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# LINA: An Augmented Reality Social Game Enhancing Sense of Belonging Among Classmates: An Uncontrolled Pre-post Evaluation Study

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## Abstract

Supportive peer relationships are fundamental in the development of well-being. Since early adolescents spend a lot of time at school, especially in their classroom, a sense of belonging among classmates plays a pivotal role for mental health and academic functioning. Programs that enhance sense of belonging among classmates through improving peer relationships in classrooms are rare. Given that early adolescents increasingly use digital media to establish and maintain relationships with classmates, there is potential in digital social games that enhance social connectivity and collaboration, especially during the difficult transition from primary to secondary school. LINA ('Lina Is Not Alone') is a novel social augmented reality game for classrooms that is designed to enhance sense of belonging among classmates through improving their relationships with classmates. We conducted an uncontrolled pre-post evaluation study to evaluate (a) player experience, (b) translation of the theory-led LINA design into user experience and (c) increases in sense of belonging after engagement with LINA. In total, data from 99 participants ($M_{age}$ = 10.94; range = 10–12; 51 girls, 48 boys) were included in this study. Our results provided evidence for (a) high satisfaction and acceptability of LINA, (b) a successful translation of theory-led design features into user experiences, and (c) increases in sense of belonging. We discuss practical implications and future development of LINA.

**Keywords** Augmented reality · Digital intervention · Feasibility study · Peer relationships · Sense of belonging

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## Introduction

The need to belong, fulfilled through meaningful relationships with individuals and groups, enhances mental health (Andersen et al., 2021; Baumeister & Leary, 1995). In accordance with this belongingness theory, supportive relationships with peers and friends at school clearly impact mental health and resilience (Moreira et al., 2021). For children and adolescents, the school environment marks a key setting to build these meaningful connections with peers. Feeling supported by peers and friends at school as well as overcoming loneliness are important factors in the development of a strong sense of belonging (Allen et al., 2018; Quintana, 2021). Yet, schools need to provide opportunities for supportive peer interactions so that children and adolescents feel included, meaningful relationships can thrive, and a sense of belonging can develop (Allen et al., 2021; Qvortrup & Qvortrup, 2018). Providing opportunities for supportive interactions between classmates might be especially important for pupils who stay together in that same class for several years or after a school transition. This study incorporates an uncontrolled pilot evaluation of the single-session proof-of-concept version of LINA ('Lina Is Not Alone'), an augmented reality (AR) social game that aims to increase a sense of belonging among classmates through improving relationships with classmates.

Good relationships with classmates have positive effects, impacting mental health and academic performance. For example, feeling supported by classmates contributes to satisfaction at school and subjective well-being, while feeling lonely and not experiencing a good time with classmates have opposing effects (Huebner et al., 2014; Oberle et al., 2011). In particular, good relationships with classmates directly impact school satisfaction, which further boosts students' subjective well-being and quality of life, highlighting the relevance of interventions which focus on relationships with classmates (Gempp & Gonzalez-Carrasco, 2021). Feeling supported by classmates also positively affects the ability to cope with stressful situations and enhance academic performance (Burke & Sass, 2013; Hoferichter et al., 2022). For example, fostering positive interactions between classmates can boost individual motivation and engagement, which in turn contributes to better academic performance (Shao et al., 2024). Additionally, good relationships with classmates have beneficial emotional effects, which manifest in fewer depressive symptoms (Franco et al., 2022; McGraw et al., 2008) and higher positive affect (Schmidt et al., 2019, 2020). Therefore, LINA was developed to provide gamified social interactions that increase positive experiences with classmates. Such positive experiences with classmates might be particularly relevant during school transition.

The transition period from primary to secondary school is marked by substantial changes and challenges in the peer network of early adolescents (Symonds & Galton, 2014). Former classmates often move to different schools and there is a need to form new peer relationships and friendships within the new classroom, which makes school transition a stressful social experience (Ng-Knight et al., 2019; Weller, 2007). During school transition, the fear of victimization and feeling alone in the new class are major social stressors for early adolescents (Stiehl et al., 2023). Indeed, victimization experiences are common during school transition (Marchante et al., 2022; Monachino et al., 2021). Yet, high classmate support and more friends within the classroom can act as protective factors against victimization experiences (Košir et al., 2020). At the same time, finding a sense of belonging among classmates during school transition is of major importance for early adolescents, marking their high willingness to develop positive relationships with classmates (Curson et al., 2019; Weller, 2007).

