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Social robots disruptive artificial intelligence educational technology: Pre-service teachers' perceptions in China, Russia and Slovenia

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ABSTRACT

Artificial intelligence transforms human learning and education. Social robots in the elementary classroom enter the human sphere in the critical period of child's development. Social robotic educational technology, designed for long-term emotional connections and relationships, raises questions in the pedagogic relations and interaction. Research on teacher perceptions and readiness is deficient. This paper reports analyses of aspects of child-social robot interaction are of concern to pre-service teachers from China, Russia and Slovenia. Findings indicate that at the heart of participating pre-service teachers in China, Russia and Slovenia concerns are authenticity and humanness. Our findings show their concerns are mainly rooted in the belief that the robot shouldnot acquire the ability to perform authentic interactions nor should undertake a teaching roles. There is a widespread agreement among participants from three cultural contexts that teachers remain essential in educational contexts. In contrast, concerns related to social Interaction indicate notable group differences. The article highlights the teacher's responsible planning and use of artificial intelligence educational technology.

Keywords: pre-service teachers, artificial intelligence, social robot, humanoid robot, anthropomorphic robot, educational technology, concerns scale, China, Russia, Slovenia

INTRODUCTION

The introduction of computers, with a rapid proliferation of diverse digital media and tools, fundamentally changed the classroom landscape and influenced the theory and practice of teaching and learning (Istenič, 2024). Human learning is scrutinised in the age of artificial intelligence with changed roles of teachers and chalenging students as authonomous and self-directed learners (Istenič Starčič, 2019). At the turn of the century, a cutting-edge artificial intelligence technology, a phisically embodied social robotic technology is tested for interacting with childreen in the classroom. This social robotic technology is designed for long-term emotional connections and relationships and is in their interactions capability fundamentally different from previous technologies. It is introduced at a developmental stage when children learn about social relationships (Pashevich, 2022) and it is questioned how it may influence child's development (Istenič et al.., 2021a, 2025). Anthropomorphic robots are designed to resemble human beings, both physically and socially and are perceived differently than mehanomorphic robots, with children developing trust and atributing them human characteristics (Stower et al., 2024; Woo et al., 2021). In recent years, social robots have progressed at an incredibly rapid pace and it is foreseen that they will be used regularly in classrooms in the near future (Cheng et al., 2018; Edwards & Cheok, 2018; Ivanov, 2016; Newton & Newton, 2019, 2019a; Sharkey, 2016; Xia & LeTendre, 2021).

Researching social robots for education is tranziting from the laboratory to real classrooms examining authentic classroom setting starting from early childhood and primary education (Crompton et al., 2018; Istenič et al., 2025; Kanda et al., 2007; LeTendre & Gray, 2024; Movellan et al., 2005; Rosanda et al., 2025; Rosanda & Istenič Starčič, 2020; Smakman et al., 2022; Woo et al., 2021) in variety of pedagogical roles. For example, in the roles of instructors, teaching assistants, tutors, care receiving robots and peers (Belpaeme et al., 2018; Ghosh &Tanaka, 2011; Mubin et al., 2013; Rosanda & Istenič Starčič, 2020; Sharkey, 2016; Tuna et al., 2019; Woo et al., 2021). They are seen by some as a solution to the shortage of teachers (Edwards & Cheok, 2018; Konijn et al., 2022; Zhai et al., 2021).

Social robots are persuasive technologies destined to change the human physical and social environment attitudes and behavior (Fogg in Siebert et al., 2019; Kumar & Choudhury, 2024; Newton & Newton, 2019a; Siebert et al., 2019) capable to lead to new behaviors (Kumar & Choudhury, 2024) with a social and moral impact on people in ways we cannot yet foresee (Kahn et al., 2012, Šabanović, 2010).

They combine artificial intelligence and autonomous behavior (Jung & Won, 2018), a robot and a social interface, where the social interface represents the social attributes by which an observer perceives the robot as a social interaction partner (Hegel et al., 2009). A human-like appearance can make them more effective than disembodied technologies (eg. mehanomorphic robots), especially if they are also physically present in the learner's environment (Li, 2015; Siebert et al., 2019).

The body is essential to the determination of one's identity (Kumar & Choudhury, 2024). The shape and structure of the robot play an important role in determining what people expect from it, how they treat it, and how they relate to it (Fong et al., 2002). Human-like body is a strong signal to users that the robot is capable of social interactions (de Graaf et al., 2015; Henschel et al., 2021; Sirazetdinov, 2019). By interacting with humans as humans interact with each other, and by structurally and functionally resembling a human, a robot's social interaction with humans can be facilitated (Fong et al., 2002). These inanimate objects (Alač, 2016) interact and cooperate with humans respecting the rules, and adapting their social behaviour to their role (Edwards et al., 2016) and to direct user attention (Fong et al., 2002). The researchers are trying to equip the robots with the most important characteristics that people expect from their partners in interaction intended to be used not only as a thing but more as an agent (Alač, 2016).

These artefacts are far more disruptive to their users than their robotic predecessors, having been deliberately designed with human social skills and artificial minds in addition to their human appearance to produce social effects (Alač 2016; Appel et al., 2020) and to create bonds between humans and robot (Serholt et al. 2017). According to Grundke (2023) they can create a sense of threat to human uniqueness in people and a human status issue in the work environment, as according to pre-service teachers confirmed for the teaching environment (Istenič et al., 2021a).

