support and systematic intervention are critical (Xie et al., 2021) (Rademacher & Koglin, 2018). It is already common-practice among many educators to encourage the implementation of evidence-based interventions and practices which address social, emotional, and behavioural needs in educational settings. Through such intervention, children can acquire additional skills and knowledge to support the regulation of their emotions (McLeod et al., 2017; Zheng, 2023). In recent years, digital apps have shown great potential as innovative tools in the field of mental health and emotion regulation; their convenience, interactivity, and universality have positioned them as practical options for emotional-regulation education (e.g., Bettis et al., 2022; Gómez-Cambronero et al., 2024; Nicolaidou et al., 2022). However, the majority of these digital apps focus on function and structure, and are primarily aimed at adults, ignoring the effectiveness of app intervention for preschool children. Furthermore, existing Chinese research has concentrated mostly on older children (e.g., Hao & Zhu, 2020) and adolescents (e.g., Gong et al., 2022), and few studies discussed emotion regulation intervention for children aged 4–5 years. Additionally, most available studies continue to rely on traditional, non-digital approaches (e.g., Tian, 2022). Of course, pre-school intervention in other regions (e.g. Rashedi et al., 2021) offer useful references, but their applicability in China is limited due to cultural differences. Overall, research on digital tools for supporting emotion regulation among Chinese preschool children is still at an early stage and lacks theory-driven, systematically designed interventions. To address these gaps, the present study draws on Emotional Intelligence Theory and Gross's process model of emotion regulation to develop *EmoPlay Pals*, a digital intervention tailored for preschool children aged 4–5. Using a quasi-experimental design, this study evaluates the effects of the intervention on three core dimensions of emotion self-regulation: attention, impulse control, and adaptability. The following research questions are considered:

1. Do preschool children who use the *EmoPlay Pals* App demonstrate better emotion regulation (attention, impulse control, and adaptability) than those who use the general picture book approach?
2. Do preschool children demonstrate significant and sustained improvements in emotion self-regulation (attention, impulse control, and adaptability) after using the *EmoPlay Pals* App?
3. How do teachers describe observed changes in preschool children's emotion regulation (attention, impulse control, and adaptability) after using the *EmoPlay Pals* App?

Through using the *EmoPlay Pals* App, children are progressively guided to recognise, understand, and regulate emotions in context, overcoming the limitations of prior research focussed solely on isolated skills. The application also integrates scaffolded animation-based tasks and interactive operations, enabling parents and teachers to actively participate in the intervention process. Compared with traditional approaches, *EmoPlay Pals* offers a more accessible and engaging option by providing a structured, participatory, and child-friendly mode of intervention. The application is unique in its combination of emotion self-regulation training with multisensory interactive technology, building a dynamic, contextualised, and operational learning environment. The design incorporates voice prompts, visual animations, and tactile feedback to strengthen attention control and kinaesthetic engagement, thereby enhancing immersion and improving the validity of self-regulation strategies. One central feature of the app is the use of animated characters that portray everyday emotional challenges and model workable strategies, allowing children to observe, imitate, and gradually apply these techniques in real situations. A key feature of the app is the use of animated characters that model emotional challenges and solution strategies, encouraging children to imitate, internalise, and apply learned techniques, creating pathways for strategy generalisation. In the implementation and testing of this application in context, the study adds to current understanding of how digital interventions can be developmentally designed to support emotion self-regulation in preschool-aged children.

2. Literature review

2.1. Traditional emotion regulation intervention research

Social learning theory asserts that children learn emotion regulation by observing and imitating the behaviour of others, especially parents and peers (Tang et al., 2023). Therefore, emotion regulation intervention emphasises role modelling and imitation learning. As emotion guides, parents can use emotion education techniques to help children recognise and manage emotions (Li et al., 2023). Role-playing games have also been shown to help children learn how to control and express emotions in simulated social situations through simulated scenarios (Lahiya et al., 2022). Evidence shows that emotion regulation ability is closely related to children's cognitive development, especially at 4–5, when children are transitioning from relying on external help to autonomous regulation (Lin & Faldowski, 2023). This suggests that effective intervention should strengthen both children's emotional understanding and their growing capacity for self-control. Cognitive behavioural therapy helps children identify negative emotions, recognise the irrational components of emotions, and regulate emotions through developing healthier thinking patterns (Terjesen et al., 2021). Social-emotional learning theories also suggest that children learn emotion regulation skills in social interactions (Hosokawa et al., 2024). Traditional social-emotional learning intervention methods generally include emotion awareness training, emotion expression training, and social skills training. For example, children learn how to regulate emotions in different social situations through role-playing activities and emotion card-matching games. In addition, some studies have shown the effectiveness of play therapy using toys, sandbox games, etc., to enable children to express their emotions in an informal environment (e.g., Kaizar & Alordiah, 2023). Similarly, art therapy can help children express their emotions through visual and auditory stimulation while enhancing their ability to understand emotions (Haeyen, 2024).

Currently, Chinese scholars have implemented various intervention measures to improve children's emotional regulation and abilities (e.g., Tian, 2022; Xie et al., 2021), such as emotional-themed picture books, music activities, themed cartoons, situational ball games, educational dramas, etc. These interventions have achieved varying degrees of significant effects, yet several limitations remain. First, these traditional interventions require a specific time and place. This may result in children being unable to continue to receive interventions in extracurricular or home environments, which minimises long-term effects. Second, many traditional methods (such as picture books, situational games, educational dramas, etc.) rely on physical materials and teacher guidance and are consequently challenging to promote on a large scale, especially in resource-poor areas. These approaches often provide limited opportunities for repeated practice and individualized feedback, making it difficult for children to internalise regulation strategies beyond the intervention context. Traditional interventions predominantly utilize static materials and verbal instruction, resulting in relatively limited interaction and difficulty maintaining young children's attention and motivation over time. Besides, most research in China focuses on children aged 5–6 years (e.g., Hao & Zhu, 2020) or adolescent and adult groups (e.g., Ding et al., 2022; Gong et al., 2022), while research on emotion regulation interventions for children aged 4–5 years, a critical developmental stage, is relatively scarce. Many prior studies rely predominantly on single post-intervention measurements or short-term pre-post comparisons (e.g., Wu et al., 2021; Xie et al., 2021), making it difficult to determine whether observed effects reflect stable developmental changes or transient. Similarly, quantitative methods alone lack a deep understanding of the actual behavioural changes in children in the classroom environment. Although intervention studies from other regions offer useful ideas, many are grounded in Western theories and classroom practices (e.g., Nicolaidou et al., 2021; Olson et al., 2019), which raises questions about cultural fit and limits their direct application to Chinese preschool settings. Table 1 presents a

Table 1

Comparison of traditional emotion regulation interventions and the present digital app-based intervention.

Intervention approach	Theoretical support	Core mechanism	Experimental Design	Participants	Implementation context
Emotion-themed picture book interventions (Hao & Zhu, 2020; Tian, 2022)	Emotion competence theory; Vygotsky's sociocultural theory	-Adult-guided story reading -Emotion word learning -Emotion understanding via story characters -Guided discussion of emotion situations (causes & outcomes) -Gradual internalisation of emotion understanding	-Quasi-experimental pre-post design -Emotion recognition / labelling tasks -Immediate post-test	Children aged 5–6 years across included studies	-Classroom-based -Teacher-led shared reading -Physical picture books; printed emotion cards
Role-play and drama-based interventions (Lahiya et al., 2022; Richard et al., 2021; Tian, 2022)	Vygotsky's sociocultural theory	-Situation enactment -Behavioural rehearsal -Perspective-taking (role assumption) -Guided imitation -Guided feedback and coaching	-Quasi-experimental or cluster-based design -Observational ratings and teacher reports -Immediate post-test	Children aged 5–6 years across multiple studies	-Classroom-based -Teacher- or adult-facilitated role-play sessions -Physical props, costumes, puppets, situational setups
Cognitive training-based interventions (Muir et al., 2023; Xie et al., 2021)	Executive function theory; Cognitive development theory	-Inhibitory control training -Attentional control training	-Randomised or quasi-experimental design -Standardised executive function and emotion-regulation tasks -Immediate post-test	Children aged approximately 4–7 years across the included studies	-Classroom- or lab-based -Adult-supervised individual or small-group tasks -Physical cognitive tasks; rule-based games; worksheets
Manualized program-based social-emotional learning interventions (Badau & Trifan, 2022; Bilir Seyhan et al., 2019; Wu et al., 2021)	Social-emotional learning framework; Social cognitive theory (Bandura)	-Explicit instruction -Guided practice -External reinforcement	-Cluster-based quasi-experimental design -Standardised SEL and behaviour rating scales -Immediate post-test	Mostly 5–6-year-olds across the included studies	-Classroom-based, curriculum-driven -Teacher-delivered scripted lessons -Printed manuals, story cards, puppets, activity materials
This study: EmoPlay Pals App	Social learning theory (Bandura) Active learning theory (Piaget) Vygotsky's sociocultural theory Gross's emotion regulation process model Piaget's Developmental Theory	-Process-oriented emotion regulation (Gross model) -Interactive feedback loops -Gradual support-to-independence transition -Child-initiated regulation practice	-Mixed-methods quasi-experimental design -Task-based measures and qualitative interviews -Pre-post-delayed follow-up	Preschool children aged 4–5 years	-Hybrid delivery (classroom + home) -Adult-supported but child-initiated interaction -Multisensory and gamified design incorporating animations -Audio narration and situational scenarios -Child-friendly interactions.

comparison between traditional emotion regulation interventions and the digital app-based approach employed in the present study.

