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# Utilizing virtual reality to assist social competence education and social support for children from under-represented backgrounds

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A R T I C L E I N F O

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A B S T R A C T

Although education is a fundamental human right for global citizens, educational inequality still exists within and among countries. Still today, many students struggle to access and receive quality education. Therefore, the value of using immersive technology to increase social competence and perceived social support for children who live in remote areas of the world, reduce inequality, and improve the quality of education requires much attention to address the lacuna between urban and rural education systems. Based on three representative pedagogies (Pedagogy of Technology, Play-based Learning, and Traditional Pedagogy), we designed three social competence educational approaches – virtual reality (VR) assisted social competence education, Lego social competence education, and traditional classroom learning – and applied them to interventions in two rural schools in Southwest China. Our results showed that VR and Lego social competence education prompted children's social competence and perceived social support with elementary school children (Study 1). Furthermore, VR social competence education resulted in substantially greater social competencies and subjective sense of social support than traditional classroom learning with middle school children (Study 2). The results suggest that VR-assisted social competence education (Pedagogy of Technology) could be a potential tool to reduce educational inequalities in underdeveloped countries and regions.

## 1. Introduction

Education is a fundamental human right for global citizens to achieve personal success and sustainable development (Assembly, 1948; King, 2011; McCowan, 2010). However, approximately 258 million children (17% of potential students) do not attend school worldwide (Deloumeaux, 2019). Moreover, many students from developing regions do not have the quality of education available to students from developed areas (OECD, 2012; UNICEF, 2022). Educational inequality is a severe social challenge for most developing countries since it leads to long-term instability and stagnation at the macro level (Cingano, 2014). Although the United Nations Sustainable Development Goal (UNSDG) 10 – "Reduced Inequalities" has advocated that each country should seek to reduce inequalities in all forms and ensure that no one is left behind in society, educational inequality exists within and among countries

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(Chzhen et al., 2018; López-Roldán & Fachelli, 2021). The UNSDG 4 – Quality Education states that the right to have quality education directly affects global human resources and future human prosperity, while chronic inequality and low-quality education can trap children in trans-generational poverty and immobility without the benefit of equal and quality education (UNDESA, 2019).

### 1.1. Educational inequality – an example in China

The challenge of inequality in education is a global issue that can be exemplified differently across countries. For instance, China's developmental resources are clustered in advanced urban areas rather than rural areas due to the imbalanced regional development of the economy (Rozelle & Hell, 2020). This unbalanced regional development includes the unequal distribution of educational resources in the state, directly leading to the educational chasm and inequality between urban and rural areas (Postiglione, 2015). For example, rural elementary pupils are more than two grade levels behind urban pupils in math, and this gap widens every year students are in school (Rozelle & Hell, 2020).

In contrast, unbalanced development has resulted in widespread poverty in rural regions, which has resulted in massive parental migration to developed urban regions from remote rural areas (Du et al., 2005; Zhou et al., 2015). This development can keep parents away from their children for prolonged periods, so children are left behind, living with only one parent or other relatives (Hu et al., 2020). Children living in underdeveloped rural areas are less likely to access high-quality education than their urban counterparts (Rozelle & Hell, 2020). Also, children who have been left behind at home are more likely to externalize lower social competence and consequently exhibit more problematic behaviors due to lower social support or less physical accompaniment (Gaydosh, 2015; Portner & Riggs, 2016). For instance, lower capacity in self-expression - delivering appropriate social messages and responses to families, peers, and teachers (Hosokawa & Katsura, 2017).

## 2. Literature review

### 2.1. The concept of social competence and social support

The concept of ***social competence*** refers to an individual's ability to appropriately engage in social occasions and develop meaningful interactions with others (Junge et al., 2020b). It usually incorporates additional components, such as social skills, social communication, social interaction, and social inference (Semrud-Clikeman, 2007). Social competence manifests in a child's emotions, behaviors, and ability to interact with others (Junge et al., 2020a). The development of social competence is essential for future functioning in society, emotional adjustment, and behavioral management (Junge et al., 2020a). For example, children who get along with others are more likely to rate themselves as happier (Ryan & Deci, 2001) and have better academic performance (Denham, 2006). Socially competent children are also more likely to grow into adults with better health (Luthar, 2006), and adults with appropriate social skills gain more prosperous reciprocal interpersonal relationships and function better in society (Lopes et al., 2015; Luthar, 2006).

***Social support*** is the perception or experience that one is cared for, esteemed, and part of a mutually supportive social network that has beneficial effects on mental and physical health. Meanwhile, research has indicated that social support facilitates social competence and positive self-conceptions (Roohafza et al., 2014). External social support (e.g., parental support and school support) are substantial factors for social competence development, in which the family is the first and most important supportive resource (Roohafza et al., 2014).

### 2.2. Current status of rural children and the importance of social competence education

The global rural population is now close to 3.4 billion (Nations, 2018). Therefore, rural children's educational development is vital for global human sustainability. Growing evidence suggests that a higher quality of education positively influences children's social competence development (Curby et al., 2009; Demirci, 2020; Exenberger et al., 2021). For instance, research has indicated that children from disadvantaged rural regions who experience higher levels of classroom learning have better social skills and fewer behavior problems than children who have not been provided with the same (Broekhuizen et al., 2016). Thus, it is essential to ensure that as many children as possible can obtain quality social competence education, which can boost their chances for future success and reduce inequality in underdeveloped rural regions.

Social Competence Education (SCE) is the concept of teaching particular social skills for students' development, future success, and social well-being (). It has also been used in various pedagogies to train rural children's social skills at school. Here we review the most popular and widely used SCE pedagogies from previous and ongoing studies, categorizing them into three categories: the traditional pedagogy — traditional classroom learning; the student-centered pedagogy — play-based learning (i.e., Lego); and a novel pedagogy — the pedagogy of technology (i.e., virtual reality).

### 2.3. SCE-related pedagogies

***Traditional Classroom Learning*** is a highly teacher-centered activity. The classroom usually consists of rows of desks and chairs, allowing students to easily observe and listen to the teacher and watch PowerPoint slides or transparencies (Zhang et al., 2004). Many schools in rural areas are small and geographically isolated, with inadequate infrastructure, limited educational offerings, and continuous student absence (Echazarra & Radinger, 2019). Therefore, over the past decades, traditional classroom learning has been employed as the primary approach in many rural schools (Mahaye, 2020; Rana et al., 2018). It can be effective despite being seen as rigorous and unprogressive. For example, research has demonstrated that students learning in a conventional setting may have higher social skills scores than those in an online environment (Shaw, 2015).

Compared to the traditional approach, ***Play-based Learning*** is a student-centered pedagogy that highlights learning through play as a valuable method for a child's development of social and emotional skills (Taylor & Boyer, 2020). As a representative of play-based learning, Lego playing has provided a practical approach to encouraging children's genuine interest in strategic play and motivating their socio-behavioral improvement by embedding social interactions through its construction activities (Huskens et al., 2015; Kristiansen & Rasmussen, 2014; Simmons, 2019). Research has illustrated that Lego may have a powerful potential to engage children and young adults in interactive and collaborative activities (Kurkovsky, 2015; Lee & Saw, 2021). Also, Lego has been harnessed globally to support many rural regions' educational sustainability and to help children's social skills education (The Lego Group, 2021). However, although many practitioners have endorsed that play-based learning is a practical pedagogy that benefits children's learning (Keung & Cheung, 2019), students might be distracted by it more than what they can gain from its learning activities (Dimitra et al., 2020).