Research highlights several strategies that can reduce prejudice and promote a sense of belonging among children and adolescents. Meta-analytic studies in children and adolescents show that contact with discredited and excluded individuals, when incorporating specific positive elements in line with Contact Theory (Allport, 1954), significantly reduces negative attitudes and behavioral intentions towards those 'outsiders' (e.g., individuals with different ethnic origins, mental illnesses or behavioral problems) (Armstrong et al., 2017; Beelmann & Heinemann, 2014; Chae et al., 2018; Corrigan et al., 2012; Waqas et al., 2020). Similarly, cooperative learning at school, which includes carefully structured group-based experiences in the classroom, can improve classmate relations and reduce victimization (Van Ryzin & Roseth, 2018). Overall, anti-stigma research in children emphasizes that positive cooperative experiences involving interdependence between group members can enhance likability and challenge negative prejudice related to ability, gender, weight, or ethnicity (Skinner & Meltzoff, 2019). In addition, storytelling has emerged as a valuable tool for fostering a sense of belonging among children and adolescents in school settings (Lindsay et al., 2013; Lucas & Soares, 2013), with evidence of its potential to reduce prejudice (Cameron & Rutland, 2006; Cameron et al., 2007) and promote perspective-taking and empathy (Skinner & Meltzoff, 2019).

AR in the school context is an ideal technology to increase sense of belonging among classmates as it has the potential to facilitate social interactions and collaboration between players (Brij & Belhadaoui, 2021), especially when including game elements (Ređep & Hajdin, 2021). Using AR technology compared to traditional material in an educational context can improve not only motivation and enjoyment,

but also the socio-emotional relationship between players (Redondo et al., 2020). However, to date the focus of AR use in school has been restricted to supplementing traditional academic disciplines (e.g., math, physics, arts, culture) (Maas & Hughes, 2020; Zhang et al., 2022). AR applications have been used to promote social skills, but these have been primarily designed for autistic populations and single players (Mittmann et al., 2023a). Given that early adolescents use their smartphones on a daily basis to communicate or play games with peers and classmates, which also helps with initiating and developing new friendships (Krammer et al., 2023; Mittmann et al., 2022b), a digital social game that uses AR to enhance sense of belonging among classmates seems promising to engage the target group. Yet, programs or games that enhance sense of belonging through improving peer relationships during childhood and adolescence rarely use digital technology (Pollak et al., 2023) despite their mentioned advantages.

## LINA 'Lina Is not Alone': Theory-Led LINA Design

To our knowledge, LINA is the first multi-player mobile game that uses a mystery-style interactive narrative with AR elements to immerse players. LINA is designed for school classes, developed for and in cooperation with early adolescents in iterative cycles (Mittmann et al., 2022a). Overall, the game elements and game design of LINA were developed with a theory-informed and early adolescents-informed integrative approach. The overarching objective of LINA is to increase a sense of belonging among players (i.e., classmates). An early evaluation study of LINA shows high acceptability (quantitative results) and qualitative indications of potential effectiveness (qualitative results) (Mittmann et al., 2022a). The current study uses a further developed version of LINA (i.e., the final single-session proof-of-concept) to evaluate player experience and provide an early-stage, uncontrolled indication of potential effectiveness. Furthermore, the study examined players' perception of LINA design, with a focus on whether its key features were successfully translated into user experience.

The design of LINA was primarily informed by Contact Theory (Allport, 1954), which argues that carefully structured contact involving (1) equal status, (2) cooperation, (3) a common goal and (4) authority support, enhances sense of belonging and minimizes division among individuals and groups. The design of LINA reflects these principles: (1) all players (i.e., classmates) begin with equal access to information; (2) progression requires cooperative gameplay and real-life communication; (3) the narrative encourages collective problem-solving to uncover the story; and (4) the experience provides structured guidance, including hints, to ensure players feel supported.

The theory-led LINA design was also informed by two qualitative studies, aiming to understand early adolescents' perspectives on school transition from primary to secondary school and their experiences with classmates in this period (Krammer et al., 2023; Stiehl et al., 2023). For example, early adolescents mentioned certain rules of communication (e.g., mutual listening, introducing oneself when encountering) and small acts of kindness that establish mutual trust and support (e.g., mutual sharing of information, encouragement for mutual success) as relevant factors for successful interactions with classmates. Thus, structured communication at the beginning of collaborative tasks in LINA were designed to ensure that players listen to and support each other, which aims to establish a feeling of safety during gameplay. Moreover, experienced fun with classmates was highlighted repeatedly for positive relationship development among classmates (Krammer et al., 2023; Stiehl et al., 2023). Thus, the design of LINA encompasses two additional contact elements, that is, a feeling of safety and experienced fun. In sum, the theory-led LINA design encompasses six key features, summarized in Fig. 1.

## The Current Study

The current study is an uncontrolled pre-post evaluation study that evaluates the player experience, translation of the theory-led LINA design into user experience and potential effectiveness of LINA, an AR social game for school classes played on smartphones. The study is characterized as a feasibility study (Skivington et al., 2021), focusing on usability and providing an initial indication of potential effectiveness of LINA.