2.2. Digital app emotion regulation intervention research

Technological development has brought forth a series of emotion regulation interventions based on mobile apps (e.g., Bettis et al., 2022; Jadhakhan et al., 2022; Montazami et al., 2022). Various studies have shown that preschool children can learn and interact through digital applications (Samuelsson et al., 2024), and that app-based interventions are more portable than traditional interventions (Zhang et al., 2024). Further, they are more suitable for modern families and educational environments (Quan et al., 2024). Parents and teachers can more easily integrate digital tools into children's daily activities without arranging specific times and venues. Currently, many digital emotion regulation apps have designed interactive content, such as gamification training, task challenges, and situational simulations (Kotsopoulos et al., 2024; Lin & Hou, 2024). This type of interactive design can not only attract children's attention and improve their interest in learning (Abd Kadir et al., 2024; Liu et al., 2021; Yao et al., 2024) but also enable children to master the ability to identify and regulate emotions in a pleasant atmosphere through gamification emotion recognition training (Nunes et al., 2025). Bers (2022) argues that digital programming activities can

help children learn empathy, patience, and emotional control. Papadakis (2022) emphasises that age-appropriate digital programming apps can improve children's concentration and self-regulation through gamified learning.

Additionally, digital emotion regulation interventions are clearly superior to traditional methods in accessibility and cost-effectiveness (Camilleri & Camilleri, 2023; Vaipoulou et al., 2023). Whether in urban or rural areas, as long as they have smart devices and an internet connection, users can access relevant emotion regulation intervention resources anytime (Mushquash et al., 2024). App-based interventions provide a viable alternative for children without regular professional psychological services (Brown & Bewick, 2023). Moreover, unlike traditional interventions that require guidance from professional teachers or counselors, once developed, apps can be widely promoted and used without additional labor costs (Hinze et al., 2023; Voshaar et al., 2023), making them a highly cost-effective tool in schools and families with limited resources. Existing digital apps have progressed in function and form, and studies have shown that digital tools have a specific positive effect on early childhood emotion regulation intervention (Hopman et al., 2023; LaMonica et al., 2024).

Digital apps incorporating Wearable Biosensing enhance children's ability to self-awareness and regulate their emotions (Palermo et al., 2023). However, it is important to consider that some studies have

pointed out from ethical and social perspectives that digital apps pose potential risks to children's mental health (e.g., [Jadhakhan et al., 2022](#); [Wadley et al., 2020](#)). Currently, many digital emotion regulation apps (e.g., [Dietel et al., 2024](#)) are rooted in Western cultural backgrounds, highlighting individualism and direct emotional expression, whereas Chinese preschoolers may rely more on social support, such as guidance from family and teachers, in emotion regulation. Therefore, these apps may be difficult to apply to Chinese preschoolers, limiting their application in the local education system. Furthermore, most of these studies focus on the apps' functional design, technical implementation, or theoretical framework, with less empirical verification of their intervention effect. Importantly, the various apps that have appeared in China are mainly used for psychological counselling, stress relief, psychological education, etc., and most of them are developed for adults, rather than child intervention experiments.

2.3. Theoretical framework of EmoPlay Pals App

This study uses emotional intelligence theory ([Mayer & Salovey, 1997](#)) and integrates emotion recognition, understanding, expression, and regulation. Unlike traditional viewing materials, the app guides children to actively practice these four abilities in multiple scenarios through the use of interactive tasks, instant feedback, and situational simulations, thereby promoting the construction and internalisation of emotional knowledge. As we have touched upon earlier, children's emotion regulation abilities are influenced by cognitive development. Children aged 4–5 are in the pre-operational stage, with limited abstract thinking ability, and their understanding of emotions depends mainly on specific situations, intuitive perception, and visual cues ([Djambazova-Popordanoska, 2016](#)). To cater for these specific needs, this application employs a multi-sensory presentation approach, incorporating storytelling, emotionally charged scenarios, and animated character demonstrations, to facilitate children's understanding of the causes and consequences of emotional events through observation, imitation, and active participation. Moreover, children at this stage begin to show an ability to think from the perspective of others. Consequently, tasks such as “choosing a role's perspective” and “helping Bob make a choice” encourage children to think about emotional triggers and possible coping strategies from the perspective of a certain role or character's perspective; thereby further promoting emotional understanding and empathy. Furthermore, the app's interactive and feedback mechanisms draw upon Bandura's social learning theory ([Bandura, 1977](#)). The animated character, Bob, demonstrates specific behaviours such as emotional outbursts, deep breathing, and cognitive reappraisal in different scenarios. Children observe Bob's behavioural outcomes, imitate his strategies, and then participate through clicks, thus forming an observation-imitation-reinforcement learning path. Voice prompts and emotional expressions further enhance children's self-efficacy, strengthening their beliefs that they can regulate their own emotions.

Appertaining to Vygotsky's sociocultural theory (1978), and with a particular emphasis on scaffolding support ([Mermelshtine, 2017](#)), the application's interactive structure employs a progressive task design, moving from easy to difficult: recognising and matching a single emotion (basic cognition); guiding children to practice deep breathing and relaxation strategies through interactive clicks (body regulation); providing scenario simulations of various emotion regulation strategies (strategy selection); and promoting strategy internalisation through role feedback and scenario reproduction (reflection and transfer). This structure aligns with the Zone of Proximal Development recommendations, which suggest that children initially complete tasks with system prompts and role demonstrations; then prompts can be gradually reduced allowing children to independently choose appropriate emotion regulation methods. Crucially, the app encourages parents and teachers to use it together, reinforcing the social interaction-internalisation mechanism put forward by Vygotsky.

This study also incorporates [Gross's \(1998, 2002\)](#) model of emotion

regulation into the interactive design of the app, allowing children to sequentially experience five steps in a contextualised process: situation selection, situation modification, attention allocation, cognitive reappraisal, and response regulation. Children first select different emotional situations, then adjust their role-playing behaviour by clicking, participate in deep breathing exercises, and observe alternative strategies and their results, ultimately achieving stable emotional regulation. Through this structured process, the app goes beyond simply presenting emotional knowledge; instead, it guides children to actively practice and

Table 2
Mapping of theoretical foundations to the functional design of the *EmoPlay Pals* App.

Theoretical Framework	Key Theoretical Constructs	Corresponding App Features / Design Elements
Emotional Intelligence Theory	-Emotion perception -Emotion understanding -Emotion expression -Emotion regulation	-Six-category emotion recognition tasks (happiness, anger, sadness, fear, disgust, surprise) -Scenario-based emotional stories and animations visualising causes and changes of emotions -Guided verbal and mimicry based emotional expression tasks -Deep-breathing practice, strategy selection, and calming routines for regulation
Piaget's Cognitive Development Theory	-Preoperational stage relies on concrete and perceptual cues -Limited abstract reasoning -Emerging perspective-taking skills	-Story-driven scenes and pictorial animations linking emotions to concrete contexts -Multisensory inputs (visual, auditory, motor clicks) supporting intuitive understanding -Role-based interactions (helping Bob make choices) enhancing early perspective-taking
Vygotsky's Sociocultural Theory & Scaffolding	-Zone of Proximal Development (ZPD) -Guided learning through scaffolds -Social interaction leading to internalisation	-Gradual, levelled learning path (recognition → calming → strategy practice) -System prompts, voice guidance, and animated modelling as scaffolding tools -Reduced prompts as competency increases, fostering independent mastery -Optional co-use with teachers/parents reinforcing social interaction
Bandura's Social Learning Theory	-Observational learning -Behavioural modelling -Development of self-efficacy	-Character “Bob” demonstrates emotional reactions and regulatory behaviours -Children imitate breathing, calming, and strategy use through interactive tasks -Visualised consequences strengthen perceived self-efficacy in emotion regulation
Gross's Emotion Regulation Process Model	-Situation selection -Situation modification -Attention allocation -Cognitive reappraisal -Response modulation	- Children choose emotional challenge scenarios - Click-based adjustments alter character behaviour or event outcomes - Guided breathing animation shifts attention to bodily sensations - Alternative explanations and strategy scenes presented through animations - Practice of breathing and strategy execution finalises emotional adjustment

gradually internalise emotion regulation skills through continuous contextual experiences and interactive exercises. Table 2 presents the mapping of theoretical foundations to the functional design of the *EmoPlay Pals* App.

3. Methodology

3.1. Research design

This study adopted a quasi-experimental design, as shown in Fig. 1, with the subjects divided into experimental and control groups. The experimental group used the *EmoPlay Pals* App, while the control group received no intervention and only read the emotional picture book as usual. Moreover, to further evaluate the effect of the app intervention, this study also conducted a pre-test, post-test, and delayed post-test on the experimental group to explore changes in emotion regulation before and after the intervention. Fig. 1 presents the quasi-experimental design of the study through which internal validity was strengthened.

This included experimental and control groups, repeated measures at pre-test, post-test, and delayed post-test, and the use of both quantitative and qualitative data. These features increase confidence that the observed improvements in attention, impulse control, and adaptability were solely the result of the *EmoPlay Pals* App. External validity was supported by embedding the intervention into real classroom activities and obtaining teacher reports, which showed that the benefits were evident in children's everyday learning contexts. Together, these elements provide a strong basis for the credibility and applicability of the findings.

3.2. Participants

100 children from two full-day kindergartens in the Jinniu District, Chengdu, where student intake, teacher qualifications, and socioeconomic backgrounds are relatively homogeneous, were randomly selected. Participants were randomly assigned to either the experimental group or the control group using a computer-generated random sequence, with each group comprising 4 classes of 25 children. The experimental group included 23 boys and 27 girls (28 aged 4 and 22 aged 5), while the control group consisted of 25 boys and 25 girls (27 aged 4 and 23 aged 5). Written informed consent was obtained from all guardians after they were informed about the purpose of the study, the

intervention procedures, and data protection measures. Exclusion criteria were as follows: (1) children with diagnosed neurodevelopmental disorders (e.g., autism spectrum disorder); (2) children who had received any psychological intervention related to emotion regulation within the past six months; and (3) children whose parents declined participation.

3.3. Intervention

3.3.1. Functions of *EmoPlay Pals* App

As shown in Fig. 2, the app consists of two core sections: emotion recognition and emotion regulation training. Children can click the icon on the left to enter the emotion recognition interface, which covers six basic emotion types: anger, sadness, fear, disgust, happiness, and surprise. Each emotion is equipped with a specific image expression, sound prompt, and concise text description to strengthen children's emotional perception ability through multisensory stimulation. The system supports the learning of the characteristics of each emotion one by one (For example, Icon 1: Angry). After completing the initial recognition training, children are required to conduct an overall review and undertake matching exercises in the centralised display interface to improve their emotion recognition ability.