***Pedagogy of Technology*** (e.g., information and communications technology) has been practiced as a novel and successful approach to establishing a quality system for education in under-developed countries/regions (Asongu et al., 2019; Asongu & Odhiambo, 2019; Kudasheva et al., 2015). Most successful cases of using the pedagogy of technology focused on the use of information and communication technology (ICT) to transform and improve teaching and learning activities, including improving educational quality in remote areas (OECD, 2016). Little research has focused on further ambitions - using novel, cutting-edge technology (virtual reality, augmented reality, and artificial intelligence) to overcome educational inequality. In fact, well-designed virtual reality (VR) applications simulate real-life conventions and human interactions for users to understand social emotions and behavioral patterns better and display great potential in SCE (Fagernäs et al., 2021; Pan & Hamilton, 2018).

The immersive function of VR can stimulate the individual's heightened emotional space and improve the user's attention and engagement in related VR activities (Johnson-Glenberg, 2018). More specifically, VR can generate a sense of *presence* allowing the user to have an illusion of "being there" in the virtual environment while knowing that he/she is not there (Slater, 2009). Furthermore, users in VR can experience a sense of embodiment, a sensation linked to being inside, having, and controlling a body (Kilteni et al., 2012). Users also can have a sense of *agency*, which is related to the subjective experience of control, intention, feeling like they are in a virtual body, and having actions in VR (referred to as "embodiment") (Kilteni et al., 2012).

In education, the sense of presence, agency, and embodiment in VR are central components in immersive learning theories including the Cognitive Affective Model of Immersive Learning (CAMIL: Makransky and Petersen, 2021), the immersion principle of multimedia learning (Makransky, 2021; Makransky & Mayer, 2022), and general learning theories such as Experimental Learning Theory (Kolb, 1984). CAMIL highlights presence and agency as the fundamental affordances of using immersive technology in learning. The theory uses existing evidence to highlight how presence and agency can facilitate learning through cognitive and affective factors such as interest, intrinsic motivation, and self-efficacy. The immersion principle in multimedia learning (Makransky and Mayer, 2022) describes how people learn better with VR than with standard media when immersive lessons are designed according to instructional design principles and the affordances of the technology. The design and function of VR applications can be bespoke to facilitate various educational scenarios and help to build up scaffolds for students' individual needs. For example, Baker et al. (2021) used social VR to investigate how virtual environments were employed to scaffold reminiscence for elders' social competence and psychological well-being. Hence, VR can be considered a tool for developing social competencies, particularly for students with limited access to social training, allowing them to engage in essential social interactions that they may not experience in the real world due to economic or social factors (Baceviciute et al., 2022; Wang et al., 2022b). According to the Experiential Learning Theory (Kolb, 1984), where learners usually progress through a cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation. When applying VR education, learners can explore the virtual learning environments freely (Chen et al., 2005), practice their knowledge synchronously, and understand the learning outcomes easily (Fromm et al., 2021). This is a way to achieve meaningful learning through active experimentation (San Chee, 2001).

### *2.4. VR-assisted social competence education*

The main benefit of using VR as a social competence education tool is the possibility of displaying real-life social situations while maintaining control over what is happening. VR can provide simulated scenarios with the exact physical and behavioral mechanism as users' real-life environment, supporting increased standardizations of procedures (Howard & Gutworth, 2020). When conducting an intervention in a VR scenario, it is possible to create interactive social situations and manipulate all the presented variables simultaneously (Pan & Hamilton, 2018). Sophisticated VR technology offers a high level of interactivity with stimulating environments, which can motivate children to learn and practice social skills. For example, VR interventions can combine delivering social knowledge, emotional regulation, social interaction, and attention practice (Plechatá et al., 2022b; Wang et al., 2021) while allowing students to practice social skills in a multi-sensorial, safe, realistic simulated, controllable, and interactive setting (Ip et al., 2018).

With the rapid development of VR education, VR-assisted SCE has emerged with related social support programs that may have the potential tohelp studentsdevelop social competence traits for today's world (Plechatá et al., 2022c; Wang et al., 2022a). Research also indicates that VR-based social competence training is as effective for the general population as for special education samples (Howard & Gutworth, 2020), and most studies related to VR-assisted SCE have focused on special education and clinical interventions. Investigating VR-assisted SCE in mainstream education, Herbst et al. (2021) used VR as an educational training tool to enhance learners' competence in behavioral health and motivational interviewing skills. (Young et al., 2021; Plechatá et al., 2022d) used VR as an "empathy-making machine" to help individuals establish perspective-taking and emphasize another person's circumstances.

Participants reported that they experienced empathy and oneness from VR sessions as VR delivered a sense of understanding that other technology-based training could not.

### 2.5. VR as a social support intervention

Studies have investigated using VR to provide social support for people with aphasia (Marshall et al., 2020), for LGBTQs in social VR (Acena & Freeman, 2021), as well as psychology students (Collange & Guegan, 2020). Although some results have not found significant positive effects (Marshall et al., 2020), the majority have reported that VR has the potential to support individuals by affording a range of inclusive interactions (Acena & Freeman, 2021), and these VR social support interventions led to a variety of benefits, such as the sense of peer support, benefaction, and gratitude (Marshall et al., 2020). Perceived social support has been established by offering students personal experience with positive aspects of VR (i.e., feeling safe and assured that they would be accepted and supported; learning more about themselves and interacting with others who may share their identity; and being the recipient of a virtual role's human action (Acena & Freeman, 2021). Hence, VR social support interventions can be compelling for generating complex emotions and enhancing individuals' hedonic experience, social connection, and reciprocity. More importantly, VR could be harnessed as a positive technology to stimulate the individual and group's function of social support (Collange & Guegan, 2020). Furthermore, a VR social support intervention has been used for educational purposes, and the interaction between students and virtual benefactors was effective in facilitating positive interpersonal and intergroup contact (Collange & Guegan, 2020).

### 2.6. Research gaps

One issue that remains constant in current studies of VR education is that most relevant research is conducted with "WEIRD" samples (Makransky & Klingenberg, 2022), which represent only 12% of the world's population (Henrich et al., 2010). Given that few studies were conducted in an actual educational context in remote rural areas (Raja & Lakshmi Priya, 2022), this deficiency has been highlighted as a general limitation in current VR learning research (Di Natale et al., 2020; Radianti et al., 2020), as well as a crucial element for future VR research and disciplinary diversity (Makransky & Klingenberg, 2022). Thus, to explore the potential of VR-assisted SCE for developing regions/countries, it is crucial to apply VR education research in non-WEIRD samples.

Furthermore, few field studies investigate VR education's applicability outside the laboratory setting (Rogers & Marshall, 2017); therefore, most studies' external validity and impact on mainstream education are limited. On the other hand, although VR education is gaining popularity in schools, little research has compared VR SCE to other pedagogies in real-life classroom learning contexts.

### 2.7. Research questions

To explore these topics further, we conducted two studies in rural schools in Southwest China to investigate the impact of three different SCE approaches on social competence and perceived social support. This approach was used to identify specific research gaps and examines the efficacy of using VR to facilitate SCE in rural classroom settings. We designed three eight-week SCE sessions to reach this goal: VR-assisted SCE, Lego SCE, and traditional classroom learning.

In Study 1, we randomly assigned elementary school children ($n = 38$) to VR or Lego SCE. In Study 2, middle school students ($n = 50$) were randomly assigned to one of the three SCE approaches – VR, Lego, or traditional classroom learning. Thus, we explored the following research questions (RQ):

RQ 1 – Can VR, Lego, and traditional classroom SCE improve children's social competencies?
RQ 2 – Which pedagogy is the most effective for developing rural children's social competence?
RQ 3 – Can VR, Lego, and traditional classroom SCE improve children's perceived social support?
RQ 4 – Which pedagogy is the most effective for developing rural children's perceived social support?

## 3. Study 1

In this study, we aim to investigate whether VR and Lego SCE can improve children's social competence and perceived social support. Children aged 9–13 years were recruited from an elementary school in a rural village located in Southwest China. The study was approved by the institute's research ethics committee.