In the classroom social robots can have the status of a tool to learn about (Ekström & Pareto, 2022; Siebert et al., 2019), a medium to learn through (Siebert et al., 2019), and a social actor to learn from and with (Ekström & Pareto, 2022; Siebert et al., 2019) in equivalent way to the human counterpart. Today, we do not yet know who will determine the status of robots in the intimate world of the human being in the learning environment, and according to what criteria. It is not clear whether robots will be given certain status in the educational environment based on a well-considered decision, or whether robots will progressively begin to occupy a certain place in the educational process, without in-depth discussion (Šabanović, 2010).

This technology, however, is technically and socialy much more sophisticated than their predecessors. Its intense human-like sociality is a departure from previous educationnal technologies and requires careful consideration regarding "How far do we want the education of our children to be delegated to machines, and social robots in particular?" (Belpaeme et al., 2018, p. 7).

RELATED WORK

People expect from a social robot companion in their intimate environment to communicate in a human-like way, take into account the social environment in which it is located, establish a trusting relationship with the user, behave authentically and not pre-programmed, express emotions and to be pleasant (de Graaf et al., 2015; Henschel et al., 2021). However, these robot capabilities may not be desirable in some environments, as suggested by the research (Istenič et al., 2021a) regarding the views of pre-service teachers about primary school students' interactions with social robot agent.

When education specialists, pedagogues or teachers (i.e. educators), freely contemplate the possibility of social robots usage in the classroom, their focus is mainly on the robot as social actor mimicking or mirorring a human rather than on problems of mastering the technical and practical aspects and adapting the technology to the needs of the learning environment (Istenič et al., 2021a; Kennedy et al., 2016). Istenič et al. (2021b) found that in an open, unguided reflection on social robots in the classroom learning situation, participants focused on the robot as a social actor, a status they considered inappropriate for pre- and primary school learning environments. They identified three groups of problems that would arise with the presence of a robot in the classroom: Legal, instructional and social-affective. However, they focused their reflection in particular on social and affective bonds with robot raising concerns within three issues: feelings and emotions, human-like behavior, interaction and relationships. This falls in line with other research results obtained among educators which identify concerns focus on robot's interactions and communication (Diep et al., 2015; Kennedy et al., 2016), bonds that children may develop with a robot (Serholt et al., 2017; Smakman et al., 2022), children atributing to a robot human emotion and empathy (Alhashmi et al., 2021; Diep et al., 2015; Kennedy et al., 2016; Serholt et al., 2017), impact on human relationships (Kahn et al., 2007; Serholt et al., 2017), children's behavior and affection (van Ewijk et al., 2020 ; Serholt et al., 2017); asymmetrical power relationships with robots (Serholt et al., 2017); loss of human contact (Istenič et al., 2021b; Smakman et al., 2022), social isolation (Kennedy et al., 2016), dehumanization (Istenič et al., 2021b; Serholt et al., 2017); robot's inability to understand intentions (Serholt et al., 2017) as well as the uniqueness of the sociocultural context (Serholt et al., 2017). Some educators also believe robot cannot provide human level comfort (Diep et al., 2015).

Educators' concerns for children interacting with a robot social actor touch upon those areas of children's socio-emotional development that are significantly associated with the primary school years, such as children's social and emotional competence, ability and effective social interaction, and healthy attachment (Istenič et al., 2021a, 2021b; Smakman et al., 2022). Basically, the authenticity (Diep et al., 2015) of the operation of the robot in the classroom is considered to be a source of concern (Rosanda & Istenič, 2023; Istenič et al., 2024, 2025).

In addition some educators raised also specifically instructional concerns. Children for example could consider robot as a toy and not as teaching aid (Alhashmi et al., 2021; Istenič et al., 2021b); the novelty effect wearing off could result in a loss of children's interest for the robot (Istenič et al., 2021b; Serholt & Barendreg, 2014), robot could represent a source of distraction for the children (Kennedy et al., 2016). On the other hand, concerns are raised that robots could replace teachers (Alhashmi et al., 2021; Istenič et al., 2021b; Serholt & Barendregt, 2014; Serholt et al., 2017) with a strong impact on education quality (Ivanov, 2016). The possibility of human replacement concerns too (Serholt & Barendregt, 2017). Some researchers (Kennedy et al., 2016; Rani et al., 2023) also cite the educators' opinion that social robots are not suitable for all subjects in the curriculum.

Social Robotic Educational Technology Supporting Authentic Learning

The problem of authenticity of robot relationships and interaction with learners has been an important human-robot interaction issue (Istenič et al., 2024; Kahn et al., 2007; Wilson & Haslam, 2013; Sharkey, 2016). Some research has been done on human uniqueness and dehumanisation in robotic social actors in contact with children (Haslam, 2006). Educatrs are questioning social robots being designed to enter the social sphere mimicking humans (Istenič et al., 2021a) identified doubt the robot's ability to understand and perform authentic humanity (Istenič et al., 2021b). Research of children perceptions anthropomorphising and accepting robots in classroom (LeTendre & Gray, 2024; Istenič et al., 2025; Stower et al., 2024; van Straten et al., 2020) and demonstrating social referencing to robot simmilar to teacher (Tolksdorf et al., 2021).