First, player experience was evaluated using a validated game user experience questionnaire. High satisfaction and acceptability ratings were expected without gender differences, based on results from a previous study using a less developed version of LINA (Mittmann et al., 2022a). Second, we evaluated player's perception of LINA design, with a focus on whether its six key features (1) equal status, (2) cooperation, (3) common goal, (4) authority support, (5) a feeling of safety, and (6) experienced fun were successfully translated into user experiences. High approval ratings were anticipated to demonstrate the successful translation of the theory-led LINA design into user experience. Third, in our main analysis we examined the potential effectiveness of LINA, hypothesizing that sense of belonging among classmates increases after engagement with LINA on participant level. Potential variation across classes was examined to account for nested data structure. To further inform robustness of the main analysis, we explored whether the change in sense of belonging differed for participants with low or high levels of peer victimization.

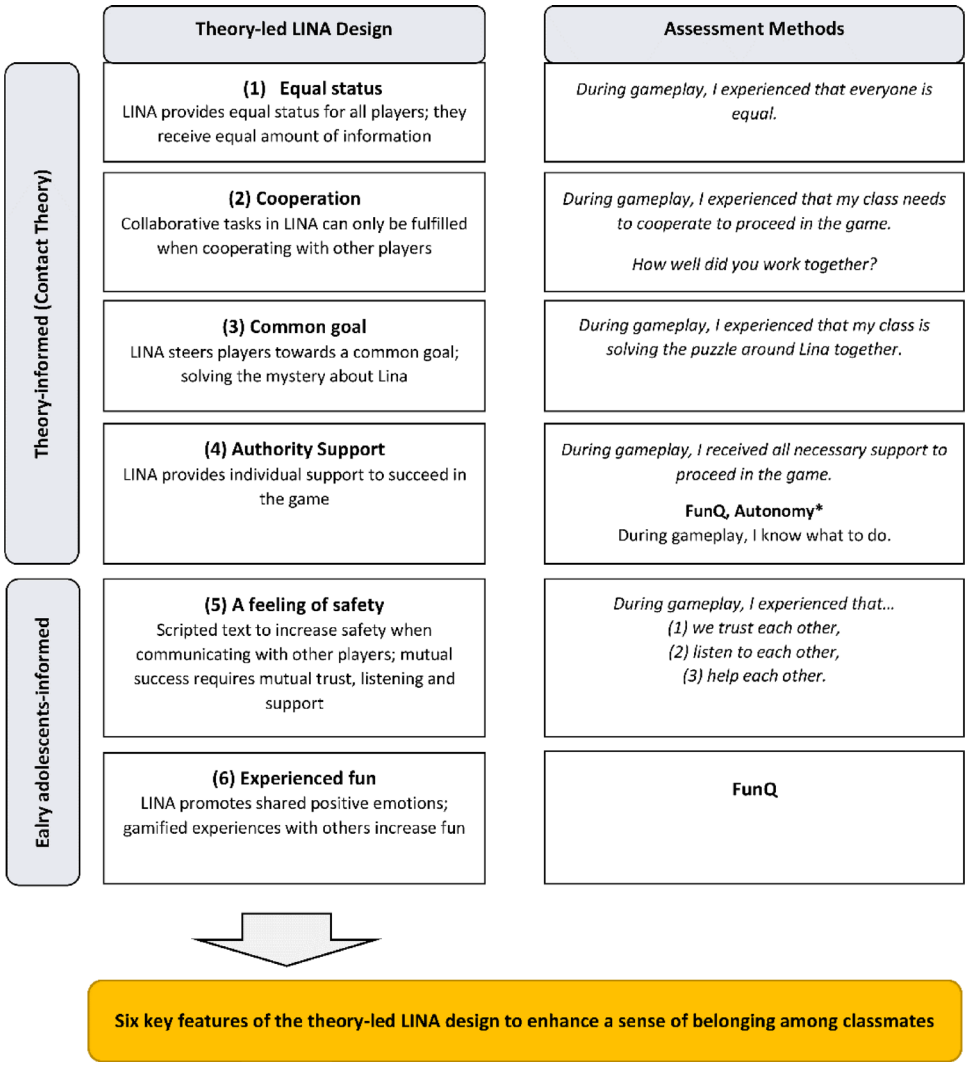


**Fig. 1** Theory-led LINA design and related assessment methods. *Note* Newly developed items are in italics. *Single item of subscale was used

## Method

### LINA

LINA is a mobile AR social game for school classes, involving all students plus one teacher. All players play at the same time and are provided with one smartphone each. Players progress through the experience at first individually, then in pairs, then in small groups and finally as an entire class, discovering AR objects their fictional classmate Lina left behind after her mysterious disappearance. Players learn about Lina's life at school, at home, and her feelings. The game combines real-world experiences with digital ones. For example, the players have to collaborate in a face-to-face setting at school to solve a digital puzzle provided on their smartphone. Through successful collaboration, players can unlock a new AR object together that provides fresh information about Lina. The game was designed by an interdisciplinary European research group and professional practitioners (encompassing a playwright and creative director, psychologists, computer scientists, and graphic designers) and co-developed with early adolescents in iterative processes [blinded for review].

The storyline of LINA focusses on solving a mystery around the sudden disappearance of a girl who feels like she does not belong. She has difficulties trusting others, making friends and – it transpires – a difficult life at home, living with and caring for a mother who has a mental illness.

