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Developing Empathy and Self-Regulation in Elementary School Students Through SEL-Based AR Learning

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ABSTRACT

The development of empathy and self-regulation in elementary school students is a major urgency in responding to the socio-emotional challenges of contemporary education. This study aims to explore the integration of Augmented Reality (AR) based on Social and Emotional Learning (SEL) as a transformative approach in shaping students' emotional skills. Using a qualitative method with a case study design, this study involved fourth-fifth grade students, teachers, and parents through observation techniques, semi-structured interviews, documentation, and exploratory questionnaires. The results show that the application of AR with interactive socio-emotional scenarios can stimulate empathy, increase self-awareness, and develop emotional regulation strategies through immersive experiences. AR acts as an affective medium that strengthens reflective and embodied learning, enabling students to experience and understand emotional dynamics in complex social situations. This study confirms that the effectiveness of AR-SEL learning is highly dependent on the quality of instructional design and teacher competence in facilitating socio-emotional values digitally. Therefore, support for educators' digital-affective literacy and the integration of a character-oriented curriculum are essential prerequisites. These findings conclude that the AR-SEL learning model has great potential to integrate cognitive and affective dimensions simultaneously in basic education.

INTRODUCTION

The social and emotional development of elementary school-aged children is a fundamental aspect of education that cannot be ignored. Children at this age are in the "industry vs. inferiority" stage, where success in forming a social and emotional identity is largely determined by supportive learning experiences (Sormin et al., 2025). However, the reality in many educational institutions shows that children still experience difficulties in recognizing their own emotions, managing conflict, and interacting empathetically. This highlights the urgency of early social-emotional education, as lack

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of skills in this area can have long-term impacts on children's mental health and social relationships (Kustiarini et al., 2024).

Learning in elementary schools has traditionally focused more on cognitive aspects, while affective development, such as empathy and self-regulation, has not received adequate attention. Empathy skills, namely the ability to understand and feel the feelings of others, and self-regulation, namely the ability to control impulses and manage emotions, are key indicators of emotional intelligence. These competencies contribute directly to improved interpersonal relationships, conflict resolution, and academic success (Usan & Suyadi, 2022). Therefore, education must transform into a space that supports holistic learning, not only nurturing the brain but also touching the heart.

Social and Emotional Learning (SEL) exists as a systematic approach to instilling social-emotional skills in schools. The SEL framework developed by the Collaborative for Academic, Social, and Emotional Learning (CASEL) encompasses five key domains: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making. Explicit SEL implementation has been shown to increase empathy, prosocial behavior, and reduce aggressive behavior in students (Wicaksono & Dwi., 2022). This demonstrates that SEL is not merely an additional approach but a structural necessity in modern learning systems, including at the elementary school level.

On the other hand, the use of educational technology is experiencing rapid development, particularly in creating more engaging and meaningful learning experiences. Augmented Reality (AR) is an interactive technology capable of enriching students' perceptions and interactions with the learning environment through a combination of real-world and virtual elements. In an educational context, AR provides a contextual and participatory learning experience, enabling students to understand concepts more deeply through simulations and visualizations (Galarza, 2025). This has great potential to support the development of empathy and self-regulation through experiential learning scenarios.

The integration of AR into SEL-based learning creates a transformative learning model. Through this technology, students can engage in interactive simulations that present real-life social-emotional situations, such as witnessing another person's perspective or navigating interpersonal conflict. A study by Diswantika & Yustiana (2022) showed that AR can be used to foster empathy through "perspective-taking" by placing students in different roles within the simulation. Thus, AR technology is not merely a visual aid but can also be an affective medium that facilitates emotional reflection and empathetic decision-making.

The development of self-regulation through AR is also supported by its ability to provide instant feedback and experiential learning. When students are faced with emotional scenarios such as frustration, disappointment, or conflict AR can guide them in choosing appropriate emotional management strategies. Students who use AR in learning experience increased attention, intrinsic motivation, and emotional engagement (Kasperski, 2025). Thus, AR opens up space for creating learning that simultaneously develops students' cognitive and affective aspects.