Educational technology has shifted from the structural component to the process component enabled by the invention of computers and digitalisation of the clasroom (Istenič, 2024). It seems that Educators are not primarily concerned with the robot as a tool, nor with the robot as a medium. The robot as a social agent is of their concern (Istenič et al., 2021b). These socially intelligent robots (Dautenhahn & Billard, 1999) equipped with artificial intelligence, which enables them to be used also for tasks requiring sophisticated mental and social abilities in the educational environment, seem to be perceived and assessed by educators more as social actors, rather than a technological tools or educational technology, when interacting in a learning environment (Istenič et al., 2021a).

Merriam Webster Dictionary (Retrieved October 10, 2023) defines authentic as "worthy of acceptance or belief as conforming to or based on fact" as well as "conforming to an original so as to reproduce essential features". For the purpose of this study, a robot in an educational role can be authentic if it can perform its role comprehensively and at the same level as it is possible to teacher so that the child's well-being and overall cognitive and personal development are not compromised by the child-robot interaction (Istenič et al., 2024)

The status of the robotic actor, able to demonstrate a high level of mental and social skills in the classroom, is not clear. Researchers envisage a division of labour between teacher and robot (Ivanov, 2016), with a change in the role of the teacher (Newton & Newton, 2019a) and the replacement of the teacher by a robot (Edwards & Cheok, 2018). Research (Rosanda & Istenič, 2021) found anxiety and educators' tendency to avoid communication with robots, leaving open the possibility that the avoidance tendency could stem from a lack of professional training, a lack of appropriate curriculum and teaching materials for teachers. However, they are more likely to interpret it as a feeling that the status of humans is threatened. Grundke (2023) notes that when faced with machines with human-like mental abilities, people tend to perceive a threat to human uniqueness, clearly expressed by the ESs with communication avoidance tendency reported (Rosanda & Istenič, 2021). As Grundke (2023) goes on to explain, people may feel threatened by the idea that a robot might challenge the distinctiveness of human beings and threaten their status as human beings.

Humaness and Empowerment of Technology with Human-like Social Skills

Elementary school children may ascribe to a robot human characteristics and experience social robot as a social being (LeTendre & Gray, 2024; Istenič et al., 2025). They have a tendency towards social behaviour with the robot (Kahn et al. 2012; Istenič et al., 2025) and perceive it as more human than the tablet (Konijn et al., 2022).

Empirical research examining the educators' perception of how children perceive anthropomorphic robots is deficient. Comparing elementary students' perceptions of NAO robot with pre-service teachers knowledge ot the mentioned students' perceptions results by Istenič et al., (2025) show that their pre-service teachers completely misunderstand students' perceptions of NAO.

Research surveying educators' put in evidence that educators' attribute to the robot social actor in a relationship with developing children in a classroom setting a negative impact on children's humanness, human nature and human uniqueness (Istenič et al., 2021a, 2021b) in line with Sharkey's (2016) conceptual paper. However, it is not entirely clear how they define these concepts.

Humanness is often mentioned in the debate about technology. Many people are concerned about how artificial intelligence technologies, including social robots, might change human beings and our view of human beings (Kumar & Choudhury, 2024). Wilson and Haslam (2013) explain humaness and it's elements in the context of folks psychology discussions regarding humans enhanced by technology. We use their findings to contextualize educators' concerns about learning situations when children interact with robots enhanced with socially interactive behavior, and human-like rather than machine-like interaction.

The proponents of enhancement are of the opinion that technology can help people to improve their human abilities and humaneness to the point of superhumanity. Opponents also mention the problem of humaness, but in a different context. Specifically, more in predictions about the loss of the human essence and the consequent automation of humans. (Wilson & Haslam, 2013)

There is no a clear definition of humaneness and human uniquness. On the contrary, we expect that we will arrive at a more complete understanding of what it means to be human, and thus of the essence of beeing a human by enhancing the social capabilities of robotic technology, (Fong et al., 2002; Kahn et al., 2007).

METHODS

Research Objectives

This study aims to explore pre-service teachers' (PSTs)concerns regarding children ineracting with social robot actor in classroom setting in Chinese, Russian and Slovenian cultural environment. Lacking such studies (Serholt et al., 2017), it is unclear which concerns about robotic social actors in classrooms are common across cultural contexts.

Our research question is: Which concerns are common to pre-service teachers with three different cultural backgrounds? We define a concern as a limiting condition, situation or relationship, which represents an obstacle that causes a state of mental discomfort and uncertainty and calls for caution. In this study, concern is considered a situation where participants feel that a robot is not appropriate in a school setting, so they are concerned about introducing a robot (Rosanda & Istenič, 2023; Istenič et al., 2024).

If robots are to be used in schools, the concerns need to be researched in depth (Konijn et al., 2022). These robots are designed to have a long-term emotional relationship with the human users and to be able to replace the human in certain situations. Before their large-scale use in education, we must understand the long-term effects of robot actors on children's social and emotional development (Pashevich, 2022).