Emotion regulation training is entered by clicking the icon on the right side of the main interface. An animated story clue is constructed around three high-frequency negative emotional situations: anger, sadness, and fear. The clue guides children to experience the complete path of "recognising emotions → understanding emotions → expressing emotions → learning to regulate" in the context of advancement. Taking the anger situation as an example, children first watch and identify the emotional response of the character, help the character complete breathing relaxation training under the guidance of animation, and then think about strategy selection, learning how to express anger in a non-aggressive way, seek help or try to think from the perspective of others in the prompts. To fit the cognitive development level of preschool children, the *EmoPlay Pals* App minimises text operations. It uses voice-over explanations and dynamic animations as the main guidance forms to lower the operation threshold and increase the element of fun. In addition to cooperating with the social interactive learning path, the *EmoPlay Pals* App design encourages parents or teachers to collaborate, provide language feedback, empathy guidance, and strategy demonstration in training; thus forming a transition process from adult support to autonomous regulation. Based on feedback from teachers and children in a small-scale pilot study, we went on to improve the interface design and interactive language.

3.3.2. Interaction flow of the *EmoPlay pals* app

The interaction flow of the *EmoPlay Pals* Apps, which leads children through a simple but structured flow that helps them recognise and manage emotions. Each step pairs the child's action with clear visual or auditory guidance suited to preschoolers. The process begins when the child selects an emotion, which triggers an animated scene that sets the context. The app then highlights the character's emotional cues, making it easier for the child to identify what the character is feeling. When the child taps the character to offer help, the app introduces a calming activity, usually guided breathing, to redirect attention and promote bodily awareness. Children then choose coping strategies from illustrated options and watch the outcomes unfold. Trying different strategies helps them compare effects and understand cause-effect relationships in emotional situations. In classroom settings, the app also prompts children to seek support from peers or teachers, adding a social learning element. Each scenario ends with brief feedback that reinforces what the child has practiced, followed by a simple reminder they can use in real-life situations, encouraging transfer beyond the app. Table 3 presents the interaction flow of the *EmoPlay Pals* App.

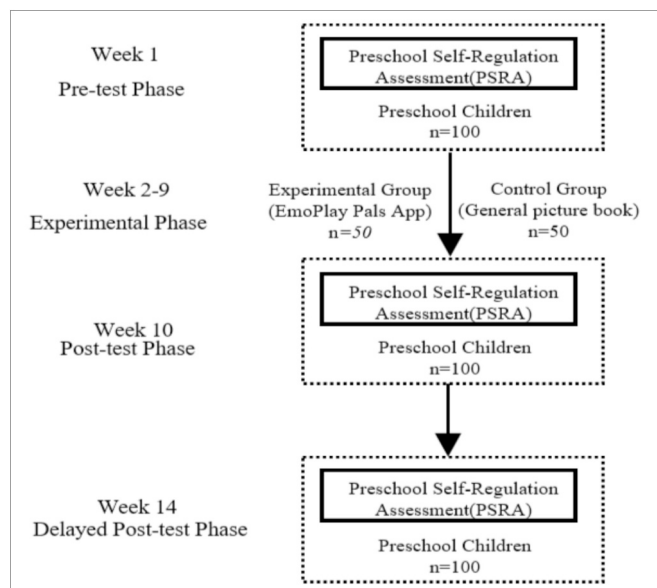


Fig. 1. Quasi-experimental design of the study.



Fig. 2. Operation interface of the *EmoPlay Pals* App.

3.3.3. Intervention process

The intervention lasted eight weeks, and both the experimental and control groups received two 15-minute emotion-related lessons each week. All sessions were delivered by the children's regular teachers, who received standardised training to ensure consistent implementation. The weekly content for the app-based intervention was reviewed by four experts in early childhood education and developmental psychology. Children in the experimental group engaged with the *EmoPlay Pals* App. The first four weeks focused on building emotion-recognition skills. During this phase, children identified basic emotions through animated facial expressions, explored short scenario videos showing emotion-triggering situations, and watched simple story animations explaining why characters felt particular emotions.

Weeks five to seven introduced emotion-regulation strategies. Children practised guided breathing, helped animated characters calm

down, and selected coping options for anger, sadness, and fear. In the final week, children completed integrated tasks within the app, applying recognition and regulation skills independently.

The control group followed the same weekly themes but learned through traditional picture-book activities instead of digital tools. In the first four weeks, teachers used picture books to teach emotion labels, emotional cues, and the causes of different feelings. In weeks five to seven, regulation strategies—such as counting, using comforting actions, and reframing fearful thoughts—were introduced through themed storybooks and guided discussion. In the eighth week, children reviewed all previously learned skills through picture-book activities and simple role-play. No digital devices were used at any point. This structure ensured that both groups received equal instructional time and covered the same emotional content, with the primary difference being the mode of delivery: an interactive digital app versus traditional picture-book

Table 3
Interaction flow of the *EmoPlay Pals* App.

No	Step	Child's Action	System Response	Learning Function	Emotion Regulation Stage
1	Scenario selection	Selects an emotion.	Plays a matching animated scene.	Sets emotional context.	Situation Selection
2.	Emotion recognition	Watches the character's expressions.	Highlights emotional cues.	Builds recognition.	Situation Selection / Modification
3.	Start calming task	Taps character to help.	Breathing animation begins.	Redirects attention.	Attention Allocation
4.	Breathing practice	Follows guided breathing.	Gives verbal encouragement.	Strengthens self-regulation.	Response Modulation
5.	Strategy choice	Choosing a coping strategy.	Shows outcome of strategy.	Supports reflection.	Cognitive Reappraisal
6	Try alternatives	Tests other strategies.	Scene changes accordingly.	Encourages flexibility.	Cognitive Reappraisal
7.	Social prompt	Share ideas with peer/teacher.	Voice prompt encourages discussion.	Adds social scaffolding.	Situation Modification / Reappraisal
8.	Feedback summary	Completes scenario.	Provides positive feedback.	Reinforces learning.	Response Modulation
9.	Real-life transfer	Selects 'Try in real life.'	Provides real-life prompt.	Supports skill transfer.	Generalisation / Regulation Maintenance

instruction. The on-site teaching activities are shown in Fig. 3.

3.4. Research instruments

This study employed Preschool Self-Regulation Assessment (PSRA; Smith-Donald et al., 2007), comprising a task-based protocol and a 26-item assessor rating scale (Roid et al., 2003). Originally designed to measure general self-regulation, the PSRA was adapted to focus specifically on emotional self-regulation by regrouping items into three validated dimensions: attention, impulse control, and adaptability, based on emotion regulation theory (Gross, 2015; Mayer & Salovey, 1997). The 4-point Likert scale enabled trained assessors to evaluate children's emotional regulation during tasks. Nine PSRA tasks and corresponding assessor rating items were reorganised to reflect the focus on emotional regulation in this study. The pilot study confirmed that the scale has good reliability and validity. Specifically, attention, the ability to

maintain task focus and resist emotional distraction was measured using the Balance Beam, Pencil Tap, and Tower Task (Items A1–A10). Impulse control, or the ability to delay emotional reactions and inhibit impulsive behaviours, was assessed using Toy Wrap, Toy Wait, and Snack Delay (Items B1–B8). Adaptability, referring to emotional flexibility and regulation in response to shifting demands, was measured through Toy Sort, Toy Return, and Tower Clean-up (Items C1–C8). To gain a deeper understanding of the actual impact of the *EmoPlay Pals* App on emotion regulation in preschool children, this study also used a semi-structured interview protocol with two preschool teachers who participated in the intervention. The questions focused on attention, impulse control, and adaptability. We asked teachers to describe any changes they observed in children's behaviour. Example prompts included: “Have you noticed improvements in children's attention during activities?” and “How do children react when routines or rules change after using the app?” Content validity was established through expert review by 4 specialists in early



Fig. 3. On-site teaching activities.

childhood education (Yusoff, 2019), with the content validity index for each item and the overall content validity index both being 1. Reliability analyses indicated good internal consistency (Hair et al., 2017), with Cronbach's α values of 0.886 (Attention), 0.892 (Impulse Control), 0.879 (Adaptability), and 0.830 (Emotion Regulation). Pre-test analyses confirmed no significant baseline differences between groups across emotion regulation, including attention, impulse control, and adaptability, indicating adequate group equivalence before the intervention.

3.5. Data analysis

The quantitative data was analysed using SPSS 28 software. Descriptive statistical analysis was performed on the pre-test, post-test, and delayed post-test scores of the experimental and control groups, and the mean was reported to indicate the trend change between the two groups. The pre-test, post-test, and delayed post-test data of the experimental and control groups were subjected to repeated measures covariance analysis to investigate the effects of app on the emotion regulation of 4–5-year-old Chinese children. This method is a powerful statistical analysis method that can compare the differences between the pre-test, post-test, and delayed post-test scores of the experimental group and the control group while controlling the influence of confounding variables (Rogers & Revesz, 2019). Normality, homogeneity of variance, and homogeneity of regression slopes were examined and met, ensuring the appropriateness of the covariance analysis (Johnson, 2016). Additionally, a paired sample t -test was used to analyse the changes in the emotion regulation of children in the experimental group between the pre-test, post-test, and delayed post-test to explore the effect of the app on individual emotional development. By comparing the differences between each pair of samples, we can more clearly see how the dependent variable changes under the experimental conditions (Blair & Higgins, 1985). The semi-structured interview data were transcribed verbatim and analysed using thematic analysis with the support of NVivo 15 software.

3.6. Ethical considerations

This study complies with ethical standards and has been approved by Chongqing University of Arts and Sciences (approval number: 202409100008). Written informed consent was obtained from all parents or legal guardians before data collection, and verbal assent was obtained from the participating children in age-appropriate language. All procedures were strictly followed the Declaration of Helsinki, ensuring voluntary participation, anonymity, and confidentiality. No identifiable personal information was recorded, and all data were used solely for research purposes. Participants were free to withdraw at any time without any consequences.