However, developing an AR learning model based on SEL requires an appropriate pedagogical approach so that social-emotional objectives are not merely an additional attribute of the learning process. Learning design is needed that is oriented towards students' affective experiences, supported by scenarios that represent authentic social-emotional realities. Teachers, as facilitators, also need to be given specific training in implementing AR technology in the SEL context, so that this medium becomes not only

a visual innovation but also capable of transforming the way students learn and experience social experiences in a profound way (Yasin et al., 2023).

Considering the social-emotional challenges of elementary school students, the urgency of implementing SEL, and the potential of AR as an interactive learning medium, developing SEL-based AR learning is a relevant, innovative solution. Integrating these two approaches not only addresses the needs of 21st-century learning but also supports holistic student character development. Therefore, it is crucial to develop a structured, evidence-based model that can be sustainably implemented in the elementary school curriculum.

The integration of Augmented Reality (AR) technology and the Social and Emotional Learning (SEL) approach necessitates a comprehensive evaluation to measure the effectiveness of its implementation in shaping students' social-emotional competencies (Addzaky et al., 2025). This evaluation should not be limited to academic achievements but must also encompass changes in affective behavior, enhanced empathy, conflict resolution skills, and the reinforcement of responsible decision-making. Therefore, the development of evaluation instruments based on authentic criteria capable of capturing the emotional dynamics of students comprehensively becomes essential.

The success of AR- and SEL-based learning implementation cannot be separated from the collaborative roles of various educational stakeholders. The involvement of teachers, school principals, parents, educational technology developers, and public policy makers plays a critical role in ensuring the sustainability and consistency of this approach. Supportive policy interventions, continuous professional development for educators, and the provision of adequate infrastructure are key prerequisites for creating a conducive learning ecosystem for technology-based social-emotional skill development (Nurvahana, 2025).

Furthermore, the development of AR learning content oriented towards SEL must be designed based on the psychopedagogical characteristics of elementary school-aged children. Learning materials should accommodate the diversity of students' social and cultural contexts as well as their developmental needs, in order to authentically represent emotional experiences. Interactive simulations presented should be contextual, relevant to children's everyday lives, and able to facilitate both intrapersonal and interpersonal reflection processes in a constructive manner.

This integrative approach is also aligned with the direction of the Merdeka Curriculum, which emphasizes the formation of the Pancasila Student Profile. Character dimensions such as faith and devotion to God Almighty, global diversity, collaboration, independence, critical thinking, and creativity can be simultaneously developed through learning that balances cognitive and affective aspects. Therefore, strengthening AR-based SEL learning is not only relevant to the demands of the 21st century but also strategic in supporting national character development.

The integration of SEL-based AR in elementary school learning can be an innovative strategy to answer the challenges of 21st-century education that demand cognitive, affective, and social skills in a balanced manner. Through authentically designed interactive simulations, students can develop self-awareness and the ability to understand other people's perspectives in depth. This approach not only strengthens empathic abilities, but also forms a reflective mindset that is the basis for ethical decision-making. Furthermore, AR-based learning experiences encourage students to internalize social values in a safe context, thereby minimizing the psychological risks that may arise

on direct interactions in the real world. Thus, AR-SEL can serve as a bridge between social-emotional learning theory and contextually relevant educational practices.

The application of the AR-SEL learning model is also in line with the principle of experiential learning which emphasizes the active involvement of students in the learning process. Through immersive interaction, students experience the dynamics of social-emotional situations for themselves, then process them through directed reflection facilitated by the teacher. This stage allows for meaningful learning, where cognitive knowledge is reinforced by authentic emotional experiences. On the other hand, AR technology provides an opportunity to adapt learning scenarios according to students' developmental levels, so that the material presented can be challenging without causing an excessive burden. This shows that AR is not just an entertainment medium, but a pedagogical device that is able to combine technological flexibility with measurable learning goals.