Teachers are responsible for the learning process in the classroom and are also concerned with children's socio-emotional development (Smakman et al., 2022) and their overall wellbeing. They are therefore interested in carefully considering the implications of the actions of other social actors in their classrooms and in working with their classroom communities (Istenič et al., 2021b). To this end, they are also provided with professional training. Teachers decide how best to use technology in teaching (Serholt et al. 2017).

Given the paucity of longitudinal studies and studies of robot activity over a period of time equivalent to a teacher's work with children in primary schools (Rosanda & Istenič, 2021; Pashevich, 2022), educators can provide useful input on what might need to be considered when introducing robots into primary schools. This is especially true when the same concerns are being expressed in different cultural contexts.

Research Design, Participants and Procedures

The survey was conducted in the population of pre-service teachers in the academic year 2021/2022 at Zhejiang University in China, at Kazan Federal University in Russian republic of Tatarstan and at Faculty of Education at the University of Primorska in Slovenija.

The convenience sample consisted of 364 pre-service teachers: 132 (36.3%) from Slovenia, 124 (34.1%) from Kazan and 108 (29.7%) from China. There is a strong female bias in the sample, as in other research on social robots between education specialists (Kennedy et al., 2016; Rosanda & Istenič, 2023; van Ewijk et al., 2020). 342 (94.0%) participants were female, 22 (6%) males. Participants mean age = 19.5, SD = 1.33, Min = 18; Max = 35. 82 (66.1%) participants were attending the first-year courses, 85 (23.4 %) the second year, 54 (14.8 %) 16 (12.9%) the third year and 18 (4.9 %) the fourth year.

32 (8.8 %) of participants have already seen social robots; 181 (49.7 %) have never seen social robots in real life; they have only seen them in media like television and newspapers; 141 (38.7 %) have never seen them before and 9 (2.5 %) have used them before.

Prior to the intervention, the participants were informed about the study, that their participation was voluntary, and that neither their participation nor their non-participation would affect their grades. They gave their free and informed consent.

In the lecture, the characteristics of social robots were presented to the participants based on a Powerpoint presentation and video viewing of social robots and their potential use in the classroom at different education levels. After video viewing, Participants completed an online questionnaire. The data collection was individual and without guidance.

Instrument

The Concerns Scale with 27 items was applied (for all scale items see Istenič et al., 2024). The instrument was developed in 2019 at the Faculty of Education, University of Primorska (Istenič et al., 2021b). The instrument design involved pre-service teachers' open reflections on the humanoid social robots operating in the classroom environment. Pre-service teachers mainly focused on the effects of robot use on students and expressed concerns on the thre levels: Socio-emotional development, instruction and legal ethical. In 2021, based on their reflections designed was a five-point Likert scale instrument and reported validity (Istenič et al., 2021b, 2024; Rosanda & Istenič., 2023).

Data Analyses

The data were analyzed using SPSS IBM statistical package. The statistical analyses included descriptive statistics and the Kruskal-Wallis test to determine items with no statistically significant difference between our three independent groups. Effect size was calculated to determine how meaningful are the differences. DSCF post-hoc test was calculated for the items with significant Kruskal-Wallis test, to determine pairwise group differences.

Table 1. Factor loadings for the two factor solution

	Teacher role	Social interaction	Communality
Robots should not replace the teacher's work and interaction with children.	.870		.72
Children need their teachers for their socio-emotional development.	.841		.66
A robot cannot replace a human.	.815		.63
Robots cannot replace a teacher's genuine contact with children. A child needs a person who will actually understand, help and encourage him/her	.799		.62
Children spend too much time with electronic devices, so it is necessary to encourage other activities, such as spending time in nature.	.628		.51
Teacher's word is valuable. Robot cannot substitute it.	.606		.49
Genuine human contact is more important and teaches and educates	.571		.56
A robot cannot establish human contacts and emotions		.803	.61
Since a child finds a person in his life as a role model, it would be wrong to attach to a robot in a similar way		.742	.61
Using a robot would contribute to poorer socialization, as people would get used to communicating with an inanimate being and lose touch with reality		.730	.47
I don't see a robot in an independent role (e.g., a teacher) because robot has no empathy for people		.705	.58
The robot does not belong in primary schools because children of this age have to learn the basics of life, not to encounter things of modern technology immediately.		.703	.48
Robots can inhibit the development of empathy.		.667	.50

FINDINGS

Factor Analysis and Reliability of Scales

A Principal Axis Factoring (PAF) analysis with Oblimin rotation was conducted to explore the underlying factor structure of the data. Oblimin rotation was chosen because it allows for correlated factors. The data consisted of responses to 27 items from the Concerns Scale (see Istenič et al., 2024, **Appendix A**, Concerns Scale, p. 14). The analysis aimed to identify the number of factors that best represent the data. As shown in **Table 1**, two factors were extracted based on the eigenvalues greater than one criterion in combination with the criterion that the average communality should be greater than or equal to .6 when the sample size is greater than 250 (Field, 2009, p. 641). Factors with eigenvalues greater than 1.0 are considered significant and retained. The eigenvalues for the first two factors were 6.15 and 1.08, respectively, suggesting that these two factors account for a substantial portion of the total variance. Teacher role factor explains 31.0% of the variance, while Factor Social interaction explains 26.3% of the variance. Together they account for 57.2% of the variance in the item set and are positively correlated ($r = .64$). The α values for both factors (.90 for Teacher role and .87 for social interaction) indicated good to excellent internal consistency, suggesting that the scales used in this analysis are reliable. Reliabile are also the original ($\alpha = .94$) and extracted ($\alpha = .91$) scale. Their Cronbach's alpha demonstrate excellent internal consistency, suggesting they are highly reliable.