#### Game Characteristics

LINA was designed to attract boys and girls equally and support the identification with their character, thus, it incorporates a fictional class where players take the role of characters of the same sex as they are (Felnhofer et al., 2022; Kinzie & Joseph, 2008). LINA encompasses imaginative role-play (including enacted scenes where players receive instructions or dialogue via the phones), exploration

(exploring the classroom through the lens of the smartphone, exploring 2D and 3D objects), problem-solving (solving puzzles together), social interaction (in pairs or groups, to better understand the mystery about Lina), and an active play element (a sequence where players must find hidden AR objects within a set time), covering various game activity preferences of early adolescents (Kinzie & Joseph, 2008).

## Recruitment

Two secondary schools in Austria were recruited via existing networks of the research group, thus resulting in a convenience sample. In Austria, pupils can attend two different school types for secondary education: (a) middle school (in Austria called Mittel Schule [MS]) and (b) grammar school (in Austria called Allgemeinbildende Höhere Schule [AHS]). While MS has four years of education and is typically attended by 10- to 14-year-olds, AHS includes eight years of education, ends with a qualification for university entrance and is typically attended by 10- to 18-year-olds. The research group contacted school directors of one AHS and one MS via e-mail with initial information on the project and then over the phone to provide time for additional information and open questions. We invited all first-year students and their main teachers to participate. Both schools agreed to participate. The main teachers then received detailed information on the study via e-mail and a preliminary meeting was scheduled to explain the purpose of the study and necessary preparations (e.g., sending and collecting informed consent to and from parents and students). In total three classes from the school type AHS and two from the school type MS were invited to participate ($N=106$ pupils). All students and their parents gave written informed consent before the study started. This study was approved by the Ethics Committee of the Karl Landsteiner University of Health Sciences (EK Nr: 1025/2020).

## Participants

In total 106 participants and their parents gave informed consent; however, not all participants could be included in the study. Two participants were not present at the days of study conduct. Another four participants were excluded because they were not present when LINA was played in class. Additionally, one participant was excluded for further analyses due to answer patterns indicative of invalid responses (i.e., always the lowest score despite reversely coded items) in two questionnaires (i.e., GUESS-GA-18, FunQ). Thus, the final sample for data analysis comprised 99 participants.

## Procedure

This study employed an uncontrolled pre-post design; therefore, all participants were assigned to one condition, that is, playing LINA. The study was conducted in May 2022 in the school setting during regular school hours.

Quantitative data were collected via online questionnaires on iPads at or smartphones at in the school setting. Assessment took place at two time points (i.e., T1 and T2). T1-assessments were administered by participating teachers on a preassigned date, one to two days before playing LINA. Participating teachers received precise information in a preliminary meeting conducted by one of two researchers over the phone, using a conversation guide to ensure all relevant information was discussed. Afterwards, teachers received a QR-Code via e-mail so that students could easily access the online questionnaires (i.e., scanning the QR-Code with their iPad, provided by their school). T2-assessment was conducted immediately after the participants played LINA, accessed via a QR-Code, provided by the research team that set up LINA in class. An overview of the data collection procedure and order of administered questionnaires is presented in Fig. 1.

## Measures

### Descriptive Data

Demographic data included information on sex, age, nationality and school type, assessed at T1. Additionally, we assessed smartphone possession (yes/no) and gaming behavior (i.e., how often they play games on their smartphone or computer ranging from 1 (*never*) to 5 (*very often*)) at T2.

### Player Experience

Player experience was assessed with the German version of the Game User Experience Satisfaction Scale (GUESS-GA-18) for adolescents (Mittmann, Zehetner, Krammer et al., 2023b), a validated instrument measuring satisfaction and acceptability of digital games. The questionnaire consists of 18 items across nine subscales (Usability/Playability, Narratives, Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, Social Connectivity, and Visual Aesthetics). Answers are rated on a 5-point Likert scale ranging from 1 (*don't agree at all*) to 5 (*totally agree*), also including reversely coded items. A previous study shows good internal consistency, concurrent validity and a good model fit of the GUESS-GA-18 (Mittmann, Zehetner, Krammer et al., 2023b). The Cronbach's alpha coefficient for this study was $\alpha=0.88$.

### Translation of Theory-led LINA Design into User Experience

The six key features of the theory-led LINA design were assessed with newly developed items and the FunQ (Tisza & Markopoulos, 2021a). The FunQ is a validated multidimensional instrument to assess experienced fun of an activity. It consists of 18 items across six dimensions (autonomy, challenge, delight, immersion, loss of social barriers, and stress), which are rated on a 5-point Likert scale ranging from 1 (*never*) to 5 (*all the time*), again with reversely coded items. The instrument shows good internal consistency for this study (Cronbach's $\alpha = 0.88$). Since the FunQ is only available in English language, the questionnaire has been translated into German language and adopted for early adolescents in iterative co-development workshops with early adolescents. The level of collaboration between peers (in-game assessment) was assessed with one newly developed question (i.e., "How well did you work together?") immediately after each of two collaborative tasks involved in playing LINA. Collaborative task 1 was done in pairs, while task 2 was done in small groups of between three and four participants. The question fit gently into the gameplay experience. On a 5-point smiley face scale ranging from 1 (sad face) to 5 (happy face), participants indicated how they felt about their collaboration. Figure 1 provides an overview of the six key features of the theory-led LINA design and related assessment methods, which were assessed at T2.