**Table 1**
Demographic characteristics for Study 1.

| Participants/Group | No. Of Participants | Gender, female (%) | Mean Age (SD) |
|---|---|---|---|
| Total Participants | 38 | 16 (42.1) | 11.18 (0.56) |
| VR Group | 18 | 6 (33.33) | 11 (0.00) |
| Lego Group | 20 | 10 (50) | 11.35 (0.75) |

Note. VR = virtual reality.

### 3.1. Participants

A total of 40 rural left-behind children from a rural elementary school were recruited to participate in Study 1. All children and guardians were provided with participation information and consent forms. After consent approval, participants were randomly divided into two groups with even numbers: VR Group ($n = 20$) and Lego Group ($n = 20$). However, during the SCE sessions, two children withdrew from the VR group, resulting in a final sample consisting of the VR Group ($n = 18$) and Lego Group ($n = 20$). See Table 1 for an overview of the characteristics of each group.

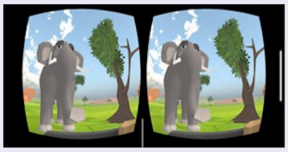
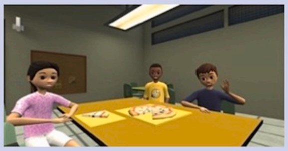
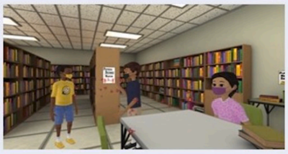
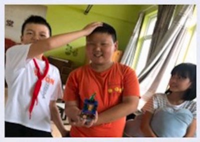
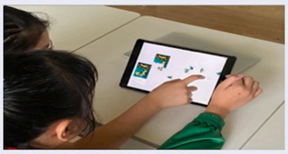
| Sessions | VR | Example Figure (VR) | Lego | Example Figure (Lego) |
|---|---|---|---|---|
| 1 | Meditation & Class participation (Floreo VR) |  | Introduction and practice of teamwork |  |
| 2 | Emotional regulation & Descriptive language (Floreo VR) |  | Communication skills |  |
| 3 | Joining a conversation & Responding to classmates (Floreo VR) |  | Learning to share |  |
| 4 | Body language training & School social events (Floreo VR) |  | Interpreting instructions |  |
| 5 | Visiting Jonathan Yeo's large-scale 3D printed sculpture (Google Arts & Culture) |  | Puzzle, game, and play |  |
| 6 | National History Museum (London) Tour |  | Problem-solving |  |
| 7 | Art Gallery Visiting - The contemporary African art collection (Google Arts & Culture) |  | Emotional growth with teammates |  |
| 8 | Science Tour - Inside the space (Google Arts & Culture) |  | Creativity & Thinking |  |

**Fig. 1.** List of session themes for the VR and Lego groups.

### 3.2. Procedure

The initial experiment consisted of eight-session interventions conducted over eight weeks, each with a different theme, such as meditation, communication skills, or body language, see Fig. 1. All participants were invited to complete the assessment form to evaluate their multidimensional social competence and perceived social support before and after the SCE sessions. After each pre-test and post-test, participants were offered a gift bag equal to 20 Chinese Yuan.

#### 3.2.1. VR group

Each child experienced eight 25–45 min VR sessions. Each session included 3–5 lessons per session, and each lesson lasted 5–10 min. There was a short break between each session to limit VR fatigue. We provided three types of VR devices (i.e., Cardboard VR, Meta Quest 2, and Tablet VR) for children to experience different functions and effects in VR.

Floreo VR was used during the first four sessions (1–4). Floreo VR is a VR platform that teaches children social, behavioral, communication, and life skills through a range of simulations concerning children's daily life scenarios (Ravindran et al., 2019). However, as certain Floreo VR modules are designed for children with autism spectrum disorder (e.g., Communicative eye gaze and Focusing), the research team only selected relevant modules for inclusive learning in the study (e.g., Joining a conversation and School social events). We chose affordable VR gear (i.e., Cardboard VR) for children to access Floreo VR, and the instructor guided and interacted with the child while watching the same session on a tablet (Fig. 2). Each VR session was designed with learning content consisting of several lessons, including learning cards to address specific subskills to develop children's social skills. The virtual scenarios occurred in school settings (i.e., classroom, playground, canteen, and library). The child was asked to proceed through each lesson's learning cards during the session to achieve the set SCE target.

During the second four sessions (5–8), students participated in VR tours and virtual public events at museums, galleries, and theatres using Google Arts & Culture with Meta Quest 2 and Tablet VR. Arts & Culture is an online platform using high-resolution images and videos, including virtual reality tours, 360-degree videos, virtual exhibitions, and virtual tours for artworks and cultural artifacts from partner cultural organizations worldwide. It offers rich arts and culture resources within various museums and galleries and powerful education functions for rural children to learn about arts and culture and acquire appropriate social knowledge from virtual public venues. In each session, children first used Meta Quest 2 to watch a 360-degree video individually, which aimed to enable children to experience immersive VR. Next, through Tablet VR, a non-immersive VR that supports multioperation with finger control, the child took virtual tours and played cooperative games with a peer. During the process, the instructor explained relevant social manners and norms for rural children's social competence learning during these sessions (Fig. 3).

#### 3.2.2. Lego group

Participants in the Lego group completed eight Lego collaborative play sessions with different themes. Each session was designed as teamwork with three children (Fig. 4) and lasted 25–45 min. When the session started, the instructor assigned children to one of three