Bartlett's Test of Sphericity was significant, (x^2 (78) = 2648, $p < .001$), suggesting that the data were appropriate for factor analysis. The overall Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was .93, indicating excellent sampling adequacy. All individual KMO values were above .6, further supporting the appropriateness of the data for factor analysis.

The Oblimin rotation allowed for correlation between the factors. Higher loadings represent stronger relationships between each variable and its respective factor. In this analysis, several variables had strong loadings on Factor Teacher role, while others had stronger loadings on Factor Social interaction.

The factor Teacher role revolves around the role of teachers in children's development and emphasizes the irreplaceable nature of human interaction in educational settings. The factor loadings indicate a strong consensus among respondents that robots are incapable of substituting the essential human dimensions of teaching. The highest-loading items (.870, .841, and .815) emphasize respondents' strong belief in the irreplaceable role of teachers in fostering children's socio-emotional development, the inability of robots to replicate human interaction, and the necessity of authentic teacher-student interaction for optimal child development. Additional items (with slightly lower factor loadings) highlight concerns about over-reliance on technology, such as children spending too much time with electronic devices and the need to encourage other enriching activities like spending time in nature. The belief that the teacher's word holds unique value and that human contact is more important in teaching and educating also emerges strongly in this factor.

The factor social interaction focuses on the limitations of robots in fostering meaningful social interactions, particularly in educational contexts. Factor Social interaction reflects a strong belief that robots can not replace teacher's emotional depth and empathy required for meaningful human interactions and social development, making them unsuitable for primary education or roles requiring emotional intelligence. It underscores the belief that robots, due to their inability to engage in authentic emotional exchanges, are ill-suited to support the social and empathetic development essential for children, particularly in early education. The factor underscores concerns about the negative impact of replacing human interactions with robotic on children's social skills and emotional growth. The highest factor loadings (.803, .742, .730) reflect concerns that robots shouldn't be put in place of establishing authentic human connections or emotions, which are central to meaningful relationships. The concern is raised that children might mistakenly form attachments to robots as role models, potentially disrupting healthy socialization by prioritizing

Table 2. Descriptive statistics for a two-factor solution

Factor	Valid	Missing	Mean	Median	Mode	SD	Skewness	SE	Kurtosis	SE	Min	Max
Teacher role	361	3	4.14	4.14	5.00	0.69	-0.65	0.13	-0.20	0.26	2.00	5.00
Social interaction	361	3	3.55	3.55	3.00	0.78	.14	0.13	-0.68	0.26	1.50	5.00

Table 3. Descriptive statistics for each factor across the three groups

Factor	Group	Valid	Missing	Mean	Median	Mode	SD	Skewness	SE	Kurtosis	SE	Min	Max
Teacher role		361	3	4.14	4.14	5.00	0.69	-0.65	0.13	-0.20	0.26	2.00	5.00
Social interaction		361	3	3.55	3.55	3.00	0.78	.14	0.13	-0.68	0.26	1.50	5.00

interactions with an inanimate object over real human connections. The concern is this could hinder their social development by reducing meaningful interactions with real people and blurring the line between humans and machines.

Further items (with factor loadings ranging from .705 to .667) suggest that robots are seen as inadequate in emotionally complex roles like teaching, due to their lack of empathy. There's also a belief that introducing robots too early, especially in primary schools, could be detrimental, as children at that age need to focus on foundational life skills and interpersonal interactions rather than engaging with technology prematurely.

Descriptive statistics (presented in **Table 2**) were calculated for both factors, the teacher role and the social interaction across 361 valid cases (with 3 missing cases for each factor). Each item was rated on a 5-point Likert-type scale, with higher values indicating greater levels of concern.

Teacher role

The teacher role factor showed a high level of concern, as indicated by both the mean and median of 4.14 (SD = 0.69). This is further supported by the mode of 5.00, suggesting that the most frequently selected response reflected the maximum level of concern. A concentration of responses at the higher end of the scale was evident, as indicated by a statistically significant negative skew (skewness = −0.65, SE = 0.13; z = −5.08). Kurtosis was −0.20 (SE = 0.26), suggesting a distribution slightly flatter than normal. Reported concern levels ranged from 2.00 to 5.00, demonstrating that all responses were within the moderate to high range of the scale, with no participants indicating low levels of concern.

Social interaction

The mean and median concern levels were both 3.55 (SD = 0.78), reflecting a moderate level of concern. The mode was 3.00 (I'm unsure how to respond), indicating that the most common response was indecision. The distribution was approximately symmetrical (skewness = 0.14, SE = 0.13), with no statistically significant deviation from normality (z = 1.07). Kurtosis was −0.68 (SE = 0.26), suggesting a relatively flat distribution with greater variability. Responses ranged from 1.50 to 5.00, indicating a broader variability compared to the Teacher role factor.