### Potential Effectiveness of LINA

Sense of belonging was assessed with the subscale social inclusion of the German version of the Perceptions of Inclusion Questionnaire (PIQ; Venetz et al., 2014). The subscale consists of 4 items (e.g., "I get along very well with my classmates"). Answers were provided on a sliding scale (1 = *not at all true* to 101 = *certainly true*). The original 4-point response scale (0 = *not at all true*, 1 = *rather not true*, 2 = *somewhat true*, and 3 = *certainly true*) was adapted to allow for a sensitivity analysis that required continuous data for each item. For the main analyses, continuous data was converted back to ordinal data (i.e., 1 thru 25 = 1; 26 thru 50 = 2; 51 thru 75 = 3; 76 thru 101 = 4). The questionnaire was completed at both time points, leading to T1-Sense of Belonging (SoB) and T2-SoB sum scores. In the validation research, the subscale had an internal consistency of Cronbach $\alpha = 0.84$ (Venetz et al., 2014). Cronbach's alpha coefficients for this study were $\alpha = 0.69$ and $\alpha = 0.67$ for T1 and T2, respectively.

The factor Social Isolation From Peers from the Chronic Stress in Childhood Questionnaire (CSiK; Richartz et al., 2009) was used to determine the students' level of chronic victimization within their class, assessed at T1. This variable on peer victimization was used for exploratory analyses[1]. On a 4-point Likert scale ranging from 1 (*never*) to 4 (*very often*), participants answered how often they experienced two statements (i.e., "Children in my class talk bad about me", "Children in my class don't let me join in") within the last weeks. Mean scores were calculated. The higher the mean score, the higher the level of chronic stress.

## Data Analysis

Statistical analyses were conducted using IBM SPSS Statistics 27. We used $p$ values $< 0.05$ to identify statistical significance for all analyses. To determine the player experience and the translation of the theory-led LINA design into user experience, we performed descriptive statistics to explore psychometric properties of the questionnaires GUESS-GA-18, FunQ, and items assessing the six key features of the theory-led LINA design, reporting means, SD, and range.

To investigate potential effectiveness of LINA, we conducted a paired t-test in the outcome variable sense of belonging over time. We expected that sense of belonging would increase from T1 to T2 and conducted a one-tailed test. According to the histogram, the differences between T1- and T2-SoB were normally distributed (Field, 2013). We looked at sex differences between T1- and T2-SoB, conducting a t-test for either time points.

### Exploratory Analyses

To assess changes over time and potential class-related differences in the outcome variable, a 2 (time: pre vs. post) × 4 (class) mixed ANOVA was conducted. Time was treated as a within-subjects factor, and class as a between-subjects factor. The analysis tested for a main effect of time (i.e., overall change in the outcome variable), a main effect of class (i.e., class differences in outcome levels), and a time × class interaction (i.e., differences in change patterns across classes). The assumption of homogeneity of covariances was tested using Box's test. Estimated marginal means were used to visualize the interaction effect with 95% confidence intervals. Partial eta-squared was used to report effect sizes.

In an additional sensitivity analysis, we investigated whether the average change in T2-SoB differs between participants with low vs. high levels of peer victimization. A median split was applied to the variable peer victimization. The median in the full sample was $M = 1.5$, and participants were categorized accordingly (0 = low peer victimization, 1 = high peer victimization). A difference score was calculated for each participant by subtracting T2-SoB from

[1] Variable warrants cautious interpretation due to low item intercorrelation.

T1-SoB. An independent samples t-test was conducted to compare the mean difference scores between the high- and low-peer victimization groups. Effect sizes were reported using Cohen's *d* with 95% confidence intervals.

### Missing Data

Unfortunately, one class had several instances of missing data at T2 for variables assessing sense of belonging and translation of the theory-led LINA design into user experience. This occurred because workshop providers mistakenly used a QR code linked to an incomplete version of the questionnaire. As a result, the class only completed part of the final questionnaire designed for the study. Therefore, this one class could only be included in the analysis of player experience.

Aside from the above, we had only a small number of missing items ($n = 15$) across eight participants. Three participants did not answer questions on the FunQ, gaming behavior, and smartphone possession because of time insufficiency. The small number of missing values led to the decision to exclude participants for analyses with missing data in the target variable, which explains the varying numbers of participants between analyses.

## Results

### Participants

In total, data from 99 participants ($M_{age}$ = 10.94; age range = 10–12; 51 girls, 48 boys) were included in this study. Ninety-two participants were born in Austria and seven in other countries (e.g., Germany). Forty-two participants attended MS and 57 AHS.