4. Results

Results are presented in line with the three research questions. For the first research question, the analysis evaluates whether the preschool children who used *EmoPlay Pals* demonstrated greater improvements in emotion self-regulation, specifically attention, impulse control, and adaptability, compared to those in the picture-book control group. For the second research question, the analysis investigates whether children in the intervention group exhibited significant and sustained pre-post gains across these dimensions. For the third research question, qualitative findings from teacher interviews are reported to illustrate observed changes in the preschool children's emotion self-regulation following the intervention. Collectively, these results provide both quantitative and qualitative evidence for the effectiveness and contextual relevance of the *EmoPlay Pals* intervention.

4.1. Quantitative statistical results

Fig. 4 presents the descriptive analyses conducted to examine changes in emotion regulation after the intervention, including attention, impulse control, adaptability, and overall emotion regulation. In regards attention, the experimental group improved from a baseline mean of $M = 2.05$ to $M = 2.26$ at post-test, with a slight increase to $M = 2.35$ at delayed post-test. However, the control group showed a downward trend, decreasing from $M = 2.00$ at baseline to $M = 1.97$ at post-test and 1.5 at delayed post-test. A similar pattern was observed in the experimental group on impulse control: scores rose from $M = 1.82$ to $M = 2.03$, then to $M = 2.09$ at delayed post-test, whereas the control group's scores first increased and then decreased (from $M = 2.01$ to $M = 1.76$ at the two time points after the intervention).

In terms of adaptability, the experimental group exhibited a slight rise from $M = 1.74$ at baseline to $M = 1.98$ at post-test, maintaining the gains at $M = 2.07$ during the delayed post-test. The control group, however, increased from $M = 1.70$ to $M = 1.98$, then decreased to $M = 1.74$. A comparable tendency was observed for emotion regulation, with experimental participants improving from $M = 1.87$ to $M = 2.09$ and then to $M = 2.17$, whereas the control group progressed from $M = 1.83$ to $M = 1.99$, then decreased to $M = 1.66$. These results suggest a clear and sustained benefit of the intervention across key self-regulatory functions, with changes evident not only immediately following the intervention but also persisting several weeks later.

Using repeated measures covariance analysis while controlling for baseline (pre-test) scores, significant differences emerged between the experimental and control groups across all four outcome variables: attention, impulse control, adaptability, and emotion regulation (Table 4). The main effect of the grouping was significant for attention ($F = 40.913, p < .001$, partial $\eta^2 = 0.297$), impulse control ($F = 4.109, p = .045$, partial $\eta^2 = 0.041$), and emotion regulation ($F = 22.821, p < .001$, partial $\eta^2 = 0.190$), with large effect sizes for attention and emotion regulation. This indicates that the experimental group consistently outperformed the control group following the intervention. Significant time * group interactions were also observed for attention ($F = 30.718, p < .001$, partial $\eta^2 = 0.241$), impulse control ($F = 10.645, p = .002$, partial $\eta^2 = 0.099$), adaptability ($F = 10.629, p = .002$, partial $\eta^2 = 0.099$), and emotion regulation ($F = 36.631, p < .001$, partial $\eta^2 = 0.274$), with medium to large effect sizes, demonstrating that the *EmoPlay Pals* intervention is more effective than traditional picture book methods in improving children's attention, impulse control, and adaptability. Although the main effect of time was nonsignificant for attention, impulse control, and adaptability, a significant time $\times$ pre-test interaction was detected for emotion regulation ($F = 4.737, p = .032$, partial $\eta^2 = 0.047$), reflecting meaningful changes after controlling for baseline levels. The line graphs further illustrate these results. They illustrate that the experimental group showed clear and sustained improvements from baseline to post-test and delayed post-test in all domains, while the control group showed only minor changes over time. These findings demonstrate that the intervention had a strong and lasting impact on participants' self-regulation abilities, even after accounting for pre-existing differences at baseline.

As shown in Table 5, Children demonstrated significant improvement from pre-test to post-test in emotional regulation ($MD = -0.22, t = -5.34, p < .001$), attention ($MD = -0.22, t = -3.25, p = .002$), impulse control ($MD = -0.22, t = -3.68, p < .001$), and adaptability ($MD = -0.24, t = -3.27, p = .002$). These gains were further reflected in the pre-test to delayed test comparisons, which showed even larger improvements across dimensions. Although the post-test to delayed-test changes were small and mostly insignificant, the slight improvement observed in emotional regulation ($MD = -0.08, t = -2.30, p = .026$) suggests continued consolidation of skills. Moreover, effect sizes were medium or large effects, with Cohen's d values exceeding 0.4 from pre-test to post-test comparisons and remaining above 0.5 between pre-test and delayed post-test. The results confirm that the intervention

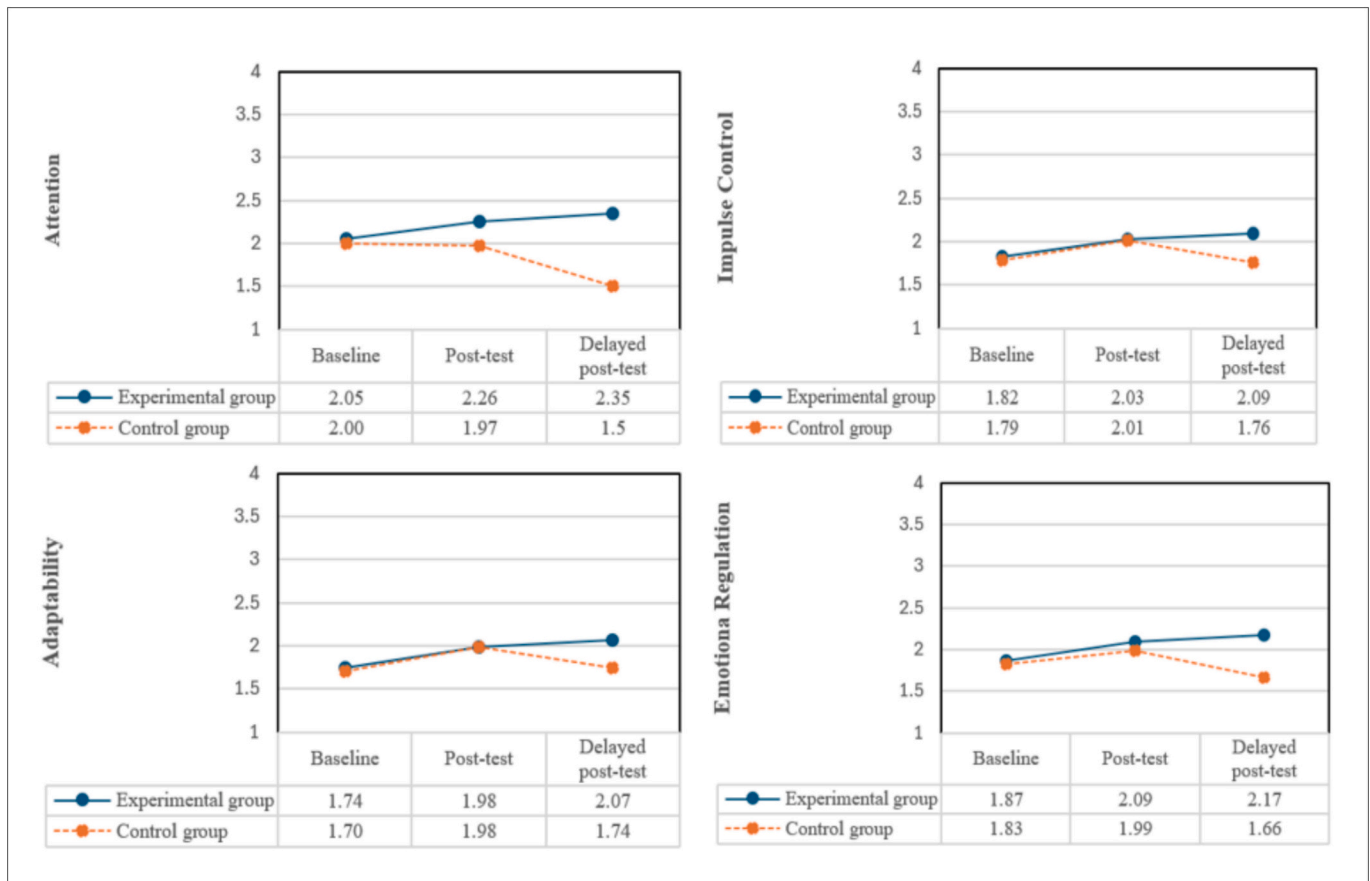


Fig. 4. Comparison between the experimental group and the control group.

Table 4
Repeated measures ANCOVA for emotion regulation.

Effect	F	df	P	Partial η^2	Sig.
Attention					
Time (Main Effect)	0.455	(1,97)	0.502	0.005	ns
Time $\times$ Pre-Attention	2.077	(1,97)	0.153	0.021	ns
Time $\times$ Group	30.718	(1,97)	<0.001	0.241	***
Pre-Attention (Covariate)	22.957	(1,97)	<0.001	0.191	***
Group	40.913	(1,97)	<0.001	0.297	***
Impulse Control					
Time (Main Effect)	0.226	(1,97)	0.636	0.002	ns
Time $\times$ Pre-Attention	0.964	(1,97)	0.329	0.01	ns
Time $\times$ Group	10.645	(1,97)	0.002	0.099	**
Pre-Attention (Covariate)	66.178	(1,97)	<0.001	0.406	***
Group	4.109	(1,97)	0.045	0.041	*
Adaptability					
Time (Main Effect)	0.085	(1,97)	0.771	0.001	ns
Time $\times$ Pre-Attention	0.002	(1,97)	0.963	0.000	ns
Time $\times$ Group	10.629	(1,97)	0.002	0.099	**
Pre-Attention (Covariate)	14.868	(1,97)	<0.001	0.133	***
Group	2.624	(1,97)	0.109	0.026	ns
Emotion Regulation					
Time (Main Effect)	2.828	(1,97)	0.096	0.028	ns
Time $\times$ Pre-Attention	4.737	(1,97)	0.032	0.047	*
Time $\times$ Group	36.631	(1,97)	<0.001	0.274	***
Pre-Attention (Covariate)	33.6	(1,97)	<0.001	0.257	***
Group	22.821	(1,97)	<0.001	0.19	***

Notes: *** $p < .001$, ** $p < .01$. Partial η^2 effect sizes: 0.01 (small), 0.06 (medium), 0.14 (large). Time refers to post-test vs. delayed post-test comparisons. Group: (Experimental vs. Control) ns: Not significant

produced sustained enhancements in emotion regulation.