**Fig. 2.** A Floreo VR session with the instructor.

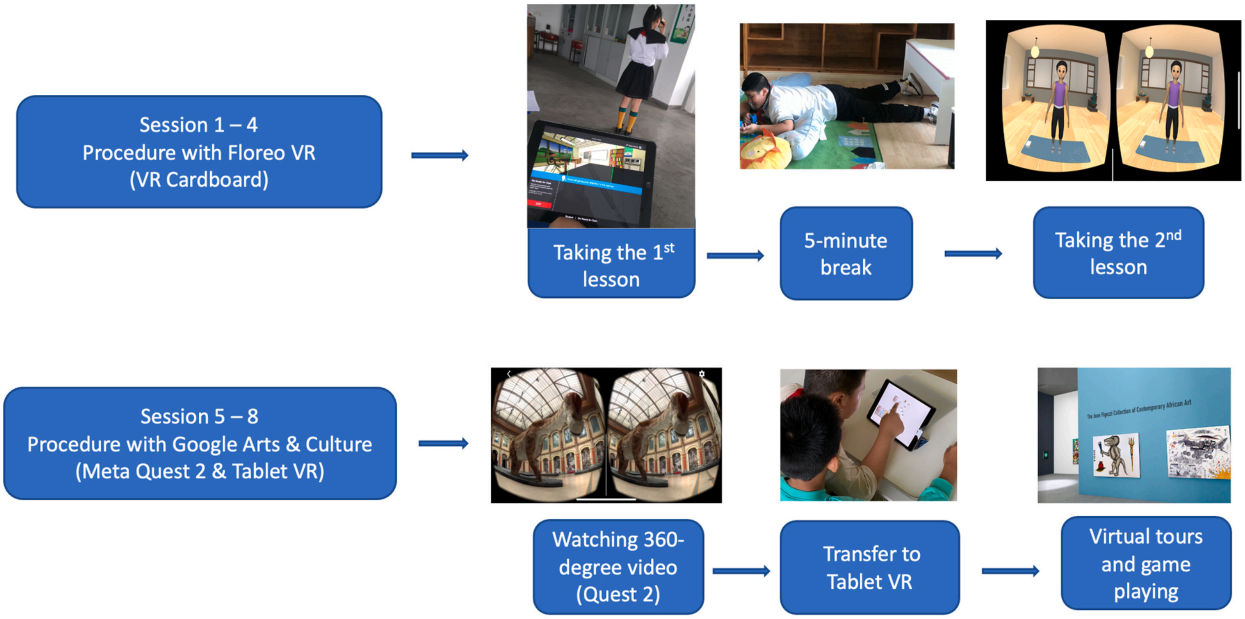



**Fig. 3.** VR sessions procedure.

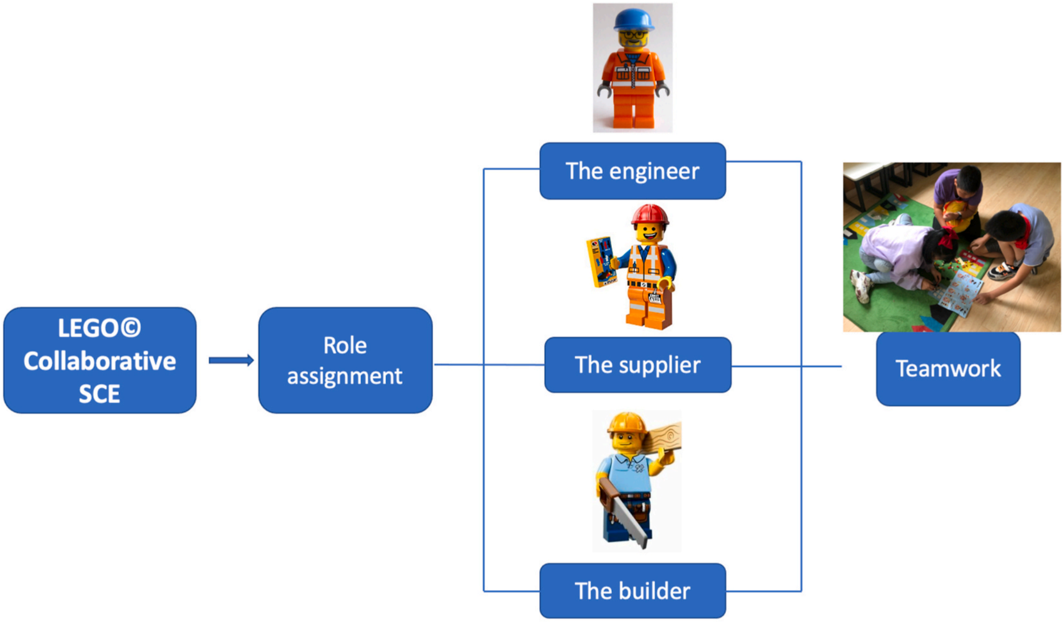



**Fig. 4.** Lego sessions procedure.

roles – engineer, supplier, and builder. The engineer looked up manual instructions and instructed the supplier to gather the correct brick(s) and deliver them to the builder. The supplier was responsible for communicating with the other two roles and coordinating the project. The builder needed to pay attention, listen, and question teammates, using problem-solving skills to complete the project (Fig. 4). The instructor's job for the Lego session was to observe their teamwork and SCE processes, guide children to process the project, and mediate the group atmosphere when team members displayed friction with each other.

### 3.3. *Outcome measures*

#### 3.3.1. *Multidimensional social competence scale (MSCS)*

MSCS (Rotatori, 1994) is a 77-item self-report questionnaire assessing the respondent's social competence across seven domains: **social motivation** – one's level of comfort, interest, and enjoyment in interactions; **social inferencing** – one's ability to detect and interpret social cues; **demonstrating empathic concern** - the individual's ability to recognize others' negative emotions and to respond in an empathic manner; **social knowledge** – the individual's understanding of social norms; **emotion regulation** – one's ability to modulate negative emotions, **verbal conversation skills** – one's skills for having a conversation with others; and **nonverbal sending skills** – one's proficiency in the "sending" of nonverbal social communication cues, such as gestures/pointing (Yager & Iarocci, 2013) (see Appendix A). MSCS precisely assesses aspects of social functioning that are fine-grained, multidimensional, and without disorder-specific purpose. The Chinese version of the MSCS has previously been validated by Trevisan et al. (2018) and Leung et al. (2019).

#### 3.3.2. *Youth social support questionnaire (YSSQ)*

YSSQ (Dai & Ye, 2017) is a 17-item Chinese self-report questionnaire to estimate children and adolescents' perceived social support and adoption of existing social resources. It includes three dimensions: **subjective sense of social** support – personal feelings of own social support; **objective social** support – the essence of actual social support; and **utilization of social resources** – the individual's active use of social resources (Appendix B). The school counselor recommended YSSQ as having particular utility in rural Chinese. YSSQ may allow us to understand if the SCE sessions can increase rural children's perceived social support, especially for left-behind children who experience long-term parental absence.

### 3.4. *Statistical analysis*

All data analyses were performed using IBM SPSS Statistics 27. With time as a within-subjects factor and condition as a between-subjects factor, mixed ANOVA was performed to determine the interactions and pre-post differences in each group. At the same time, Bonferroni correction was applied when making multiple comparisons to account for a type 1 error, alpha = .05/7 = 0.007 in MSCS, and alpha = .05/3 = 0.017 in YSSQ.

### 3.5. *Results*

#### 3.5.1. *Questionnaires reliability*

Before the primary analyses, we investigated the reliability of the MSCS and YSSQ using Cronbach's alpha. The analyses identified several items that did not have satisfactory psychometric qualities. These items were also evaluated qualitatively for linguistic and cultural content by a native speaker, which made it clear that cultural factors made it difficult for rural children to understand the items as intended. Thus, 21 items that decreased the scale's reliability and/or were identified as having linguistic or cultural issues were eliminated before conducting the analyses. The final MSCS used in Study 1 and Study 2 included 71 items. The reliability of the MSCS and the seven subscales, as well as a list of included and deleted items, are reported in Appendix C and D. In the case of YSSQ, two items that decreased the reliability were eliminated before conducting the analyses. The final YSSQ used in Study 1 and Study 2 included 15

**Table 2**
Results from mixed ANOVA (Study 1).

| Scales Dimensions | M (SD) M (SD) | | | | Time Sig. | ηp2 | Time × Group Sig. | ηp2 |
|---|---|---|---|---|---|---|---|---|
| | VR (n = 18) | | Lego (n = 20) | | | | | |
| | Pre-test | Post-test | Pre-test | Post-test | | | | |
| **MSCS Total (Bonferroni α = .007)** | 188.44 (31.69) | 211.56 (14.27) | 187.75 (7.21) | 211.65 (19.35) | **.000** | .478 | .832 | .001 |
| SM | 33.44 (6.67) | 37.83 (4.45) | 33.95 (3.68) | 38.85 (5.27) | .000 *** | .386 | .795 | .002 |
| SI | 20.00 (4.45) | 22.88 (3.14) | 19.30 (2.05) | 23.25 (3.87) | .000 *** | .327 | .520 | .012 |
| DEC | 35.83 (6.81) | 37.61 (4.57) | 36.15 (3.60) | 40.55 (6.03) | **.014** | .156 | .282 | .032 |
| SK | 36.05 (5.59) | 42.27 (3.19) | 36.35 (3.95) | 41.00 (5.49) | .000 *** | .423 | .462 | .015 |
| VCS | 20.83 (4.07) | 25.44 (3.58) | 22.20 (2.66) | 24.65 (5.25) | .001 *** | .288 | .250 | .037 |
| NSS | 24.50 (13.55) | 26.22 (2.57) | 22.50 (2.50) | 26.75 (3.94) | .071 | .088 | .436 | .017 |
| ER | 17.77 (6.50) | 19.27 (3.00) | 17.30 (2.40) | 17.60 (3.66) | .347 | .025 | .530 | .011 |
| **YSSQ Total (Bonferroni α = .017)** | 47.16 (10.51) | 57.55 (8.17) | 48.30 (9.06) | 56.50 (8.84) | .000 *** | .394 | .573 | .009 |
| SSS | 8.88 (2.69) | 11.33 (1.94) | 9.30 (2.07) | 10.90 (2.40) | .000 *** | .320 | .396 | .020 |
| OSS | 19.50 (5.24) | 23.61 (4.07) | 19.65 (4.01) | 23.75 (4.51) | .000 *** | .321 | .996 | .000 |
| USR | 18.77 (4.06) | 22.61 (3.98) | 19.35 (5.13) | 21.85 (3.84) | .001** | .266 | .452 | .016 |

Note. MSCS = multidimensional social competence scale, SM = social motivation, SI = social inferencing, DEC = demonstrating empathic concern, SK = social knowledge, VCS = verbal conversation skills, and NSS = nonverbal sending skills, ER = emotion regulation; YSSQ = youth social support questionnaire, SSS = subjective sense of social support, OSS = objective social support, USR = utilization of social resources. VR = virtual reality. We applied Bonferroni correction for multiple comparisons, and MSCS alpha = .05/7 = 0.007; YSSQ alpha = .05/3 = 0.017.

items. The reliability of the final measure and subdimensions are reported in Appendix C and D.