The success of AR-SEL implementation relies heavily on the quality of instructional design that considers the balance between visual, narrative, and social interaction aspects. The scenario designed should contain conflicts or moral dilemmas that are relevant to the student's life, thereby triggering emotional engagement while encouraging the perspective-taking process. In addition, the integration of real-time feedback features in AR applications allows students to immediately evaluate their choices, strengthening self-regulation skills and the ability to predict the social consequences of certain actions. The teacher plays a central role in directing students' interpretation of these experiences, so that learning stays on a path that supports positive development. With the right design, AR-SEL can be a medium that not only facilitates individual learning, but also strengthens social cohesion in the classroom.

From an education policy perspective, the implementation of AR-SEL requires systemic support that includes the procurement of equipment, teacher training, and integration into the national curriculum. Investment in technological infrastructure must be balanced with the development of teachers' digital-affective literacy, so that they are able to utilize AR as a means to instill social-emotional values effectively. In addition, continuous evaluation needs to be carried out to ensure that the use of AR really has a positive impact on the development of students' empathy and self-regulation. A collaborative approach between governments, schools, and educational technology developers can accelerate this adaptation process. If implemented consistently, AR-SEL has the potential to become one of the important pillars in shaping a generation that is academically competent, emotionally resilient, and adaptive to future social changes.

Taking into account the social-emotional challenges of elementary school students, the urgency of implementing SEL, and the potential of AR as an interactive learning medium, the development of SEL-based AR learning is a relevant innovative solution. The integration of these two approaches not only responds to the needs of 21st-century learning, but also supports the formation of student character holistically. Therefore, it is important to develop a model that is structured, empirically evidence-based, and capable of being implemented sustainably in the primary school curriculum.

METHODOLOGY

This research uses a qualitative approach with a case study design to explore the application of Social and Emotional Learning (SEL)-based Augmented Reality (AR) in developing empathy and self-regulation in elementary school students. The case study

was chosen because it allows for an in-depth understanding of students' social-emotional phenomena in a real-life learning context (Yin, 2018).

The phenomenon highlighted refers to the increasing need to strengthen social-emotional skills among elementary school students, especially after prolonged online learning. Findings from Afifah et al. (2024) indicate that AR learning can increase empathy, while a study by Mittmann et al. (2022) and recent research from 2025 demonstrate that AR is also effective in improving self-regulation.

The research subjects were students in grades IV–V who were selected purposively, involving teachers and parents as supporting informants. Data were collected through observation, semi-structured interviews, documentation, and exploratory questionnaires.

The research was conducted in three stages: planning an SEL-based AR design, implementing learning using interactive social scenarios, and evaluating student behavior changes. Data analysis was conducted thematically, and data validity was strengthened through triangulation, member checking, and peer debriefing. Bottom of Form

RESULTS AND DISCUSSION

Technological advances in education have encouraged the creation of new approaches that focus not only on cognitive achievement but also on the development of students' affective and social aspects. One prominent innovation is the use of Augmented Reality (AR) in learning, which can create immersive, contextual, and interactive learning experiences. The integration of AR with Social and Emotional Learning (SEL) approaches is gaining increasing attention due to its proven effectiveness in supporting the development of empathy, emotional regulation, and social skills in elementary school-aged children (Dewi et al., 2025). This is reflected in various studies reviewed in the accompanying case study table, which show that the use of AR can significantly improve students' socio-emotional dimensions through learning scenarios involving social conflict, historical perspectives, and collaborative decision-making.