4.2. Qualitative findings

As presented in Table 6, the interviews highlighted clear improvements in preschool children's emotion regulation following the app intervention, with consistent evidence across three main themes: attention, impulse control, and adaptability. In terms of attention, teachers repeatedly observed an extended attention span. Children could sustain focus on classroom tasks for longer than before. As one teacher noted, "...Previously they often lost focus in class, now they can persist until..." (T3). Meanwhile, the app's multisensory and interactive design enhanced engagement. Teachers described how children "stared at the screen carefully and followed the character's actions" (T2), and how "...the app provided voice prompts or interactive questions, children showed higher engagement" (T1). Regarding impulse control, children demonstrated progress in delay of gratification. Rather than rushing or competing, they increasingly paused and waited their turn. One teacher emphasised, "Children lined up and waited instead of rushing" (T2). Complementing this, children also adopted breathing and calming strategies modelled in the app. As observed, "They placed their hands on the stomach to do deep breathing, ..." (T3), and "...the breathing method learned from the animation was applied in class, ..." (T4). Such practices reflected the transfer of digital training into real classroom contexts. In terms of adaptability, teachers reported that children showed greater acceptance of rule changes where they had previously resisted alterations: "In the past they cried when rules changed, now they adapt smoothly, ..." (T2). Beyond compliance, they also demonstrated more flexible problem-solving skills. Instead of giving up, they sought alternative solutions or support, with one teacher explaining, "They asked peers or teachers for help rather than quitting" (T3). These findings indicate that the app intervention not only improved attention and reduced impulsivity but also enabled children to adapt more effectively to changing

Table 5

Paired-samples *t*-tests and 95 % confidence intervals of mean differences.

Dimension	Comparison	MD	SE	95 % CI (Lower, Upper)	t(df)	p	Cohen's d
Emotion Regulation	Pre – Post	–0.22	0.04	[–0.31, –0.14]	–5.34 (49)	< 0.001	0.75
	Pre – Delayed	–0.30	0.05	[–0.40, –0.21]	–6.39 (49)	< 0.001	0.87
	Post – Delayed	–0.08	0.03	[–0.15, –0.01]	–2.30 (49)	0.026	0.31
Attention	Pre – Post	–0.22	0.07	[–0.35, –0.08]	–3.25 (49)	0.002	0.45
	Pre – Delayed	–0.30	0.09	[–0.48, –0.13]	–3.55 (49)	< 0.001	0.5
	Post – Delayed	–0.09	0.06	[–0.21, 0.04]	–1.39 (49)	0.171	0.19
Impulse Control	Pre – Post	–0.22	0.06	[–0.33, –0.10]	–3.68 (49)	< 0.001	0.52
	Pre – Delayed	–0.28	0.07	[–0.42, –0.13]	–3.84 (49)	< 0.001	0.54
	Post – Delayed	–0.06	0.06	[–0.18, 0.05]	–1.12 (49)	0.27	0.15
Adaptability	Pre – Post	–0.24	0.07	[–0.39, –0.09]	–3.27 (49)	0.002	0.46
	Pre – Delayed	–0.33	0.07	[–0.46, –0.19]	–4.83 (49)	< 0.001	0.66
	Post – Delayed	–0.09	0.06	[–0.21, 0.04]	–1.41 (49)	0.164	0.2

Cd: Cohen's d = 0.2 (small), 0.5 (medium), 0.8 (large).

Table 6

Themes and subthemes of children's emotion regulation in the interviews.

Selected Statements	Subthemes	Themes
“Children could stay focused longer during activities....” (T1)	Extended attention span	Attention
“They concentrated fully when watching the app animation and....” (T2)		
“...Previously they often lost focus in class, now they can persist until....” (T3)		
“During group work, they kept attention on the task instead of chatting.” (T3)	Improved engagement	Attention
“They stared at the screen carefully and followed the character's actions .” (T2)		
“...said the character was breathing and wanted to breathe together .” (T3)		
“...the app provided voice prompts or interactive questions, children showed higher engagement .” (T1)	Delay of gratification	Impulse Control
“..., now they pause and wait .” (T1)		
“Children lined up and waited instead of rushing.” (T2)		
“...said, “Teacher, I will wait a moment .” (T2)	Breathing and calming strategies	Impulse Control
“...imitated the waiting strategy shown in the app characters.” (T4)		
“...calmed down by deep breathing instead of crying.” (T2)		
“..., a child said, “I will breathe first .” (T1)	Acceptance of rule changes	Adaptability
“They placed their hands on the stomach to do deep breathing” (T3)		
“...the breathing method learned from the animation was applied in class....” (T4)		
“..., children quickly accepted and continued playing” (T1)	Flexible problem-solving	Adaptability
“In the past they cried when rules changed, now they adapt smoothly” (T2)		
“In group activities, they accepted teachers' temporary adjustments .” (T2)		
“..., they were willing to try new game modes instead of sticking to the old ones.” (T4)	Flexible problem-solving	Adaptability
“Children tried different solutions instead of giving up quickly.” (T3)		
“... they discussed different answers or methods to find appropriate strategies .” (T1)		
“... referred to app characters' strategies to solve problems .” (T3)	Flexible problem-solving	Adaptability
“They asked peers or teachers for help rather than quitting.” (T4)		

Note: T1 = Teacher 1, T2 = Teacher 2, T3 = Teacher 3, T4 = Teacher 4.

circumstances. The subthemes provide evidence that regulatory strategies initially learned in digital environments were internalised and generalised to classroom settings, enhancing children's emotion regulation.

5. Discussion

The data from the study clearly demonstrated that the attention level of the children in the experimental group was significantly higher than that of the children in the control group, and also significantly higher than the level in their pre-test. This finding indicates that the *EmoPlay Pals* App was effective in strengthening children's attentional control. The app's interactive design, including contextual simulation, task feedback, and simple point-and-click operation, helped guide children's focus and sustained their attention during the emotion regulation task. The evidence supports earlier findings (Fan et al., 2024) that multisensory features, such as visual and voice prompts, improve children's ability to process information and maintain attention. In line with Gross's (2002) emotion regulation process model, we can predict that directing attention is a central step towards emotion regulation. By engaging with the *EmoPlay Pals* App, children learned to shift their attention away from negative emotions and concentrate on constructive tasks. Daniel and Suleiman (2023) also found that interactive clicker tools encourage children to pause and monitor their focus, which leads to greater attention stability. Likewise, multisensory digital environments have been shown to hold children's attention better than traditional picture books (Xiao & Lu, 2024), and furthermore, these skills can then be transferred into daily learning situations (Joines, 2023). In addition, because the *EmoPlay Pals* App required children to follow clear steps to complete tasks, the structured approach promoted focus more effectively than casual reading activities (Sun, 2023).

Additionally, children in the experimental group showed higher levels of impulse control than both the control group and compared with their own pre-test. The *EmoPlay Pals* App's design played a key role in helping children learn to manage their impulses, especially in tasks that required waiting for the right moment to respond. Based on sociocultural theory, children best develop self-control in guided environments providing step-by-step support (Mermelshtine, 2017). The *EmoPlay Pals* App applied this principle by introducing challenges in small steps, from short waiting times to more complex situations. Empirical evidence also demonstrates that children's impulse control improves with regular practice (Joines, 2023); the app provided this through repeated click operations and hand-eye coordination activities. The animated characters also gave children examples of how to manage emotions, allowing them to observe and imitate positive behaviours (Richard et al., 2021; Yue et al., 2024). For example, when facing fear, the children were guided to try coping strategies instead of reacting quickly. Another aspect of this teaching strategy was that classroom activities built around the app also required turn-taking and following rules, which further strengthened impulse control (Chen et al., 2023; Dong et al., 2021; Raghunathan et al., 2023). Compared with irregular picture book reading, the app provided steady and structured practice, making it easier for children to internalise strategies for managing impulses.

Similarly, the *EmoPlay Pals* App improved children's adaptive emotion regulation strategies, including deep breathing, self-talk, and

positive thinking. This finding is consistent with Gross's (1998, 2002) process model, which explains that emotion regulation involves steps such as choosing situations, directing attention, rethinking events, and controlling expression. The app gave children the chance to learn and apply these steps in realistic scenarios. For example, when faced with tension, they practiced calming themselves, shifting attention, or seeking help. This method of learning through situations has been found to be effective because young children rely heavily on context and direct experience (Wang et al., 2023). The App also provided real-time voice feedback that guided children to apply the right strategy; a key factor in supporting them to build their confidence as well as inspiring repeated use of positive methods (Nicolaidou et al., 2021). In addition, group-based activities within the app invited children to share strategies and learn from one another, promoting deeper understanding and wider use of adaptive skills (Li & Disney, 2023). Unlike static picture book reading, the app offered continuous opportunities for practice in different situations, allowing children to apply what they had learned more flexibly.

Correspondingly, the qualitative data from teacher interviews supported these findings. Teachers reported that children in the experimental group showed better focus, stronger self-control, and greater flexibility when facing classroom challenges. These classroom observations confirmed the statistical results, suggesting that the *EmoPlay Pals* App produced real and observable changes in children's behaviour. Finally, even though the app intervention ended before the delayed post-test, children's performance in all three areas continued to improve slightly. This suggests that children were able to take what they practiced in the app and use it independently in daily situations, indicating that the apps may be a useful tool for both classrooms teaching and at-home learning.