#### 3.5.2. VR and Lego's impact on social competence (MSCS results)

To investigate VR and Lego's impact on children's social competence, we applied mixed ANOVA (Table 2). The results indicate that there was a significant effect over time ($p < .001$). However, there was no significant interaction over time by group (VR/Lego). When looking at subscales, results show that four dimensions of the MSCS significantly increased from pre-to post-test. Specifically, social motivation ($p < .001$), social inferencing ($p < .001$), social knowledge, ($p < .001$), and verbal conversation skills ($p = .001$) increased significantly following the educational sessions after Bonferroni correction. It is worth noting that before Bonferroni correction ($p < .05$), the increase in demonstrating empathic concern was significant ($p = .014$) over time.

#### 3.5.3. Impact of VR and lego on perceived social support (YSSQ results)

We also investigated VR and Lego's impact on children's perceived social support using mixed ANOVA (Table 2). The results indicated that there was a significant effect of time on the overall score ($p < .001$). However, there was no interaction between time and group (VR/Lego). When looking at the subscales, Table 2 indicates that all three domains increased significantly following the educational session. Specifically, subjective sense of social support ($p < .001$), objective social support ($p < .001$), and utilization of social resources ($p = .001$) increased significantly following the intervention after the Bonferroni correction.

### 3.6. Study 1 discussion

The general findings in Study 1 showed that both SCE approaches (VR and Lego) led to an increase in social competence and perceived social support. In terms of domains of social competence, social motivation, social inferencing, social knowledge, and verbal conversation skills increased significantly after the intervention. Domains of nonverbal sending skills, and emotion regulation did not improve significantly from pre-to post-test. The increase in demonstrating empathetic concern was only significant before applying the Bonferonni correction. That could be due to the low power of the study. For example, students are told that they need to pay attention to their teacher; and raise their hands when they want to ask questions during class (Barry et al., 2011). Furthermore, children's emotion regulation was not increased after the intervention. Previous study has indicated that the emotion regulation training conducted on youths with emotion regulation difficulties led only to a small improvement (Moltrecht et al., 2021). Therefore, as the targeted sample did not suffer from any psychopathological symptoms, we can assume that a much larger sample size and more targeted training would be necessary to detect improvements in emotion regulation. Similarly, we did not find a significant increase in students' ability in nonverbal sending skills, which may relate to the fact that tested interventions did not provide students with more nonverbal skill training than they were receiving from their teacher controlling and instructing in the class (Neill, 2017).

The findings indicate that VR and Lego can improve children's perceived social support in all domains, specifically in subjective sense of social support, objective social support, and utilization of social resources. However, the current study's limitation was a missing control group, such as traditional classroom learning, which limited the possibility to draw firm conclusions about the effectiveness of the presented approaches. Therefore, we conducted a follow-up study (Study 2) with a different population of children from a rural middle school in the same region of China to assess if the designed VR and Lego SCE approaches could be successfully applied to an older group of students, and to investigate if the methods could be more effective in increasing social competence and perceived social support comparing to traditional classroom learning.

## 4. Study 2

Study 1 presented that both VR and Lego improved rural children's social competence and perceived social support. However, considering the lack of a control condition as a baseline to evaluate the experimental effectiveness, we executed a follow-up study (Study 2) with the Traditional Pedagogy - traditional classroom learning as a control condition. Children aged 12–15 years were recruited from a middle school in a rural town located in Southwest China. This study was also approved by the institute's research ethics committee.

### 4.1. Participants

A total of 50 middle school children were recruited to participate in this experiment (Table 3). Consequently, due to the limited number of VR devices, 10 children were randomly assigned to the VR group, 10 to the Lego group, and 30 to the traditional classroom

**Table 3**
Participants' demographics profile: divided by approaches (Study 2).

| Participants/Group | No. Of Participants | Gender, female % | Age mean (Years) |
|---|---|---|---|
| Total Participants | 50 | 21 (42) | 13.06 (0.78) |
| VR Group | 10 | 4 (40) | 12.9 (0.74) |
| Lego Group | 10 | 3 (30) | 12.9 (0.74) |
| TC Group | 30 | 14 (46.67) | 13.17 (0.79) |

Note. VR = virtual reality, TC = traditional classroom.

(TC).

### 4.2. Procedure, outcome measures, and statistical analysis

The experimental procedure, outcome measures, and rewards for participants (a gift bag equal to 20 Chinese Yuan) of Study 2 were identical to Study 1, except for the traditional classroom condition. The process of traditional classroom learning was designed close to the original curriculum structure with a slightly altered lesson plan and executed in a structured format. This approach was built on traditional classroom learning concerning social skills training, which aimed to provide children with an open exchange of ideas and face-to-face interaction. To be specific, firstly, before each class, the teacher hosted a 5-min meeting for children to discuss subjects based on their social experiences. Session topics included hobbies, sports, pop culture, video games, leisure time, friends, travel, and family. Secondly, children were taking the class with a local teacher for 20–25 min. Next, there was a learning content-based group discussion in the last 5–10 min in the classroom to spark children's self-expression. Fig. 5 demonstrates an overview of the steps for the traditional classroom learning procedure.

All data analyses were performed using IBM SPSS Statistics 27. Mixed ANOVA was performed to determine the interactions and pre-post-test differences in the three groups. In the case of significant time by group interaction post hoc Bonferroni test was used to determine differences between groups. At the same time, Bonferroni correction was applied as alpha = .05/7 = 0.007 in MSCS and alpha = .05/3 = 0.017 in YSSQ.

### 4.3. Results

#### 4.3.1. Impact on social competence (MSCS results)

We used mixed ANOVA to investigate if the three approaches (VR, Lego, and TC) influenced children's social competence (RQ 1). Results indicated that after Bonferroni correction, there was a significant effect over time on general social competence ($p < .001$). More specifically, social motivation ($p = .003$), social inferencing ($p < .001$), demonstrating empathic concern, ($p < .001$); and verbal conversation skills ($p < .001$) indicated a significant increase from pre-to post-test.

Moreover, there was also a significant interaction effect over time by group (VR, Lego, and TC) on general social competence ($p = .002$) and social knowledge ($p = .004$), verbal conversation skills ($p = .004$), and nonverbal sending skills ($p = .003$) (Table 4). The Post hoc Tukey test results showed that the VR group improved significantly more than the TC group in general social competence ($p = .005$). Moreover, VR group reported a significantly higher increase in nonverbal sending skills compared to TC group ($p = .048$). The results for the remaining subscales, i.e., social motivation ($p = .073$), social inferencing ($p = .082$), demonstrating empathic concern ($p = .025$), and emotion regulation ($p = .579$) were not significant.

Before Bonferroni correction ($p < .05$), social knowledge ($p = .014$) increased over time. Furthermore, the interaction between the time and group in demonstrating empathic concern ($p = .025$) was significant before the correction, but the post hoc test did not show any significant difference between groups (RQ2).