Table 1. List of International Case Studies on AR Implementation for Empathy and Self-Regulation Development in Elementary School Students

No.	Journal Title / Author	Year	Focus	Subject / Level	Key Findings
1	Design and Evaluation of an Augmented Reality Cyberphysical Game for the Development of Empathic Abilities – Lopez & Jaen (2023)	2023	AR & empathy	Elementary school students (30 students)	Empathy and perspective are significantly increased through AR media.
2	Gamified AR Comic to Promote Empathy in Children – Nunes et al (2025).	2025	AR & empathy	Children aged 8–12 years (389 children)	Enhancing cognitive and affective empathy through interactive narratives
3	Virtual and Augmented Reality to Develop Empathy: A Review – Lacle., et al (2025)	2025	AR & empathy	Elementary School Children (Malaysia)	AR empathy case studies are recognized as relevant for primary education
4	Looking past seeing present: teaching historical empathy skills via augmented reality – Çakiroğlu et al.	2024	AR & historical empathy	Elementary school students	Social awareness and historical perspective are increased through AR-based learning.

No.	Journal Title / Author	Year	Focus	Subject / Level	Key Findings
5	An Embodied Perspective on an Augmented Reality Game in School	2024	AR & collaborative empathy	Elementary school students	Collaboration, empathy between peers, and social engagement increase
6	Lina: A Social Augmented Reality Game Around Mental Health – Mittmann et al.	2022	AR, mental health, emotional regulation	Early adolescence (~11 years)	Improving emotional regulation & sense of belonging through participatory games
7	Leveraging AR and Gamification for Enhanced Self-Regulation in Science Education – Ates., et al (2025)	2025	AR & self-regulation	Elementary school students	Self-regulation (goal-setting, monitoring) is increased with interactive AR features.

The integration of Augmented Reality (AR)-based learning with the Social and Emotional Learning (SEL) approach in elementary education demonstrates a significant evolution in pedagogical construction, leading to the synthesis of cognition, emotion, and social relations in a transformative learning environment. In the context of elementary school-aged children, the need to develop social-emotional competencies such as empathy, self-regulation, social awareness, and responsible decision-making is a necessity, as emphasized in the CASEL framework, which serves as a global reference in SEL implementation. AR technology, with its characteristics of immersive visualization, real-time interactivity, and multimodal narrative capacity, offers a unique medium that not only supports cognitive engagement but also intensively activates the affective dimension of learners. This is realized through the presentation of complex social scenarios packaged in a safe environment, where students can experiment with action choices, experience the emotional consequences of those decisions, and receive direct emotional feedback from virtual characters. For example, in a study by Lopez & Jaen (2023), the use of an AR game by 30 elementary school students was shown to significantly improve their capacity to understand others' perspectives and foster reflective empathy. In this learning scenario, students not only watch the storyline, but also become active subjects involved in social decision-making through affective digital interactions. Similar findings were also confirmed by Nunes et al. (2025), who involved 389 children aged 8–12 years in an AR-based interactive comic narrative, where increased cognitive and affective empathy was reflected in students' tendency to express understanding of others' emotions and display more consistent prosocial behavior in classroom interactions. This interactive narrative approach allows for the internalization of social values not only through verbal instructions, but through emotional experiences presented in a participatory context.

Beyond empathy, AR also shows great potential in supporting students' self-regulation. The Lina game studied by Stalheim et al. (2024), for example, showed that students' participation in digital scenarios related to mental health issues encouraged emotional reflection and an increased sense of belonging, even in early adolescents. More relevant to elementary education, the study "Leveraging AR and Gamification for Enhanced Self-Regulation in Science Education" (2025) demonstrated that AR features such as goal-setting, self-monitoring, and real-time feedback stimulate elementary school students' metacognitive capacities, encouraging them to set goals, monitor progress, and adjust learning strategies independently. Thus, AR technology not only enables data-driven and interactive learning processes but also supports the development of reflective

and self-management dimensions, which are central to social-emotional learning. The potential of AR in shaping social awareness and historical empathy is also demonstrated in the study by Çakiroğlu et al. (2023), which shows that the use of AR-based historical simulations allows students to understand the emotional experiences of historical figures more deeply, triggers moral reflection, and broadens their social perspectives into the temporal dimension. Meanwhile, the collaborative approach in AR also plays a crucial role in shaping students' relational skills. The study "An Embodied Perspective on an Augmented Reality Game in School" (2024) shows that when elementary school students engage in AR-based collaborative games, there is a marked increase in cooperation, empathy among peers, and awareness of shared social responsibility. This indicates that AR can be a shared affective space that enables social co-regulation to occur in a fun and constructive context.