Under general picture book instruction, the control group showed slight improvement on the post-test, but their performance declined on the delayed post-test. We argue that this phenomenon is primarily due to three factors. First, traditional picture book instruction relies primarily on storytelling and passive listening, lacking structured training and repeated practice. While this can stimulate interest in the short term, it fails to achieve lasting results. Second, emotional skills learned from this type of teaching with a picture book are difficult to transfer to tasks like the PSRA, which require immediate response and self-regulation. The lack of multi-dimensional reinforcement leads to insufficient skill retention. Finally, 4–5-year-old children are in a critical period of self-regulation development, a period of volatility that is easily influenced by classroom atmosphere, family environment, and emotional state. While the experimental group's systematic intervention was able to offset some of these fluctuations, the control group, lacking ongoing support, was more likely to experience a decline on the delayed test due to such external factors. This suggests that traditional picture book instruction is limited in effectiveness in this area, and therefore sustained improvement in children's self-regulation is restricted.

6. Conclusion

The findings of this study provide strong evidence that the *EmoPlay Pals* App enhanced preschool children's emotion regulation, as reflected in significant improvements in attention, impulse control, and adaptability. These outcomes confirm that technology-supported, interactive learning environments can serve as effective tools for advancing young children's emotional development. Children in the experimental group demonstrated greater attentional control compared to their peers in the control group and relative to their own baseline. This finding underscores the value of structured, interactive tasks in sustaining children's focus. Features such as contextual simulation, real-time feedback, and simple point-and-click navigation engaged children in ways that traditional picture book methods could not. This is consistent with prior empirical evidence pointing to the scope of multisensory environments in enhancing children's processing capacity and attentional stability (Daniel & Suleiman, 2023; Fan et al., 2024; Xiao & Lu, 2024). According

to Gross's (2002) emotion regulation process model, attentional deployment is a crucial step in regulating emotions. In line with this theory, the *EmoPlay Pals* App provided repeated opportunities for children to redirect attention away from potential negative responses towards constructive activities. Additionally, the intervention also significantly improved the ability of the children to manage impulsive behaviours. This outcome reflects the app's design, which scaffolded children's learning by gradually introducing challenges requiring delayed responses. Sociocultural theory suggests that impulse control develops best when children receive structured support within the Zone of Proximal Development (Mermelshtine, 2017). The *EmoPlay Pals* App operationalised this principle by embedding progressive waiting tasks, interactive rules, and animated role models, all of which promoted self-regulation through observation, imitation, and practice (Richard et al., 2021; Yue et al., 2024). Classroom activities reinforced these effects by requiring turn-taking and adherence to task rules, confirming that systematic and guided practice is more effective than unstructured learning experiences (Chen et al., 2023; Dong et al., 2021; Raghunathan et al., 2023).

The study further showed gains in adaptive emotion regulation strategies, such as deep breathing, self-talk, and positive thinking. These strategies align with key components of Gross's (1998, 2002) model, including situation selection, attention redirection, cognitive reappraisal, and control of emotional expression. The *EmoPlay Pals* App supported these processes by situating learning within realistic contexts and providing real-time voice feedback that guided children towards adaptive responses. Such structured practice enhanced the children's sense of efficacy and encouraged repeated use of positive strategies, while peer-based interactions within the app further promoted shared learning and transfer of skills (Li & Disney, 2023; Nicolaidou et al., 2021; Wang et al., 2023). Importantly, qualitative feedback from teachers reinforced these statistical results. Teachers observed that children in the experimental group showed better focus, stronger self-control, and greater flexibility when managing classroom demands. The delayed post-test results showed that children's emotion regulation skills continued to improve, despite the intervention having already ended. We can infer from this that the skills children learned with the *EmoPlay Pals* App were carried over into their own behaviour and used independently, rather than fading once the training ended. These results indicate that digital tools can have lasting benefits for children's emotional development. Overall, the findings show that technology-based interventions, when designed with interactive and multisensory features, can effectively support emotion regulation in early childhood. The *EmoPlay Pals* App illustrates how structured and context-rich activities can complement traditional approaches and be scaled for broader use in preschool settings. By drawing on emotional intelligence theory and Gross's model, this study is a real-life example of how theory can be successfully applied into the design of a practical tool for preschool education.

6.1. Practical implications

This study provides a practical digital pathway for early intervention into working with children's emotion regulation skills, which has practical implications for kindergarten education, family parenting styles, and the design of educational technology products. Kindergarten teachers can incorporate emotion regulation apps into their daily curricula to supplement social learning, helping children acquire specific regulation strategies in actual or simulated situations. Furthermore, this study also provides parents with practical tools for emotional education in the home environment. Through the *EmoPlay Pals* App's parent-child co-reading and co-playing functions, parents can identify emotions and explore regulation strategies with children, thus strengthening the emotional connection among family members. Considering that the preschool stage is a critical period for emotional socialisation, the embedded intervention of digital tools provides new

resources for family education and builds a technical support bridge for family-school cooperation. For developers of educational technology products, the design concept of ‘theory-driven + interactive experience’ revealed in this study provides theoretical support and a design paradigm for the subsequent development of preschool education apps.

6.2. Research limitations and future directions

This study provides encouraging evidence for the effectiveness of the *EmoPlay Pals* App in strengthening preschool children's emotion regulation, as well as addressing several gaps in the current literature. It extends prior research in its demonstration that digital interventions can improve three key components of emotion regulation: attention, impulse control, and adaptability, among preschoolers in China. The research also presents the method in which emotional intelligence theory and Gross's process model can be applied in a practical, technology-based tool, bridging the gap between theoretical frameworks and classroom practice. In addition, the inclusion of a delayed post-test offers initial evidence of the sustainability of intervention effects, an area that has often been overlooked in previous studies.

It is important to address, nonetheless, how future research can build on these contributions further. First, the sample was drawn from preschool children in one province, which provides valuable insights but does not capture the full diversity of children's experiences. Expanding future studies to include children from different cultural and educational settings, as well as those with special needs, will help to test the wider applicability of the *EmoPlay Pals* App. Second, the study focused on children aged 4 to 5, a stage where self-regulation skills are rapidly developing. Future research may incorporate other socioemotional or cognitive indicators to offer a more comprehensive developmental evaluation. Third, while the *EmoPlay Pals* App already integrates multisensory interaction and contextual simulations, future versions could expand the range of scenarios and strategies, especially for more complex emotions. Adaptive features that tailor activities to children's individual needs may further enhance engagement and effectiveness. Finally, although the delayed post-test showed encouraging evidence of sustained improvement, longer-term longitudinal research is needed to track the durability of gains and their influence on children's broader development, including social relationships and academic outcomes. Future studies that build on this work can deepen both our theoretical understanding and practical use of digital tools for children's emotion regulation. This study contributes to existing literature in the area by demonstrating how a digital-based intervention can enhance preschool children's emotion regulation, addressing a gap in Chinese early childhood research while also informing global debates on the role of interactive technologies in supporting young children's socio-emotional development.

Financial interests

The authors declare they have no financial interests.

CRediT authorship contribution statement

Meng Yao: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Melissa Ng Lee Yen Abdullah:** Writing – review & editing, Validation, Supervision, Conceptualization.

Ethics approval and consent to participate

Informed consent was obtained from the parents or legal guardians of the kindergarten children involved in this study. The research protocol was reviewed and approved by the Academic Ethics Committee of Chengdu University of Arts and Sciences (approval number: 202409100008). All procedures were conducted in accordance with

relevant guidelines and regulations, including the Declaration of Helsinki.

Funding information

No funding was received to conduct this study.

Declaration of competing interest

The authors declare no conflict of interest or personal relationships that could have influenced the work reported in this paper.

Data availability

doi:<https://doi.org/10.6084/m9.figshare.30069280.v2>.