Overall, the vast majority (99%) possessed their own smartphone. While almost half of the girls (49%) played smartphone games often or very often, they rarely played computer games (16% played often or very often). In contrast, 80% boys played smartphone games often or very often and 64% also played computer games often or very often. In sum, boys played digital games more regularly than girls, but both showed a preference for playing games on smartphones over computers[2].

Since we had to exclude one class ($n = 19$) due to missing data for all analyses, except determining player experience, we compared demographic data for this subsample with the overall sample. We did not detect any significant deviations regarding sex, age, or nationality. Hence, the subsample is not described further.

**Table 1** *Psychometric properties of the GUESS-GA-18*

| | *n* | M | SD | Range | |
|---|---|---|---|---|---|
| | | | | Potential | Actual |
| GUESS-GA-18 score | 96 | 35.73 | 5.54 | 9–45 | 14–44 |
| Usability | 96 | 3.83 | 0.95 | 1–5 | 1–5 |
| Narratives | 96 | 4.53 | 0.70 | 1–5 | 1–5 |
| Play Engrossment | 96 | 3.45 | 1.051 | 1–5 | 1–5 |
| Enjoyment | 96 | 4.51 | 0.74 | 1–5 | 2–5 |
| Creative Freedom | 96 | 3.36 | 1.06 | 1–5 | 1–5 |
| Audio Aesthetics | 96 | 3.99 | 1.12 | 1–5 | 1–5 |
| Personal Gratification | 96 | 3.69 | 0.98 | 1–5 | 1–5 |
| Social Connectivity | 96 | 4.34 | 0.76 | 1–5 | 1–5 |
| Visual Aesthetics | 96 | 4.02 | 0.96 | 1–5 | 1–5 |

Note. $n_{girls} = 49$; $n_{boys} = 47$; values range from 1 (*don't agree at all*) to 5 (*totally agree*); data assessed at T2

### Player Experience

Table 1 presents psychometric properties of the questionnaire GUESS-GA-18, used to assess player experience. The overall satisfaction score was 35.73. The highest mean scores were reached in the subscales narratives (mean score = 4.53), enjoyment (mean score = 4.51), and social connectivity (mean score = 4.34). No sex differences were found in the overall GUESS-GA-18 score, therefore, no further analyses regarding sex differences were conducted.

### Translation of Theory-led LINA Design into User Experience

Table 2 reports the psychometric properties of the six key features of the theory-led LINA design. Players perceived that they met on equal terms, had to cooperate to solve a common goal, received appropriate support, felt safe during social interactions, and experienced fun throughout the activity. For both collaborative tasks, participants reported extremely good collaboration with their peers. 95% stated that they were happy or extremely happy with their collaboration in task 1 and task 2, respectively. Results point to a successful translation of the key features of the theory-led LINA design into user experience.

[a] single item of the FunQ (Tisza & Markopoulos, 2021a).

### Potential Effectiveness of LINA

Table 3 shows a statistically significant increase in sense of belonging from T1 to T2 with a small effect Cohen's $d = 0.21$ (Cohen, 1992). No significant sex differences were found on either time points ($t_1(77) = 1.760$, $p > .05$; $t_2(77) = 1.645$, $p > .05$).

[2] Percentages are calculated for $n = 78$ due to missing data.

**Table 2** *Psychometric properties of the six key features of the Theory-led LINA design*

| Topic | *n* | M | SD | Range | |
|---|---|---|---|---|---|
| | | | | Potential | Actual |
| Cooperation | | | | | |
| During gameplay, I experienced that my class needs to cooperate to proceed in the game | 79 | 79.89 | 29.11 | 1-101 | 1-101 |
| How well did you work together? | | | | | |
| Task1 – collaboration in pairs | 99 | 4.56 | 0.70 | 1–5 | 1–5 |
| Task2 – collaboration in small groups | 99 | 4.74 | 0.55 | 1–5 | 3–5 |
| Equal Status | | | | | |
| During gameplay, I experienced that everyone is equal | 80 | 83.06 | 27.77 | 1-101 | 1-101 |
| Common goal | | | | | |
| During gameplay, I experienced that my class is solving the puzzle around Lina together | 80 | 93.06 | 16.76 | 1-101 | 1-101 |
| Authority support | | | | | |
| During gameplay, I received all necessary support to proceed in the game | 79 | 79.68 | 29.62 | 1-101 | 1-101 |
| During gameplay, I know what to do[a] | 93 | 3.87 | 1.09 | 1–5 | 1–5 |
| A feeling of safety | | | | | |
| During gameplay, I experienced that… | | | | | |
| (1) we trust each other. | 80 | 84.21 | 25.40 | 1-101 | 1-101 |
| (2) listen to each other. | 79 | 82.51 | 26.64 | 1-101 | 1-101 |
| (3) help each other. | 80 | 86.66 | 24.52 | 1-101 | 1-101 |
| Experienced fun | | | | | |
| FunQ Score | 93 | 73.19 | 11.45 | 18–90 | 33–90 |

Note. The variation in sample size is due to the variation in the number of excluded cases because of missing data. Data was assessed at T2. Higher mean scores indicate higher approval

### Exploratory Analyses

The mixed ANOVA revealed a significant main effect of time, $F(1, 75) = 6.693$, $p = .012$, partial $\eta^2 = 0.082$, indicating that the outcome variable sense of belonging significantly increased from T1 to T2 across all classes. The interaction effect between time and classroom was not statistically significant, $F(3, 75) = 2.100$, $p = .107$, partial $\eta^2 = 0.077$. This suggests that the degree of change over time did not differ substantially between classes (further information in supplementary material).