Comparison between factors

Participants reported higher and more consistent concern levels regarding the teacher role compared to social interaction in the context of robot-assisted learning.

Shared Concerns and Significant Differences across Three Goups

To explore potential shared concerns among pre-service teachers (PSTs) in Russia (RU PSTs), China (CN PSTs), and Slovenia (SLO PSTs), a Kruskal–Wallis H test was conducted. This nonparametric test detects whether there are statistically significant differences in scores on the factors teacher role and social interaction across the groups, and identifies the specific factors or groups where these differences occur.

The factor teacher role

There was a statistically significant difference among the groups on the factor teacher role, $H(2) = 40.55$, $p < .001$, with a moderate effect size ($\varepsilon^2 = .11$). Differences were supported by the descriptive statistics for each factor across the three groups (**Table 3**).

Descriptive statistics (**Table 3**) indicated that SLO PSTs reported the highest level of concern (M = 4.35, SD = 0.66), followed closely by CN PSTs (M = 4.27, SD = 0.49), while RU PSTs reported a lower average level of concern (M = 3.80, SD = 0.74). The medians for SLO PST (4.57) and CN PSTs (4.29) indicate that at least half of participants rated their concern well above the scale midpoint, while the modes of 5.00 for both PSTs groups reflect a strong clustering at the maximum response value, suggesting widespread and intense apprehension regarding the teacher's role in robot-assisted education. The lower median (4.00) and mode (4.00) for the RU PSTs indicate a more moderate level of concern, reflecting fewer participants selecting the highest response option. All three distributions were negatively skewed, indicating a tendency toward higher concern scores: CN PSTs (Skewness = –0.52, SE = 0.23), RU PSTs (Skewness = –0.29, SE = 0.22), and SLO PSTs (Skewness = –0.80, SE = 0.21), , with the strongest skew observed among SLO PSTs. Kurtosis values ranged from –0.63 (RU PSTs) to 0.65 (CN PSTs), indicating distributions close to normal. The minimum observed concern scores differed across groups, with CN PSTs reporting a minimum of 2.57, RU PSTs a minimum of 2.00, and SLO PSTs a minimum of 2.71. None of the groups exhibited extremely low concern levels, as all minimum scores were at or above the lower midpoint of the scale. All groups reported a maximum concern score of 5.00, indicating that participants from each group expressed the highest possible level of concern.

Afterwards, we tested the statistical significance of differences identified by the Kruskal–Wallis test, as reflected in the descriptive statistics for each factor across the three groups. The Dwass–Steel–Critchlow–Fligner (DSCF) post hoc test was conducted to assess all pairwise comparisons between three groups.

As a non-parametric multiple comparison method, the DSCF test identifies which specific group pairs show statistically significant differences. The Bonferroni adjustment was applied to control for the increased risk of Type I errors due to multiple comparisons. Post hoc pairwise comparisons using the Dwass-Steel-Critchlow-Fligner test revealed that the difference between CN PSTs and SLO PSTs was not statistically significant ($p = .35$). In contrast, the differences between RU PSTs and CN PSTs ($p < .001$), and between RU PSTs and SLO PSTs ($p < .001$), were statistically significant.

The significant differences between groups from different countries could suggest cultural or regional variations in how people perceive the impact of robot-assisted teaching on these important areas of child development. In terms of the DFSC (Dwass-Steel-Critchlow-Fligner) interpretation the differences reflect each country's unique factors (economic, cultural, political) influence.

Analysing the concerns associated with the first factor, the teacher role, as expressed by all participants in this study (Chinese, Russian, and Slovenian) is compared with the factor solutions conducted separately on the Slovenian and Russian samples (Istenič et al., 2024; Rosanda & Istenič, 2023). The exploratory factor analysis (EFA) conducted exclusively on the RU PSTs sample (Istenič et al., 2024) yielded a one-factor solution, the factor named: »Reluctance towards authenticity-imbued social robots«. This single factor captured pre-service teachers' concerns about the appropriateness of using social robots in educational settings. It partially overlaps the factor Teacher role in this study of three cultural environments. RU PSTs place particular importance on the role and value of the teacher, expressing the belief that it would be inappropriate to introduce a robot into the classroom for such a purpose. They do not consider the robot's human-like interaction abilities sufficient to justify its assignment as a social agent or interaction partner in educational settings (Istenič et al., 2024). This perspective partially overlaps with the Teacher role factor identified in the three-cultural-environment study. Specifically, participants expressed discomfort with the fact that these robots are designed to simulate authenticity, arguing that authenticity is a distinctly human trait that should remain the responsibility of teachers. Consequently, the RU PSTs were generally reluctant to envision a future in which robot teachers play a significant role in education (Istenič et al., 2024).

The exploratory factor analysis (EFA) conducted exclusively on the Slovenian sample of these three cultural environment studies provided a two-factor concerns solution (Rosanda & Istenič, 2023). The first factor Lack of Social Skills partially overlaps with the Russian one-factor solution (Istenič et al., 2024).

Both samples, Slovenian and Russian share the following concerns from Teacher role factor of the two-factor solution identified across all three cultural samples:

(1) Robots should not replace the teacher's work and interaction with children;

(2) Children need their teachers for their socio-emotional development;

(3) A robot cannot replace a human;

(4) Robots cannot replace a teacher's authentic contact with children.