References

- Abd Kadir, K., Idris, N., & Anuar, A. I. (2024). Exploring surah ad-Dhuha: A fun and educational Tafsis app for kids. *International Journal of Advanced Research in Future Ready Learning and Education*, 34(1), 31–52. <https://doi.org/10.37934/frie.34.1.3152>
- Badau, A., & Trifan, I.-M. (2022). Promoting positive behaviors in preschoolers by implementing an innovative educational program for the training and development of social and emotional skills (DeCo-SE). *International Journal of Environmental Research and Public Health*, 19(22), Article 14931. <https://doi.org/10.3390/ijerph192214931>
- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84(2), 191–215. <https://doi.org/10.1037/0033-295X.84.2.191>
- Bers, M. U. (2022). *Beyond coding: How children learn human values through programming*. MIT Press.
- Bettis, A. H., Burke, T. A., Nesi, J., & Liu, R. T. (2022). Digital technologies for emotion-regulation assessment and intervention: A conceptual review. *Clinical Psychological Science*, 10(1), 3–26. <https://doi.org/10.1177/21677026211011982>
- Bilir Seyhan, G., Ocak Karabay, S., Arda Tuncdemir, T. B., Greenberg, M. T., & Domitrovich, C. (2019). The effects of the promoting alternative thinking strategies preschool program on teacher-child relationships and children's social competence in Turkey. *International Journal of Psychology*, 54(1), 61–69. <https://doi.org/10.1002/ijop.12426>
- Blair, R. C., & Higgins, J. J. (1985). Comparison of the power of the paired samples t test to that of Wilcoxon's signed-ranks test under various population shapes. *Psychological Bulletin*, 97(1), 119. <https://doi.org/10.1037/0033-2909.97.1.119>
- Brown, T. M. H., & Bewick, M. (2023). Digital health education: The need for a digitally ready workforce. *Archives of Disease in Childhood-Education and Practice*, 108(3), 214–217. <https://doi.org/10.1136/archdischild-2021-322022>
- Camilleri, M. A., & Camilleri, A. C. (2023). Learning from anywhere, anytime: Utilitarian motivations and facilitating conditions for mobile learning. *Technology, Knowledge and Learning*, 28(4), 1687–1705. <https://doi.org/10.1007/s10758-022-09608-8>
- Chambers, R., Gullone, E., & Allen, N. B. (2009). Mindful emotion regulation: An integrative review. *Clinical Psychology Review*, 29(6), 560–572. <https://doi.org/10.1016/j.cpr.2009.06.005>
- Chen, J., Cao, B., & Li, F. (2023). Do after "not to do": Deinhhibition in cognitive control. *Memory & Cognition*, 51(6), 1388–1403. <https://doi.org/10.3758/s13421-023-01403-9>
- Daniel, A., & Suleiman, I. A. (2023). Enhancing pupil engagement and learning through augmented reality-based interactive phonetics education. *World Journal of Advanced Engineering Technology and Sciences*, 9(1), 260–271. <https://doi.org/10.30574/wjaets.2023.9.1.0131>
- Deng, Y., Cherian, J., Khan, N. U. N., Kumari, K., Sial, M. S., Comite, U., ... Popp, J. (2022). Family and academic stress and their impact on students' depression level and academic performance. *Frontiers in Psychiatry*, 13, Article 869337. <https://doi.org/10.3389/fpsy.2022.869337>
- Dietel, F. A., Rupprecht, R., Seriy, A. M., Post, M., Sudhoff, B., Reichart, J., ... Buhlmann, U. (2024). Efficacy of a smartphone-based cognitive bias modification program for emotion regulation: A randomized-controlled crossover trial. *Internet Interventions*, 35, Article 100719. <https://doi.org/10.1016/j.invent.2024.100719>
- Ding, R., Wu, N., Tang, S., Liu, T., Li, W., & Ni, S. (2022). Relations between parental response to children's negative emotions and suicidal ideation in Chinese adolescents: Internalizing problems, emotion regulation, and perceived relationship quality with parents as mediators. *Journal of Affective Disorders*, 301, 205–216. <https://doi.org/10.1016/j.jad.2022.01.043>
- Djambazova-Popordanoska, S. (2016). Implications of emotion regulation on young children's emotional wellbeing and educational achievement. *Educational Review*, 68(4), 497–515. <https://doi.org/10.1080/00131911.2016.1144559>
- Dong, S., Dubas, J. S., Deković, M., & Wang, Z. (2021). Cool and hot effortful control moderate how parenting predicts child internalization in Chinese families. *Journal of Experimental Child Psychology*, 206, Article 105099. <https://doi.org/10.1016/j.jecp.2021.105099>
- Fan, Y., Chong, D. K., & Li, Y. (2024). Beyond play: A comparative study of multisensory and traditional toys in child education. *Frontiers in Education*, 9, Article 1182660. <https://doi.org/10.3389/feduc.2024.1182660>

- Gómez-Cambronero, Á., Mann, A. L., Mira, A., Doherty, G., & Casteleyn, S. (2024). Smartphone-based serious games for mental health: A scoping review. *Multimedia Tools and Applications*, 83(36), 84047–84094. <https://doi.org/10.1007/s11042-024-18971-w>
- Gong, J., Wang, M. C., Zhang, X., Zeng, H., & Yang, W. (2022). The emotion regulation questionnaire for children and adolescents (ERQ-CA): Factor structure and measurement invariance in a Chinese student samples. *Journal of Personality Assessment*, 104(6), 774–783. <https://doi.org/10.1080/00223891.2021.2014506>
- Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, 2(3), 271–299. <https://doi.org/10.1037/1089-2680.2.3.271>
- Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology*, 39(3), 281–291. <https://doi.org/10.1017/S0048577201393198>
- Gross, J. J. (2015). The extended process model of emotion regulation: Elaborations, applications, and future directions. *Psychological Inquiry*, 26(1), 130–137. <https://doi.org/10.1080/1047840X.2015.989751>
- Haeyen, S. (2024). A theoretical exploration of polyvagal theory in creative arts and psychomotor therapies for emotion regulation in stress and trauma. *Frontiers in Psychology*, 15, Article 1382007. <https://doi.org/10.3389/fpsyg.2024.1382007>
- Hair, J. F., Jr., Sarstedt, M., Ringle, C. M., & Gudergan, S. P. (2017). *Advanced issues in partial LeastSquares structural equation modeling*. Los Angeles: SAGE Publications.
- Hao, X. Y., & Zhu, X. H. (2020). Research on promoting the development of children's emotional regulation ability through emotional theme picture book reading activities. *Education Observation*, 24(33–35), 82. <https://doi.org/10.16070/j.cnki.cn45-1388/g4s.2020.24.011>
- Hinze, A., Vanderschantz, N., Timpany, C., Cunningham, S. J., Saravani, S. J., & Wilkinson, C. (2023). A study of mobile app use for teaching and research in higher education. *Technology, Knowledge and Learning*, 28(3), 1271–1299. <https://doi.org/10.1007/s10758-022-09599-6>
- Hopman, K., Richards, D., & Norberg, M. M. (2023). A digital coach to promote emotion regulation skills. *Multimodal Technologies and Interaction*, 7(6), 57. <https://doi.org/10.3390/mti7060057>
- Hosokawa, R., Matsumoto, Y., Nishida, C., Funato, K., & Mitani, A. (2024). Enhancing social-emotional skills in early childhood: Intervention study on the effectiveness of social and emotional learning. *BMC Psychology*, 12(1), 761. <https://doi.org/10.1186/s40359-024-02280-w>
- Huang, Y., Li, R. Y., Fang, L., Wu, Z., & Wang, X., Z. (2022). Relationship between family rearing style and 3–6-year-old children's emotional and behavioral problems. *Chinese Journal of School Health*, 43(2), 242–246. <https://doi.org/10.16835/j.cnki.1000-9817.2022.02.019>
- Jadhakhan, F., Blake, H., Hett, D., & Marwaha, S. (2022). Efficacy of digital technologies aimed at enhancing emotion regulation skills: Literature review. *Frontiers in Psychiatry*, 13, Article 809332. <https://doi.org/10.3389/fpsyg.2022.809332>
- Johnson, T. R. (2016). Violation of the homogeneity of regression slopes assumption in ANCOVA for two-group pre-post designs: Tutorial on a modified Johnson-Neyman procedure. *The Quantitative Methods for Psychology*, 12(3), 253–263. <https://doi.org/10.20982/tqmp.12.3.p253>
- Joines, F. (2023). *Embracing technology in the early years: A practitioner's guide*. Routledge. <https://doi.org/10.4324/9781003023173-1>
- Kaizar, V. O., & Alordiah, C. O. (2023). Understanding the role of play in promoting cognitive, social, and emotional development in school children: Implications for counsellors and evaluators. *University of Delta Journal of Contemporary Studies in Education*, 2(1), 138–152.
- Kotsopoulos, K. I., Chourdaki, P., Tsois, D., Antoniadis, R., Pavlidis, G., & Assimakopoulos, N. (2024). An authoring platform for developing smart apps which elevate cultural heritage experiences: A system dynamics approach in gamification. *Journal of Ambient Intelligence and Humanized Computing*, 15, 1679–1695. <https://doi.org/10.1007/s12652-019-01505-w>
- Lahiya, A., Hasini, L., Mamonto, T., Mamonto, M. F., & Mokodenseho, S. (2022). Improving early childhood social-emotional intelligence through role-playing methods in group B. *Bulletin of Early Childhood*, 1(2), 93–101. <https://doi.org/10.51278/bec.v1i2.643>
- LaMonica, H. M., Song, Y. J., Loblay, V., Ekambareshwar, M., Naderbagi, A., Zahed, I. U. M., ... Hickie, I. B. (2024). Promoting social, emotional, and cognitive development in early childhood: A protocol for early valuation of a culturally adapted digital tool for supporting optimal childrearing practices. *Digital Health*, 10, 1–16. <https://doi.org/10.1177/20552076241242559>
- Li, L., & Disney, L. (2023). Young children's mathematical problem solving and thinking in a playworld. *Mathematics Education Research Journal*, 35(1), 23–44. <https://doi.org/10.1007/s13394-021-00373-y>
- Li, S., Tang, Y., & Zheng, Y. (2023). How the home learning environment contributes to children's social-emotional competence: A moderated mediation model. *Frontiers in Psychology*, 14, Article 1065978. <https://doi.org/10.3389/fpsyg.2023.1065978>
- Lin, M. L., & Faldowski, R. A. (2023). The relationship of parent support and child emotional regulation to school readiness. *International Journal of Environmental Research and Public Health*, 20(6), 4867. <https://doi.org/10.3390/ijerph20064867>
- Lin, Y. C., & Hou, H. T. (2024). The evaluation of a scaffolding-based augmented reality educational board game with competition-oriented and collaboration-oriented mechanisms: Differences analysis of learning effectiveness, motivation, flow, and anxiety. *Interactive Learning Environments*, 32(2), 502–521. <https://doi.org/10.1080/10494820.2022.2091606>
- Liu, W., Tan, L., Huang, D., Chen, N., & Liu, F. (2021). When preschoolers use tablets: The effect of educational serious games on children's attention development. *International Journal of Human-Computer Interaction*, 37(3), 234–248. <https://doi.org/10.1080/10447318.2020.1818999>
- Mayer, J. D., & Salovey, P. (1997). What is emotional intelligence? In P. Salovey, & D. Sluyter (Eds.), *Emotional development and emotional intelligence: Implications for educators* (pp. 3–31). New York: Basic Books.
- McLeod, B. D., Sutherland, K. S., Martinez, R. G., Conroy, M. A., Snyder, P. A., & Southam-Gerow, M. A. (2017). Identifying common practice elements to improve social, emotional, and behavioral outcomes of young children in early childhood classrooms. *Prevention Science*, 18, 204–213. <https://doi.org/10.1007/s11121-016-0703-y>
- Mermelstine, R. (2017). Parent–child learning interactions: A review of the literature on scaffolding. *British Journal of Educational Psychology*, 87(2), 241–254. <https://doi.org/10.1111/bjep.12147>
- Montazami, A., Pearson, H. A., Dubé, A. K., Kacmaz, G., Wen, R., & Alam, S. S. (2022). Why this app? How parents choose good educational apps from app stores. *British Journal of Educational Technology*, 53(6), 1766–1792. <https://doi.org/10.1111/bjet.13213>
- Muir, R. A., Howard, S. J., & Kervin, L. (2023). Interventions and approaches targeting early self-regulation or executive functioning in preschools: A systematic review. *Educational Psychology Review*, 35(1). Article 27 <https://doi.org/10.1007/s10648-023-09740-6>
- Mushquash, A. R., Neufeld, T., Malik, I., Toombs, E., Olthuis, J. V., Schmidt, F., ... Stewart, S. H. (2024). Increasing access to mental health supports for 12–17-year-old indigenous youth with the JoyPop mobile mental health app: Study protocol for a randomized controlled trial. *Trials*, 25(1), 234. <https://doi.org/10.1186/s13063-024-08076-y>
- Nicolaïdou, I., Aristeidis, L., & Lambrinos, L. (2022). A gamified app for supporting undergraduate students' mental health: A feasibility and usability study. *DIGITAL HEALTH*, 8, 1–12. <https://doi.org/10.1177/20552076221109059>
- Nicolaïdou, I., Tozzi, F., & Antoniadis, A. (2021). A gamified app on emotion recognition and anger management for preschool children. *International Journal of Child-Computer Interaction*, 31, Article 100449. <https://doi.org/10.1016/j.ijcci.2021.100449>
- Nunes, M., Oliveira, A., & Fidalgo, F. (2025). Gamification and emotional intelligence: Development of a digital application for children. *Education Sciences*, 15(4), 453. <https://doi.org/10.3390/educsci15040453>
- Olson, S. L., Lansford, J. E., Evans, E. M., Blumstein, K. P., & Ip, K. I. (2019). Parents' ethnotheories of maladaptive behavior in young children. *Child Development Perspectives*, 13(3), 153–158. <https://doi.org/10.1111/cdep.12330>
- Palermo, E. H., Young, A. V., Deswert, S., Brown, A., Goldberg, M., Sultanik, E., ... Nuske, H. J. (2023). A digital mental health app incorporating wearable biosensing for teachers of children on the autism spectrum to support emotion regulation: Protocol for a pilot randomized controlled trial. *JMIR Research Protocols*, 12(1), Article e45852. <https://preprints.jmir.org/preprint/45852>
- Papadakis, S. (2022). Apps to promote computational thinking and coding skills to young age children: A pedagogical challenge for the 21st century learners. *Educational Process: International Journal (EDUPIJ)*, 11(1), 7–13.
- Quan, Z., Grant, L., Hocking, D., & Connor, A. (2024). Distinctive mobile learning: Where it is different and how it can make a difference. *Interactive Learning Environments*, 32(1), 257–272. <https://doi.org/10.1080/10494820.2022.2086267>
- Rademacher, A., & Koglin, U. (2018). The concept of self-regulation and preschoolers' social-emotional development: A systematic review. *Early Child Development and Care*, 189(14), 2299–2317. <https://doi.org/10.1080/03004430.2018.1450251>
- Raghunathan, R. S., Musci, R. J., Knudsen, N., & Johnson, S. B. (2023). What children do while they wait: The role of self-control strategies in delaying gratification. *Journal of Experimental Child Psychology*, 226, Article 105576. <https://doi.org/10.1016/j.jecp.2022.105576>
- Rashedi, R. N., Rowe, S. E., Thompson, R. A., Solari, E. J., & Schonert-Reichl, K. A. (2021). A yoga intervention for young children: Self-regulation and emotion regulation. *Journal of Child and Family Studies*, 30(8), 2028–2041. <https://doi.org/10.1007/s10826-021-01992-6>
- Richard, S., Baud-Bovy, G., Clerc-Georgy, A., & Gentaz, E. (2021). The effects of a 'pretend play-based training' designed to promote the development of emotion comprehension, emotion regulation, and prosocial behaviour in 5-to 6-year-old Swiss children. *British Journal of Psychology*, 112(3), 690–719. <https://doi.org/10.1111/bjop.12484>
- Rogers, J., & Revesz, A. (2019). Experimental and quasi-experimental designs. In *The Routledge handbook of research methods in applied linguistics* (pp. 133–143). Routledge.
- Roid, G., Nellis, L., & McLellan, M. (2003). Assessment with the Leiter international performance scale—Revised and the S-BIT. In R. S. McCallum (Ed.), *Handbook of nonverbal assessment*. Boston, MA: Springer. https://doi.org/10.1007/978-1-4615-0153-4_6
- Samuelsson, R., Price, S., & Jewitt, C. (2024). How young children's play is shaped through common iPad applications: A study of 2 and 4–5 year-olds. *Learning, Media and Technology*, 49(2), 151–169. <https://doi.org/10.1080/17439884.2022.2141252>
- Smith-Donald, R., Raver, C. C., Hayes, T., & Richardson, B. (2007). Preliminary construct and concurrent validity of the preschool self-regulation assessment (PSRA) for field-based research. *Early Childhood Research Quarterly*, 22(2), 173–187. <https://doi.org/10.1016/j.ecresq.2007.01.002>
- Spinelli, M., Lionetti, F., Setti, A., & Fasolo, M. (2021). Parenting stress during the COVID-19 outbreak: Socioeconomic and environmental risk factors and implications for children emotion regulation. *Family Process*, 60(2), 639–653. <https://doi.org/10.1111/famp.12601>
- Sun, H. (2023). Practical paths for integrating kindergarten curriculum and emotional education. *Educational Practice and Research*, C(04), 57–59. <https://doi.org/10.14160/j.cnki.13-1259/g4-c.2023.04.001>
- Tang, Y., Li, S., Ma, L., Zheng, Y., & Li, Y. (2023). The effects of mother-father relationships on children's social-emotional competence: The chain mediating model