#### 4.3.2. Impact on perceived social support (YSSQ results)

We also used mixed ANOVA (Table 4) to investigate if the three approaches (VR, Lego, and TC) influenced different domains of children's perceived social support (RQ 3). We found that an increase in general perceived social support ($p = .017$) was significant before applying Bonferroni correction. When looking at the subscales, there was a significant change over time in subjective sense of

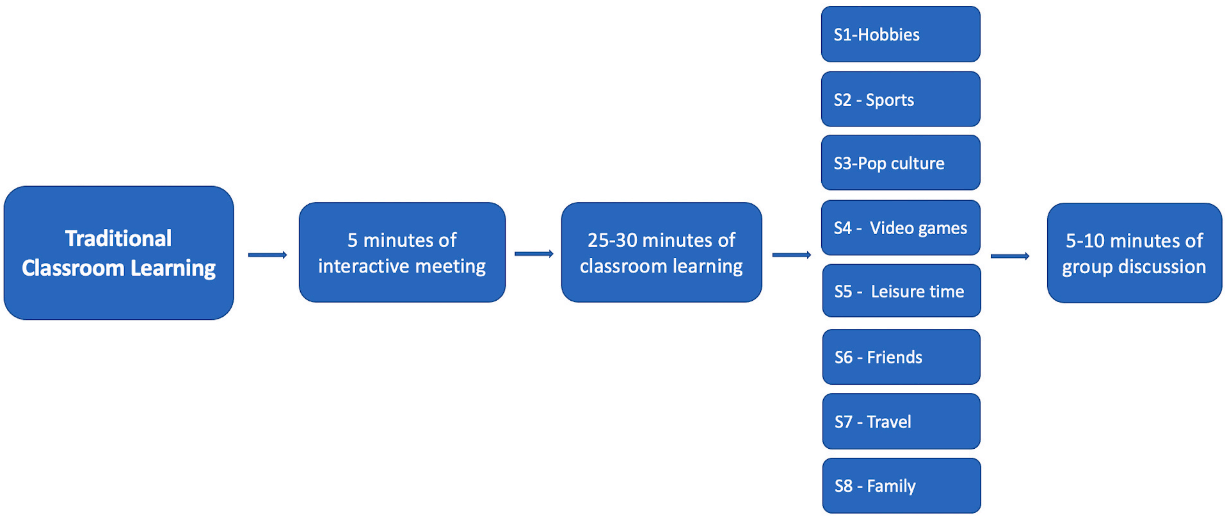



**Fig. 5.** Traditional classroom learning sessions.

**Table 4**
Results from mixed ANOVA (Study 2).

| Scales & Dimensions | M (SD) | | | | | | Time Sig. | ηp2 | Time × Group Sig. | ηp2 |
|---|---|---|---|---|---|---|---|---|---|---|
| | VR (n = 10) | | Lego (n = 10) | | TC (n = 30) | | | | | |
| | Pre-test | Post-test | Pre-test | Post-test | Pre-test | Post-test | | | | |
| MSCS Total **(Bonferroni α = .007)** | 188.10 (19.18) | 224.20 (12.70) | 187.80 (21.06) | 211.50 (22.06) | 190.46 (18.55) | 192.06 (15.81) | .000 *** | .330 | .002 ** | .240 |
| SM | 33.60 (5.03) | 38.30 (4.73) | 32.30 (3.74) | 37.50 (5.44) | 32.76 (3.76) | 33.13 (4.90) | .003 ** | .173 | .073 | .105 |
| SI | 21.30 (2.90) | 27.50 (2.50) | 20.90 (1.92) | 26.80 (4.21) | 20.53 (3.43) | 23.56 (3.31) | .000 *** | .502 | .082 | .101 |
| DEC | 37.90 (5.72) | 46.20 (3.22) | 38.30 (5.59) | 41.10 (5.56) | 38.00 (5.20) | 39.33 (5.57) | .000 *** | .241 | **.025** | .145 |
| SK | 34.40 (5.35) | 42.00 (3.69) | 35.00 (6.53) | 39.10 (6.29) | 36.96 (5.32) | 35.03 (4.65) | **.014** | .123 | .004 ** | .212 |
| VCS | 20.80 (2.93) | 25.20 (2.39) | 20.90 (4.22) | 25.00 (2.44) | 22.93 (4.38) | 22.66 (3.12) | .000 *** | .237 | .004 ** | .208 |
| NSS | 22.80 (2.89) | 27.30 (2.58) | 23.80 (3.88) | 23.20 (3.22) | 23.70 (3.59) | 22.33 (2.74) | .246 | .029 | .003 ** | .219 |
| ER | 17.30 (2.83) | 17.70 (2.75) | 16.60 (4.24) | 18.80 (2.78) | 15.63 (2.98) | 16.00 (3.35) | .217 | .032 | .579 | .023 |
| YSSQ Total **(Bonferroni α = .017)** | 52.70 (11.09) | 61.10 (8.73) | 55.20 (8.62) | 60.70 (8.30) | 54.02 (9.58) | 55.06 (8.48) | **.017** | .115 | .233 | .060 |
| SSS | 10.80 (2.52) | 14.10 (0.87) | 10.60 (2.27) | 12.70 (1.76) | 10.66 (2.12) | 11.16 (1.94) | .000 *** | .268 | **.031** | .138 |
| OSS | 20.80 (5.26) | 24.70 (4.76) | 22.20 (3.91) | 24.20 (4.37) | 22.06 (4.37) | 22.26 (4.19) | **.033** | .093 | .203 | .066 |
| USR | 21.10 (3.813) | 22.30 (5.18) | 22.40 (3.16) | 23.80 (3.79) | 21.33 (4.11) | 21.63 (3.49) | .275 | .025 | .814 | .009 |

Note. MSCS = multidimensional social competence scale, SM = social motivation, SI = social inferencing, DEC = demonstrating empathic concern, SK = social knowledge, VCS = verbal conversation skills, and NSS = nonverbal sending skills, ER = emotion regulation; YSSQ = youth social support questionnaire, SSS = subjective sense of social support, OSS = objective social support, USR = utilization of social resources. VR = virtual reality, TC = traditional classroom. We applied Bonferroni correction for multiple comparisons, and MSCS alpha = .05/7 = 0.007; YSSQ alpha = .05/3 = 0.017.

social support ($p < .0001$). However, there was no significant interaction between time and group.

Before Bonferroni correction ($p < .05$), the increase in general perceived social support ($p = .017$) and objective social support ($p = .033$) were significant. Similarly, the interaction between time and group was significant for the subjective sense of social support ($p = .031$). The Post hoc Tukey test showed that the VR group increased their subjective sense of social support significantly more than the TC group ($p = .007$) (RQ4).

### *4.4. Study 2 discussion*

Study 2 investigated the effectiveness of using VR, Lego, and TC to improve rural children's social competence and perceived social support. Results demonstrated that the three conditions led to increases in general social competence over time. Investigating MSCS and its subscales individually, the children in the VR group increased their general social competence and nonverbal sending skills significantly more than the children in the TC group. This finding supports the idea thaVRt VR users may get increased social skills and a feeling of connectedness with others in a virtual environment (Huang et al., 2019). During the experiment, we provided three types of VR devices (Cardboard VR, Meta Quest 2, and Tablet VR) and two VR applications (Floreo VR and Arts & Culture) for children's SCE, which resulted in positive influences in different domains of children's social competence. This finding is consistent with the previous study - children could gain improvement in social competence from VR (Dechsling et al., 2021; Parmaxi et al., 2017). Likewise, it is in line with findings that children are provided with nonverbal sending skills by manipulating virtual avatars, performing gestures, playing games, and making facial expressions in VR (Hasler & Friedman, 2012). Furthermore, a higher sense of embodiment experienced in immersive VR (Kilteni et al., 2012) can be beneficial for nonverbal communication skills and can provoke children to focus on the learning content, sometimes with body movement interactions, instead of verbal communication (Bailey & Bailenson, 2017). Nevertheless, consistent with the results from Study 1, we did not find any improvements in the emotion regulation domain.