A child needs a person who will actually understand, help and encourage him/her.

The belief that a robot cannot replace a human emerged as a shared concern in the first factor of this three-cultural-environment study, appearing specifically in the first factor of both the Slovenian (Rosanda & Istenič, 2023) and Russian groups (Istenič et al., 2024).

This concern is consistent with findings from previous studies, including the perspectives of 35 education experts in the United Kingdom on the use of robots in schools (Kennedy et al., 2016), as well as the views of 18 Dutch primary school teachers who emphasized children's need for human contact (Ewijk et al., 2020).

The factor social interaction

For factor social interaction, the Kruskal–Wallis H test revealed a statistically significant difference among the three groups, $H(2) = 80.11$, $p < .001$, indicating a large effect size ($\varepsilon^2 = .22$).

Descriptive statistics (**Table 3**) shows concern scores for social interaction varied more distinctly across three groups. SLO PSTs reported the highest mean concern score ($M = 4.01$, $SD = 0.72$), with a median of 4.00 and mode of 5.00, suggesting that many respondents selected the highest possible rating, reflecting strong and consistent apprehension about how robots may affect children's social development. In contrast RU PSTs ($M = 3.43$, $SD = 0.74$), and CN PSTs ($M = 3.13$, $SD = 0.58$) reported lower levels of concern, with medians of 3.33 and 3.17, and modes of 3.00, indicating more neutral or idecided views, and a tendency toward mid-scale responses that is indecision. These patterns suggest that, in RU PSTs and CN PSTs samples, concern about social interaction is more evenly distributed and less intense. The skewness values reinforce this interpretation: for SLO PSTs showed slight negative skew (–0.34, SE = 0.21), indicating a lean toward higher concern, whereas for CN PSTs (0.29 SE = 0.23) and RU PSTs (0.12, SE = 0.22) showed slight positive skewness, indicating broader dispersion and less clustering at the high end. The observed skewness patterns point to potential cultural or contextual influences on how social interaction concerns are perceived and reported. Kurtosis values were negative for all three groups, indicating slightly flatter distributions: CN PSTs (Kurtosis = –0.18, SE = 0.46), RU PSTs (Kurtosis = –0.22, SE = 0.43), and SLO PSTs (Kurtosis = –0.77, SE = 0.42) may reflect a broader range of responses and less concentration around the mean, indicating more varied perspectives within each group. Minimum scores ranged from 1.50 (RU PSTs) to 2.33 (SLO PSTs), and maximum scores ranged from 4.67 (CN) to 5.00 (RU and SLO).

Post-hoc tests puts in evidence that these differences between all pairs of groups are significant with the following p values between CN PSTs and RU PSTs .007, between CN PSTs and SLO PSTs < .001, and also between RU PSTs and SLO PSTs < .001.

Post-hoc tests for the social interaction factor puts in evidence all-pairwise differences are significant (betweenCN PSTs and RU PSTs p= .007, between CN PSTs and SLO PSTs p< .001 and between RU PSTs and SLO PSTs p < .001) further highlighting the distinct national patterns in concern levels.

Based on these findings, could be concluded that cultural differences shape perceptions of introducing robots in classrooms, regarding teacher role and social interaction. The results suggest that the distributions of both factors vary significantly across the groups, with more pronounced differences observed in factor social interaction.

Further research could examine how specific cultural values about human interaction in education influence acceptance or resistance to robot-assisted teaching. In this context it is also important to consider that social robots present themselves as an extension of a tool, specifically as a social partner, which adds another layer to these perceptions. Understanding these nuances can help policymakers and educators create interventions that respect each society's values and ensure technology supports rather than disrupts the social dynamics of learning.

Analysing the concerns associated with the second factor, the social interaction, as expressed by all participants in this study (Chinese, Russian, and Slovenian) is compared with the factor solutions conducted separately on the Slovenian and Russian samples (Istenič et al., 2024; Rosanda & Istenič, 2023). Whereas factor analysis conducted exclusively on the Slovenian sample produced a two-factor solution (the first factor named: »Lack of social skills«, the second factor named: »The inadequacy of robots for enhancing student development«, the exploratory factor analysis (EFA) performed on the Russian sample yielded a one-factor solution (namely, »Reluctance towards authenticity-imbued social robots«). This suggests that Russian respondents may view concerns about teacher roles and social interaction as a single, unified issue rather than distinct areas of impact. Such variation in the way concerns are conceptualized reflects deeper cultural or contextual differences in how robotic technologies in education are understood.

Lacking the second factor in Russian sample, it was not possible to compare the concerns between the Slovenian and Russian samples with the results of the second factor (Social interaction) in the overall sample of this study

Concerns in the Factor Solutions of the Russian and Slovenian samples Examined Independently of Specific Factor Loadings. All the concerns statements from the two-factor solution, conducted on the full sample (CN; RU and SLO) in this study, were used as the basis for comparison. These concerns were then compared with all the concerns from the factor solutions derived separately from the Russian (Istenič et al., 2024) and Slovenian (Rosanda & Istenič, 2023) samples. Six concerns from the whole sample two factor solution are present also in the factor solutions of Russian and Slovenian samples:

(1) Robots should not replace the teacher's work and interaction with children;

(2) Children need their teachers for their socio-emotional development;

(3) A robot cannot replace a human;

(4) Robots cannot replace a teacher's authentic contact with children, as children need someone who will actually understand, help, and encourage them.