- of parental emotional expression and parent-child attachment. *Children and Youth Services Review*, 155, Article 107227. <https://doi.org/10.1016/j.chidyouth.2023.107227>
- Terjesen, M. D., Duhning, C., Pata, A. K., & Prizer, J. K. (2021). The current status of rational emotive and cognitive behavioral therapy (RE-CBT) research with children and adolescents. In *Rational-emotive and cognitive-behavioral approaches to child and adolescent mental health: Theory, practice, research, applications* (pp. 31–49). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-53901-6_2
- Tian, M. L. (2022). The expression of children's negative emotions and parents' coping strategies—Take children in District H of Sanmenxia City as an example. *Educational Observation*, 12, 50–52. <https://doi.org/10.16070/j.cnki.cn45-1388/g4s.2022.12.024>
- Vaioopoulou, J., Papadakis, S., Sifaki, E., Kalogiannakis, M., & Stamovlasis, D. (2023). Classification and evaluation of educational apps for early childhood: Security matters. *Education and Information Technologies*, 28(3), 2547–2578. <https://doi.org/10.1007/s10639-022-11289-w>
- Voshaar, J., Knipp, M., Loy, T., Zimmermann, J., & Johannsen, F. (2023). The impact of using a mobile app on learning success in accounting education. *Accounting Education*, 32(2), 222–247. <https://doi.org/10.1080/09639284.2022.2041057>
- Wadley, G., Smith, W., Koval, P., & Gross, J. J. (2020). Digital emotion regulation. *Current Directions in Psychological Science*, 29(4), 412–418. <https://doi.org/10.1177/0963721420920592>
- Wang, Y., Wen, F., & Zuo, B. (2023). The preference and development for societal-type cues in 3-to 8-year-olds' perception of groups. *Acta Psychologica Sinica*, 55(9), 1424. <https://doi.org/10.3724/SP.J.1041.2023.01424>
- Wu, J., Zhang, M., Lin, W., Wu, Y., & Li, H. (2021). School-based training for sustainable emotional development in Chinese preschoolers: A quasi-experimental study. *Sustainability*, 13(11), 6331. <https://doi.org/10.3390/su13116331>
- Wyman, P. A., Cross, W., Hendricks Brown, C., Yu, Q., Tu, X., & Eberly, S. (2010). Intervention to strengthen emotional self-regulation in children with emerging mental health problems: Proximal impact on school behavior. *Journal of Abnormal Child Psychology*, 38, 707–720. <https://doi.org/10.1007/s10802-010-9398-x>
- Xiao, Y., & Lu, Q. (2024). Analysis of research hotspots and trends in emotional theme painting based on cite-space. *Oriental Baby: Painting and Education*, 03, 41–43.
- Xie, J., Liu, S., & Fang, P. (2021). Cognitive training improves emotion regulation in Chinese preschool children. *Pediatrics International*, 63(11), 1303–1310. <https://doi.org/10.1111/ped.14661>
- Yao, W., Wang, L., & Liu, D. (2024). Augmented reality-based language and math learning applications for preschool children education. *Universal Access in the Information Society*, 24, 759–770. <https://doi.org/10.1007/s10209-024-01101-6>
- Yue, Y., Guo, J., Ma, Y., Yuan, H., & Li, M. (2024). The relationship of family support and peer acceptance in children aged 4–6: The mediating role of emotion regulation strategies. *Early Child Development and Care*, 194(13–14), 1366–1383. <https://doi.org/10.1080/03004430.2024.2371920>
- Yusoff, M. S. B. (2019). ABC of content validation and content validity index calculation. *Education in Medicine Journal*, 11, 49–54. <https://doi.org/10.21315/eimj2019.11.2.6>
- Zhang, X., Hai, Y. J., & Li, C. (2024). Learning management system in education via mobile app: Trends and patterns in mobile learning. *International Journal of Interactive Mobile Technologies*, 18(9), 19. <https://doi.org/10.3991/ijim.v18i09.49027>
- Zheng, J. (2023). Analyzing the developmental processes and influencing factors of children's emotional recognition, expression, and regulation abilities: A comprehensive review. *Studies in Psychological Science*, 1(2), 1–16. <https://doi.org/10.56397/SPS.2023.09.01>