These findings are reinforced by various current educational and neuroscience theories that emphasize the importance of emotional engagement in the learning process. Emotions are not a barrier to cognitive learning, but rather its biological foundation, as affective processes work integrally with logical processing in the child's brain (Zhou, 2021). In this paradigm, AR functions as an affective-socio-cognitive environment that enables simultaneous learning experiences between the rational and social brains. This approach aligns with Kolb's (1984) experiential learning model, where meaningful learning emerges from direct experience, critical reflection, and personal transformation of meaning. A study by Egunjobi & Adeyeye (2024) also showed that the use of AR in social simulation scenarios not only increases cognitive engagement but also strengthens students' emotional retention of the learned content. Pedagogically, this approach is reinforced by the theory of embodied cognition, which emphasizes that conceptual understanding is enhanced through bodily involvement and the dimensional space that is highly accommodated in AR-based learning experiences. On the other hand, narrative as a form of representation of social values also plays an important role in fostering empathy, as explained by Wijayanti (2020) who emphasized that exposure to social conflict narratives encourages the development of theory of mind in children, namely the ability to recognize and understand the emotions and perspectives of others.

Thus, in the context of the case studies analyzed and supported by scientific theories, the integration of SEL-based AR in elementary education has not only practical justification but also strong epistemological and pedagogical foundations. AR is not simply a technological innovation, but a transformative tool that connects students with real-life social experiences through affective simulations, reflective narratives, and collaborative interactions. The success of this approach depends heavily on the depth of instructional design, the competence of teachers as affective facilitators, and the courage of the education system to transform the curriculum to be more humanistic. In this configuration, learning is no longer simply a process of transferring information, but rather an effort to shape individuals who think rationally, feel empathetically, and behave ethically in an ever-changing social environment.

The implementation of Augmented Reality (AR) based on Social and Emotional Learning (SEL) in the context of elementary education requires a synergy between the development of educational technology and the role of teachers as co-designers of learning. Teachers are no longer the sole source of information; rather, they serve as facilitators of empathy, mediators of virtual social conflicts, and companions in students' emotional reflection within digital environments. Therefore, professional training for educators on the use of AR in social-emotional contexts becomes essential. Initiatives

such as the "AR-Pedagogical Training for SEL Teachers" demonstrate that teachers trained in designing emotion-based narrative scenarios are more capable of enhancing students' affective and cognitive engagement during the learning process (Srisuk et al., 2024).

Moreover, the integration of AR and SEL also requires attention to digital ethics and students' emotional safety. Since social simulations presented through AR can evoke deep affective responses, content design must consider cultural sensitivity, developmental age, and the potential for triggering trauma. Overly intense AR experiences may lead to emotional fatigue if not accompanied by reflective pauses and adequate social support. Thus, the implementation of AR for SEL development must incorporate principles of digital well-being, such as student participation control, affective data privacy, and limitations on exposure duration.

Beyond strengthening intrapersonal and interpersonal domains, AR also holds the potential to expand students' multicultural awareness through cross-cultural scenarios. For example, in the "Global Kids AR" application, students are invited to interact with characters from diverse cultural backgrounds who convey values of diversity, tolerance, and social justice. When students encounter social conflict within another cultural context, they are challenged not only to understand differences but also to build empathy across identities. This aligns with UNESCO's vision of global education, which emphasizes the importance of "global citizenship education," where students are nurtured to become not only local citizens but also global citizens who are sensitive to global social dynamics.

Another strength of this approach is its capacity to holistically integrate 21st-century competencies. Through AR-SEL-based activities, students not only learn to collaborate and communicate effectively but also simultaneously develop creativity, complex problem-solving skills, and technological literacy. This creates a transdisciplinary learning space in which the boundaries between social studies, technology, and life skills become fluid. In this context, AR is not merely a learning aid, but a learning ecosystem that prepares students to face real-life challenges with mature social and emotional capital.