These concerns echo prior research. For instance, Kennedy et al. (2016) found that UK education experts emphasized the irreplaceability of human presence in classrooms. Similarly, Dutch teachers in Ewijk et al. (2020) questioned the ability of robots to meet children's emotional needs. These consistent concerns across contexts suggest that doubts about robot-assisted teaching are not limited to isolated cases but are instead embedded in broader cultural and professional values.

Cultural differences also reveal varying views on the teacher's role in technology-enhanced learning, particularly regarding socio-emotional development, human interaction, and the impact of social robots on students' social skills. These findings suggest that cultural attitudes and societal values significantly shape concerns about robot-assisted teaching. For example, some cultures may view technology as a beneficial learning tool, while others see it as potentially disruptive. Trust in educational systems and beliefs about the irreplaceability of teachers in children's social and emotional development may also influence acceptance of robot teachers. Additionally, historical context may play an important role.

DISCUSSION

This study examined cross-cultural (CN, RU and SLO) pre-service teachers' sample concerns regarding robot integration in early childhood education. Two key dimensions, the teacher role and social interaction, were extracted from a 27-item scale aplying Principal Axis Factoring with Oblimin rotation.

Participants reported higher and more consistent levels of concern regarding the teacher role compared to social interaction in the context of robot-assisted learning, indicating stronger apprehensions about robots potentially replacing human educators. The concern of robot or any teaching agent replacing human is reported in a sistematic review of artificial intelligence application in education by Zhai et al. (2021). Results of the study reported in this paper show a widespread agreement among participants that teachers remain essential in educational contexts. In contrast, concerns related to social interaction indicate notable group differences.

Teacher role concerns were generally high across all groups, with Slovenian participants reporting the highest concerns levels, followed by those from China and Russia. The negatively skewed distributions across samples suggest that most participants expressed strong concerns in this area, particularly Slovenian participants, where this pattern was most pronounced.

In contrast, concerns related to social interaction showed greater cross-cultural variation. While Slovenian participants again reported the highest levels of concern, Chinese and Russian participants showed progressively lower mean scores.

The findings highlight that cultural differences shape perceptions of introducing robots in classrooms, particularly in relation to the teacher's role and social interaction. Nevertheless, some concerns are shared across different cultural contexts. The following four concerns were identified as recurring across the full sample, as well as in the report (Istenič et al., 2024) of the Russian and Slovenian samples:

(1) Robots should not replace the teacher's work and interaction with children;

(2) Children need their teachers for their socio-emotional development;

(3) A robot cannot replace a human;

(4) Robots cannot replace a teacher's authentic contact with children, as children need someone who will actually understand, help, and encourage them.

These four concerns appear to reflect pan-cultural resistance to the idea of replacing human teachers with robots, particularly in the context of early education. The shared emphasis on genuine human interaction, emotional understanding, and the teacher's irreplaceable social role suggests that participants across cultural contexts (Slovenian, Russian, and Chinese) perceive the teacher-child relationship as fundamentally human and non-transferable to machines. These concerns focus on robots' perceived inability to fulfill the affective, relational, and developmental functions of teaching. This consistency across samples may imply a broadly shared cultural expectation that early childhood education must be grounded in empathy, emotional support, and authentic interpersonal connection-qualities currently associated exclusively with human teachers.

CONCLUSIONS

In the future teacher training, it is essential to instill a strong belief in the importance of developing skills that strengthen interpersonal relationships in the classroom and support students' social and emotional development. Teachers must help students understand that human interaction is unique and fundamentally different from its robotic imitation, even as social robots grow more capable. Educators' roles are growing with the proliferation of the generative and conversational artificial intelligence in human living and learning environments. Education has to focus on caring for students as whole individuals, with the full complexity of human nature. This will help young generations live and learn alongside technology, at a time when opting out is no longer realistic, without being overly controlled by it or left to face it alone.

LIMITATIONS

While the findings of this study contribute to our understanding of cultural differences in perceptions of robot-assisted teaching, several limitations should be acknowledged. First, the sample was limited to participants from only three countries, which may restrict the generalizability of the results to other cultural contexts. Future research should aim to include a more diverse range of countries with varying educational traditions in order to better understand how cultural values influence perceptions of educational technology. Second, as is common in robotics research, a convenience sample was used, which further limits the generalizability of the findings.

IMPLICATIONS AND FUTURE RESEARCH

These findings have important implications for the development and implementation of social robot educational technology. Developers and policymakers must consider cultural differences in attitudes toward human-robot interaction, especially in sensitive domains such as early childhood education. Technology design should prioritize transparency about robot limitations and supporting teacher rather than teacher replacement.

Future research should further explore the role of cultural norms, social and emotional expectations alignew with pedagogy and instructional design in shaping educators' responsivenes to robot-assisted teaching. Longitudinal studies are needed to examine how attitudes evolve over time as exposure to robotic systems increases or as educational policy shifts.

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