In an additional sensitivity analysis, we examined whether the average change in sense of belonging differed between participants with low ($n = 51$) versus high levels of peer victimization ($n = 28$). Descriptively, those with higher peer victimization showed a slightly greater improvement in the outcome ($M = 0.71$, $SD = 2.48$) than those with lower levels ($M = 0.43$, $SD = 1.32$). However, this difference was small with a small effect (Cohen's $d = 0.18$) and did not reach statistical significance ($p = .557$). Greater variability in the high-victimization group suggests more heterogeneous individual responses.

## Discussion

The aim of this study was to evaluate player experience, the transition of the theory-led LINA design into user experience, and potential effectiveness of LINA. Overall, early adolescents had a great player experience with high satisfaction and acceptability ratings. In addition, high approval ratings on all six key features of theory-led LINA design demonstrate a successful translation of theory led features into user experience. Moreover, early adolescents not only enjoyed playing LINA, their sense of belonging also increased significantly following engagement with LINA (an effect that was robust across all classes). Results also seem to be robust for participants with high and low levels of peer victimization, as both subgroups benefitted equally from LINA.

### Player Experience

The high overall satisfaction scores in the GUESS-GA-18 support an excellent player experience of LINA. Compared to an earlier evaluation of a less polished version of LINA at the end of the co-development phase in June 2021, the overall player experience further increased (Mittmann et al., 2022a). Comparing the satisfaction score to another serious game about well-being for adolescents that used the same evaluation instrument, LINA reached an even higher score (Schorer & Protopsaltis, 2021).

The highest scores in the subscale narratives, enjoyment and social connectivity, highlight the special emphasis that

**Table 3** *T1 to T2 mean differences in sense of belonging*

| | Time 1 | | | Time 2 | | | | | Cohen's d |
|---|---|---|---|---|---|---|---|---|---|
| | M (SD) | SE | Range | M (SD) | SE | Range | t (78) | *p* | |
| Sense of belonging | 13.59 (2.56) | 0.29 | 5–16 | 14.13 (2.78) | 0.31 | 4–16 | 2.62 | 0.005* | 0.21 |

Note. $N = 79$

was put on these aspects during game development. For example, the narratives have gently been co-developed with early adolescents in iterative stages, involving early adolescents in storytelling and as experts of their own experiences at school. Additionally, the narratives were enriched by real world experiences from interviews with adult children of parents with a mental illness to tell a realistic story (Mittmann et al., 2022a). These iterative feedback loops were also used to optimize enjoyment of LINA among players. The high score in the subscale social connectivity demonstrates that LINA also gently supports social interactions between players, suggesting it is a highly positive multiplayer experience.

### Translation of Theory-led LINA Design into User Experience

In accordance with our theory-led LINA design (see Fig. 1), the six key features received high approval rates meeting at least 79.86%, with one exception (i.e., "During gameplay, I know what to do") meeting 77.40%. These findings support that players experienced equal status, cooperation to solve a common goal, received appropriate support, felt safe during social interactions, and experienced fun throughout the activity. In particular, players experienced a high feeling of safety, reporting that they can trust, listen to, and help each other during gameplay. We also assessed experienced fun of LINA, which was exceptionally high compared to other educational games or activities using the same instrument (Tisza & Markopoulos, 2021b; Tisza et al., 2021).

### Potential Effectiveness of LINA

For the first time, LINA was tested for increases in sense of belonging before and after gameplay. The significant increase over time suggests that LINA has great potential to enhance sense of belonging among classmates.

This study makes an important contribution to classroom-based programs during early adolescence with a focus on enhancing a sense of belonging among classmates. While early childhood is well-studied, the age group typically confronted with school transition (8–14 age range) remains underrepresented in intervention research (Milton et al., 2021). In particular, the focus on fostering relationships between classmates in its own rights received little attention (Pollak et al., 2023). LINA provides unique classroom-focused components and social interactions with multiple classmates in both, digital and face-to-face ways. We argue that LINA holds potential to add to the small list of universal, classroom-based programs that facilitate relationships among classmates (Pollak et al., 2023).

Although increases in sense of belonging were observed across all four classrooms in our study, our exploratory analyses showed some variation across these classes (see also supplementary material). Our findings suggest that these classes are affected by pedagogically relevant group differences (e.g., general class climate, teachers). Indeed, relationships between classmates, but also teacher-student relationships and individual student factors (e.g., gender, migration background) can affect classroom processes and students' well-being (Saxer et al., 2024). Therefore, including other pedagogically relevant aspects on class level in future LINA development might add important knowledge to our results.