Finally, the successful integration of AR and SEL in elementary education must be supported by progressive, evidence-based educational policies. Governments and stakeholders need to promote further research, allocate funding for the development of locally contextualized AR platforms, and design curricula that accommodate technology-based affective learning. If implemented systematically, this integration can serve as a future learning model that not only enhances academic achievement but also shapes students' character as empathetic, resilient individuals who are ready to contribute to a dynamic and inclusive society.

The application of Augmented Reality (AR) based on Social and Emotional Learning (SEL) at the elementary school level represents a paradigm shift in education from a teacher-centered model to a student-centered model that places students as active subjects. Through direct involvement in virtual social-emotional scenarios, students gain the opportunity to experiment, take on different roles, as well as experience the emotional consequences of every decision they make. This interactive process not only fosters an awareness of personal responsibility, but also strengthens metacognitive skills in the form of the ability to do critical self-reflection. The integration of AR-SEL for teacher-facilitated post-simulation discussions, where virtual experiences are linked to factual situations experienced by students in school and family environments. Thus, learning

does not stop at the level of simulation, but continues at the process of internalizing values that are oriented towards real behavior changes.

Collaboration between AR technology and SEL frameworks can be a strategic mechanism to bridge the gap between learners' cognitive and affective development. The reality of education in primary school shows that academic and social-emotional aspects are often taught separately, even though the two have a significant mutual relationship. Through instructional design that blends academic learning concepts with AR-based social simulations, students not only understand the content of the material, but also hone interpersonal skills such as empathy, effective communication, and collaborative problem-solving. This process contributes to increased knowledge retention while forming consistent prosocial behaviors in daily life. Therefore, this integrated approach can be positioned as a pedagogical innovation that harmonizes the cognitive and affective dimensions simultaneously.

The success of the implementation of AR-SEL in the context of basic education is greatly influenced by the readiness of the learning ecosystem, especially related to the competence of teachers as technology facilitators and emotional mediators. Teachers have a central role not only in operating AR media, but also in directing student interactions to take place in a productive and constructive corridor. To achieve this, a teacher professional development program is needed that includes technical mastery of the use of AR, a deep understanding of the principles of SEL, and emotional reflection facilitation skills. This kind of training will ensure that AR is used not only as a visualization instrument, but as a pedagogical medium that has transformative value. Thus, teachers are able to integrate technology and social-emotional values harmoniously into the learning process.

The implementation of AR-SEL in primary education has long-term implications for the formation of a generation that is intellectually superior as well as emotionally mature. The cultivation of empathy, self-regulation, and social awareness skills from an early age is an important capital to deal with the increasingly complex dynamics of social life. In the context of globalization and the demands of 21st century competencies, the ability to understand and appreciate cross-cultural perspectives will be a significant competitive advantage. By utilizing AR as a medium that presents social experiences in an immersive and reflective manner, learning is not only knowledge transfer, but also character transformation. Therefore, AR-SEL integration needs to be seen as a strategic investment that is able to support the development of human resources with character, adaptiveness, and global competitiveness

CONCLUSION

Augmented reality (AR)-based learning combined with a social and emotional learning (SEL) approach can be an effective and enjoyable method in elementary education. Through AR, students can engage in engaging and interactive learning situations, where they can experience social experiences directly in virtual form. These experiences help children better understand their own and others' feelings, build empathy, and enhance their ability to collaborate. AR technology also allows students to learn directly from real-life experiences, with the help of digital stories and responses appropriate to their actions. This makes the learning process more meaningful and goes beyond memorization. However, the success of this method still depends on how teachers design learning activities and support students. Teachers who understand how to use technology while also guiding students' emotions will make the learning process more

lively and meaningful. With the right support, this approach not only equips students with future skills but also helps them grow as well-rounded individuals with character.

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