On the other hand, the VR group had significantly higher scores than the TC group in subjective sense of social support. This might be due to children's communication with the avatar, their peers, and the teacher during the VR sessions (Acena & Freeman, 2021; Liu et al., 2015), and this kind of communication might be limited in a traditional classroom setting. Thus, given that many children are left-behind in rural China, this finding suggests that making good use of technology and teachers' concerns could be beneficial for children who experience long-term parental absence.

Additionally, although previous research presents that Lego can enhance individuals' trust, communication practice, social support, and social conflict-solving skills (Bazoolnejad et al., 2021), our findings from the Lego group did not exhibit significant differences from other groups. This may be because of the small sample size. At the same time, domains of general social support and objective social support were close to having a positive influence on rural children in Study 2, but not utilization of social resources. This indicates that neither VR, Lego, nor TC can comprehensively enhance children's perceived social support because these rural children are typically left-behind youth who experienced insufficient parental companionship and community support (Biao, 2007). It is difficult to greatly prompt their perceived social support in the short term by teaching and learning SCE.

## 5. General discussion

### 5.1. Empirical contribution

The presented studies examined the efficacy of Pedagogy of Technology (VR), Play-based Learning (Lego), and Traditional Pedagogy (TC) on rural children's social competence education and perceived social support. In terms of the research question "**Can VR, Lego, and traditional classroom SCE improve children's social competencies? (RQ1)**", results across Study 1 and Study 2 demonstrated that rural children had increased their social competence during the eight SCE sessions. We report pre-post changes in all subdomains of the muti-social competence scale except for emotion regulation and nonverbal sending skills. As noted in a recent meta-analysis, the changes in emotion regulation following training can be subtle which might be especially true in a sample of healthy youths (Moltrecht et al., 2021). The interventions were not specifically designed for children's emotional regulation, which might give rise to no enhancement in children's emotional regulation in both studies especially considering the low sample size.

Concerning the research question "**Which pedagogy is the most effective means for developing rural children's social competence? (RQ2)**". In general, the results support the value of using Pedagogy of Technology (VR) and Play-based Learning (Lego) in developing social competence with a significant increase on available scales in elementary school children (Study 1); and Pedagogy of Technology showed a stronger increase in general social competence than Traditional Pedagogy with middle school children (Study 2). These findings support previous research that VR social training applications enable participants to apply learned skills to specific social knowledge effectively and to gain practical communication skills with less cognitive load (Park et al., 2011). Moreover, VR allows students to embody virtual roles through visual, aural, and haptic feedback (Young et al., 2020, 2023; Plechatá et al., 2022a). Furthermore, when investigating the sub-dimensions of social competence, the results showed that VR-assisted SCE increased overall social competence and nonverbal sending skills significantly more compared to Traditional Pedagogy. This is in line with that VR training programs are more effective than traditional SCE approaches for social skills development (Howard & Gutworth, 2020). Our results indicated that VR-assisted SCE could be a more effective approach to prompt children's social competence than traditional education in a rural context.

Lego SCE did not notably increase children's social competence more than the other two groups in Study 2 with middle school children, yet Lego and VR prompted elementary school children's social competence and perceived social support to a similar extent in Study 1.

In response to "Can VR, Lego, and traditional classroom SCE improve children's perceived social support? (RQ 3)" and "Which pedagogy is the most effective for developing rural children's perceived social support (RQ4)", we confirmed that both VR and Lego enhanced elementary school children's perceived social support, including the subjective sense of social support, objective social support, and utilization of social resources in Study 1. Moreover, VR enhanced middle school children's subjective sense of social support to a higher extent than traditional classroom learning in Study 2. However, we did not find evidence for Lego to have an evident advantage in improving middle school children's perceived social support compared to traditional classroom learning. This can refer to middle children being less interested in using Lego (Kulkarni, 2019), as many of them collaboratively finished the session in a shorter time than the elementary school children. Nevertheless, children's utilization of social resources and objective social support were not improved by any of the pedagogies in Study 2. This can be due to the social resources that already exist in the child's living environment (e.g., family support and school support) are unlikely to be changed without environmental changes.

As VR and Lego led to a significant enhancement in perceived social support in Study 1, the missing effect in Study 2 might be due to the low sample size of VR and Lego groups. This suggests that apart from existing Traditional Pedagogy in rural education, Pedagogy of Technology and Play-based Learning could be investigated individually as potential approaches for developing actual social support in future studies. Likewise, all three approaches prompted children's general perceived social support in Study 2, which means school time is still meaningful to support these left-behind children when their parent(s) are working away.

### 5.2. Practical implications

The presented results suggest that VR-assisted SCE and Lego SCE are feasible and valuable in rural mainstream education. Novel technologies, including VR, have great potential to facilitate under-developed countries/regions' social competence education by bringing immersive and interactive educational resources to settings where it is too expensive to engage in field trips (Stenberd & Makransky, 2023; Makransky & Mayer, 2022; Petersen et al., 2020). For example, VR applications with affordable solutions, such as Floreo VR, Youtube VR, and Arts & Culture can be easily accessed by Cardboard VR. Although Cardboard VR education is a controller-free interaction method in teaching and learning (Yoo & Parker, 2015), and a few children reported discomfort, it is still a low-budget, easy assembly, and stereoscopic viewer that can be used with most smartphone devices. Previous studies have found that Cardboard VR can trigger students' learning motivation and enjoyment better than flat-screen devices (Lee et al., 2017) and traditional teaching approaches (Oigara, 2019). Therefore, Cardboard VR holds potential for under-developed regions that need to reform and improve their educational systems, but have limited resources. In the meantime, Arts & Culture particularly took children to various public areas virtually, including educational venues, such as museums, galleries, and science labs. Children learned how to indirectly understand social information from public occasions and related comprehensive knowledge, which broadened their horizons on external resources and environments. This outcome is significant and advantageous for rural children with less travel experience and left-behind children with less family education than their peers.

To a macro level, such approaches offer solutions for regions with educational disadvantages to access diverse educational resources (e.g., social competence education and perceived social support), regardless of geographical restrictions. Both elementary VR sets and Lego sets have become more affordable for many schools today, making it possible to develop advanced educational experiences in underdeveloped countries and regions. These accessible tools can be practically utilized in various learning settings, fostering meaningful learning and social skills development. This can potentially level the playing field for children with limited opportunities, and ultimately contributes to a more inclusive educational environment for all.

However, in most rural areas in underdeveloped countries, serious challenges make it difficult to adapt existing state-of-the-art technologies and apply them to the education system (Utoikamanu, 2019). Hence, Lego can be a cost-effective and pragmatic strategy for schools in these regions since a) VR products can be costly for most schools across the world, and b) systematic training for rural educators to use VR is difficult since rural teachers may be resistant to applying cutting-edge technology to their classroom activity. For example, some rural teachers exhibited their curiosity during the VR sessions, whereas when researchers invited them to join the process and observe how to give a VR lesson for students' social competence education, they showed uncertainty. It is, therefore, essential to identify and understand the relevant factors that play a role in rural teachers' behavioral intentions to use VR (Bower et al., 2020). On the other hand, some rural educators showed existing knowledge of Lego play and actively observed and communicated with participants during their session observation.