Finally, sense of belonging did not differ between participants with low or high levels of peer victimization, which suggests that all pupils can benefit regardless of their peer victimization level. This result is promising since victimized peers have difficulties establishing good relationships at school, which might be particularly true after a transition (Ehrhardt et al., 2022). There is evidence that face-to-face collaborative games can reduce the level of self-reported peer rejection (Mikami et al., 2005), a potential effect that might apply to LINA as well. If LINA with merged digital and face-to-face collaboration can also minimize feelings of peer rejection, needs further investigation.

### Practical Implications and Future Directions

To our knowledge LINA is the first mobile AR social game that focuses specifically on relationships between classmates, instead of peers in general or friends only. Yet, teacher-student relationships play an additional role in the development of positive relationships with classmates and their well-being (Saxer et al., 2024). For example, when teachers create a warm and supportive classroom environment, it strengthens relationships between classmates, especially through fostering closeness rather than merely reducing conflict. In future, LINA should add playful elements that also addresses teacher-student relationships within the game. For example, by instructing the teacher to make positive intentional comments about students, which may further enhance student inclusion in the classroom (Saxer et al., 2024). In line with these considerations, future studies should assess not only changes in student-student but also teacher-student relationships.

While LINA could achieve a feeling of safety through structured contact situations, it is unclear how much contact is needed to achieve even better results and how quality and quantity of contact interact (Skinner & Meltzoff, 2019). Another digital game supporting peer relationships with focus on social skills training showed effective results after nine online episodes (Sanchez et al., 2017). In general,

programs supporting peer relationships in children and adolescents last an average of 18 weeks (Pollak et al., 2023). Thus, extending playtime of LINA including several episodes might be a promising avenue to explore. Moreover, successful programs that exclusively focus on rejected or victimized peers and the promotion of their peer relationships typically include social skills training (e.g., DeRosier, 2004; Healy & Sanders, 2014). Thus, LINA might be improved by proving optional support material after each episode, opening up further opportunities for discussions in class or traditional active practice in social skills training to best support at-risk children (Pollak et al., 2023).

To our knowledge LINA is the first mobile AR social game that creates an immersive social game for multiple players to promote sense of belonging. The high scores on satisfaction, collaboration, experienced fun and feeling of safety during social interactions suggest that the school environment might only be one of many possible application areas. For example, also at university the establishment of good peer relationships is essential for mental health (Maunder, 2017; Swenson et al., 2008), suggesting that LINA could be adjusted for university courses to foster relationships and well-being when transitioning to university.

LINA is developed with theoretical considerations primarily based on Contact Theory, which typically investigate the reduction of prejudice, attitude or behavioral changes towards particularly disliked individuals or members of social groups (e.g., Armstrong et al., 2017; Beelmann & Heinemann, 2014). These aspects have not been investigated so far. Moreover, since the narrative addresses a story about children of parents with a mental illness (COPMI), attitude changes towards COPMI, and mental health literacy in general, could also be addressed in future LINA episodes and research.

### Strengths and Limitations

Although the development of LINA has only reached proof-of-concept status, a statistically significant increase in sense of belonging could be demonstrated over the course of only one episode. This result, combined with the high ratings of player experience and excellent ratings on experienced fun and collaboration, make LINA a highly promising social experience with many potential application areas, which should be further investigated. Yet, the current study uses a convenience sample without a control group, which does not allow for conclusions regarding true intervention effects. There is a possibility that students would have improved their sense of belonging naturally over time without LINA or that students overestimated how their sense of belonging changed over time because of their investment in the study. Another limitation of this study is the small cluster size (i.e., data were drawn from only four classrooms in two schools), which falls below the recommended 10–15 clusters for reliable multilevel analyses (McNeish & Stapleton, 2016). Future research should test LINA with a larger sample and more robust study design (e.g., a randomized controlled trial) to enable robust multilevel modeling. Nevertheless, this study provides promising results on potential effectiveness with a reasonable sample size that can be used to determine statistical power for future studies, an important foundation for future trials. We showed that a sense of belonging among classmates can change in the assessed time period and with the measure we applied. Yet, the measure assessing the variable sense of belonging produced ceiling effects, as 33% of participants indicated the highest score at T1, leaving no room for further improvement. To reduce these effects, other operationalization methods could be considered.

## Conclusion

LINA is a novel AR social game to increase sense of belonging among classmates by promoting their relationships in the classrooms. Early adolescents were highly satisfied with the player experience. The high approval ratings on the six key features of the theory-led LINA design demonstrate successful application of the theory-led design into user experiences. LINA provided opportunities for good collaboration where players meet on equal grounds and safe social interactions are possible. Further development of LINA should add to the complexity of classroom processes by taking aspects such as teacher-student relationships and individual factors into account.

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