As the availability of technology such as VR increases worldwide (Pimentel et al., 2022), some of these current challenges may decline. Next, VR could eventually help quality education by increasing the accessibility and affordability of extended reality (XR) devices (Plechatá et al., 2022a). For example, through leveraging immersive technology, individuals worldwide could participate in the metaverse in the next decade and have access to high-quality educational programs, which will be similar to how many users in developing countries can currently access inclusive knowledge through videos from YouTube (ElKarmi et al., 2017; Lotto et al., 2019). Regarding implementation in the classroom, the literature is quite clear about using VR for experiential learning and supplementing the VR experience with pre-training (Meyer et al., 2019), and including reflection activities following a VR-lesson (Elme et al., 2022; Makransky et al., 2021). In the presented study, the Pedagogy of Technology (VR) was combined with other classroom activities (e.g., educational games) that were beneficial for learning. From a practical point of view, using immersive VR for an entire lesson can be problematic due to possible cybersickness symptoms, such as facial stiffness, eyestrain, and nausea (Wang et al., 2021; Luong et al., 2022), and longer VR sessions can lead to cognitive load (Andersen et al., 2022). Similarly, not every rural educator appreciated Lego SCE as an unstructured program because it might have lacked scientific learning content, concepts, and syllabus. Therefore, for educational interventions to be successful, it is crucial to understand the local context as well as the educators' values and priorities.

### *5.3. Limitation and future studies*

This study focuses on educational inequality and children from under-represented backgrounds. Therefore, we expected to collect data across provinces within China's most rural and disadvantaged areas. However, we could only recruit participants from two rural schools – an elementary school and a middle school in Southwest China due to the local Covid-19 pandemic restrictions. Also, due to the lack of VR headsets, we only selected a small group of participants ($n = 10$) to participate in the VR and Lego groups in Study 2. Even though findings show that VR, representing Pedagogy of Technology, and Lego, representing Play-based Learning, are promising approaches for rural children's SCE, the small sample size is a limitation that might restrict the generalizability of the current findings, and it may be challenging to explore more similarities and differences between groups and conditions. We therefore encourage future studies to consider including a larger, more diverse sample to mitigate potential biases and increase the applicability of the results to broader under-represented populations and communities.

Similarly, this research primarily explored rural children's experience of SCE in VR, Lego, and traditional classroom learning; thus, it did not include rural educators' perspectives of the VR application in the rural classroom. Yet, the results show noticeable possibilities that VR is a constructive and beneficial technology for future rural education. Hence, further studies may extend the research sample and increase the utilization of VR or Lego for rural educators. Further, extended studies may need to design research with qualitative components that can lead to a deeper understanding of participants' subjective experiences. Finally, the curriculum design regarding VR-based teaching and learning should be considered a curtail factor for rural schools' systematic enhancement and sustainable development.

## 6. Conclusion

We conducted two studies investigating whether VR and Lego social competence education could increase rural children's social competence and perceived social support. In Study 1, performed with elementary school children, we found that both VR and Lego social competence education prompted children's social competence and perceived social support, whereas, in Study 2, conducted with middle school children, VR social competence education presented substantially greater effectiveness in improving social competence and subjective sense of social support than the traditional classroom. As a novel educational approach, VR-assisted social competence education exhibits evident potential to be generalized to schools and populations in disadvantaged regions. Although there are still many challenges, based on our findings, educational practitioners may consider VR education as a potential tool that can be used in combination with other interventions to reduce educational inequalities in underdeveloped countries and regions. At the same time, Lego social competence education was a practical approach that got more rural educators' attention since it is easier to apply in classroom teaching. Therefore, it could be used as an alternative approach when it is impractical or impossible to implement VR education and related Pedagogy of Technology. Based on this prospect, we suggest that both VR and Lego could be applied to social competence education in under-represented rural areas.

## Credit author statement

**Xining Wang:** Conceptualization, Methodology, Field experiments with assistants, Data Analysis, Original draft preparation, Writing- Reviewing and Editing, **Gareth W. Young.** Writing- Reviewing, Editing, and Supervision, **Adéla Plechatác**: Data Analysis, Editing, and Revision, **Conor Mc Guckin**: Discussion and Supervision, Guido Makransky: Conceptualization, Methodology, Editing, and Supervision.

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## Declaration of competing interest

The authors report no conflicts of interest.

## Data availability

The authors do not have permission to share data.

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## Appendix. Questionnaire items and reliability

### *Appendix A. Multidimensional Social Competence Scale*

The full scale can be viewed here：

Trevisan et al., 2018a Trevisan, D. A., Tafreshi, D., Slaney, K. L., Yager, J., & Iarocci, G. (2018a). A psychometric evaluation of the Multidimensional Social Competence Scale (MSCS) for young adults. PLoS One, 13 (11), e0206800. Https://doi.org/10.1371/journal.pone.0206,800.

### *Appendix B. Youth Social Support Questionnaire*

The full scale can be viewed here：

Dai and Ye, 2017a Dai, X., & Ye, Y. (2017a). The Development of Social Support Scale for College Students 大学生社会支持评定量表的编制. Chinese Journal of Clinical Psychology, 15, 456–458.

### *Appendix C. The reliability and items included and deleted in MSCS and YSSQ (Elementary School)*

| Dimensions | Pre-test α | Post-test α | Items deleted | Pre-test α | Post-test α | Items left |
|---|---|---|---|---|---|---|
| MSCS | 0.83 | 0.83 | 21 | 0.86 | 0.88 | 56 |
| SM | 0.43 | 7.6 | 42 | 0.67 | 0.7 | 10 |
| SK | 0.72 | 0.84 | 73 | 0.6 | 0.72 | 11 |
| DEC | 0.37 | 0.87 | NA | 0.75 | 0.87 | 11 |
| SI | 0.38 | 0.57 | 59, 13, 40, 52, 67 | 0.65 | 0.67 | 6 |
| ER | 0.37 | 0.26 | 46, 25, 41, 15, 68, 4 | 0.53 | 0.58 | 5 |
| NSS | 0.37 | 0.33 | 70, 29, 51, 62 | 0.67 | 0.68 | 7 |
| VCS | 0.7* | 0.748 | 56, 63, 61, 50 | 0.5 | 0.71 | 7 |
| YSSQ | 0.84 | 0.89 | 2 | 0.88 | 0.93 | 15 |
| SSS | 0.83 | 0.9 | 4，7 | 0.58 | 0.68 | 5 |
| OSS | 0.86 | 0.89 | N/A | 0.86 | 0.89 | 6 |
| USR | 0.84 | 0.88 | N/A | 0.84 | 0.88 | 6 |

Note. N/A = not applicable.

*Appendix D. The reliability and items included and deleted in MSCS and YSSQ (Middle School)*

| Dimensions | Pre-test α | Post-test α | Items deleted | Pre-test α | Post-test α | Items left |
|---|---|---|---|---|---|---|
| MSCS | 0.79 | 0.85 | 21 | 0.86 | 0.88 | 56 |
| SM | 0.43 | 7.6 | 42 | 0.67 | 0.7 | 10 |
| SK | 0.72 | 0.84 | 73 | 0.6 | 0.72 | 11 |
| DEC | 0.37 | 0.87 | NA | 0.75 | 0.87 | 11 |
| SI | 0.38 | 0.57 | 59, 13, 40, 52, 67 | 0.65 | 0.67 | 6 |
| ER | 0.37 | 0.26 | 46, 25, 41, 15, 68, 4 | 0.53 | 0.58 | 5 |
| NSS | 0.37 | 0.33 | 70, 29, 51, 62 | 0.67 | 0.68 | 7 |
| VCS | 0.7 | 0.748 | 56, 63, 61, 50 | 0.5 | 0.71 | 7 |
| YSSQ | 0.92 | 0.87 | 2 | 0.93 | 0.88 | 15 |
| SSS | 0.83 | 0.9 | 4，7 | 0.58 | 0.68 | 5 |
| OSS | 0.86 | 0.89 | N/A | 0.86 | 0.89 | 6 |
| USR | 0.84 | 0.88 | N/A | 0.84 | 0.88 | 6 |

Note. N/A = not applicable.

## References


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