Pre-Service Teachers' Concerns about Social Robots in the Classroom: A Model for Development

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Abstract
Social robots are being tested in the educational arena with current thinking in two main directions. One is arguing for the benefits of robots in affective and efficient instruction and is more teacher-centered. Within the second, more student-centered oriented, proponents of human uniqueness are raising long-term concerns. Teacher-centeredness and student-centeredness form pedagogical beliefs underpinning teachers' attitudes guiding technology integration. Limited research has explored teachers' underlying beliefs and attitudes to social robots, with some presenting mixed feelings identifying some concerns with some identifying more positive attitudes. Preservice education is critical in forming beliefs, and this paper presents a qualitative study of Slovene pre-service pre-primary school and primary classroom pre-service teachers' attitudes and underlying beliefs. Students were asked to reflect on their perception of social robotic educational technology in which they would highlight at their own discretion the positive, neutral and negative aspects. Students' reflections predominantly expressed concerns. The research model was designed in part, drawing from participants reflections and on related studies. Previous studies indicated the concerns teachers hold about robotic technology, but lacked a more holistic model. We built a threefold model distinguishing instructional, social-emotional, and legal concerns. Our findings differ from related studies because they identified participants' negative attitudes and a clear rejection of robot technology with a human-like appearance and social skills in the classroom. Previous student-centered studies reported on single groups of concerns within specific contexts without developing a holistic view relating diverse concerns in one picture. Related teacher-centered studies were arguing for refinements anticipating robot's social intelligence affordance in the classroom. The participants in our study are not rejecting social robots as such, but in their view, the robot is not granted the status of a social entity capable of engaging in student-centered teaching and taking care of child wellbeing and development. The findings of our study call for action and informed robot development, taking into consideration teachers as co-designers.
Keywords: Embodied humanoid social robots, pre-service teachers, early learning, educational robotics, beliefs.

Отношение учителей к социальным роботам в образовании: Модель развития

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Аннотация
Социальные роботы в сфере образования тестируются в двух направлениях: одно ориентировано на учителя и подчеркивает их эффективность – второе, ориентированное на студентов, выражает обеспокоенность обезличенным характером подобного обучения. В данной статье представлено качественное исследование отношения словенских студентов – будущих учителей дошкольного образования и начальных классов – к роботизированной образовательной технологии, в которой они по своему усмотрению должны были выделить положительные, нейтральные и отрицательные аспекты. Студенты выразили преимущественно обеспокоенность. Нами была разработана трехкомпонентная модель исследования, включающая учебные, социально-эмоциональные и правовые стороны проблемы. Результаты выявили негативное отношение участников к роботам с внешностью человека и социальными навыками и полный отказ от их использования в классе. Участники исследования, не отвергая социальных роботов как таковых, отказывают им в статусе социального субъекта, способного учитывать индивидуальность учащихся и адекватно заботиться о благополучии и развитии детей. Результаты исследования призывают к осознанному созданию роботов с привлечением учителей в качестве со-дизайнеров.
Ключевые слова: гуманоидные социальные роботы, студенты-будущие учителя, раннее развитие, образовательная робототехника, убеждения.

Highlights

- This study examined pre-service teachers' reflections on social robots in the classroom.
- It developed a comprehensive concerns model in the instructional, socio-emotional and legal aspect.
- In contrast to previous research, negative attitudes and rejection were identified.
- Student-centered beliefs underpin refusal of robot's social intelligence in the classroom.

Introduction

There is a rapid pervasion of technology in all areas of life, and work with anthropomorphic social robots enabled by artificial intelligence (AI) being tested in

education. When introducing new robotic technology, it is necessary to understand the representations that lie behind robot embodiment in social space and within educational concepts. Educational concepts with historical origins and more recent representations of social robots, are both manifest in teachers' beliefs, which influence their readiness for their acceptance among teacher practitioners and pre-service teachers. Limited research has explored the beliefs and attitudes of teacher practitioners and pre-service teachers regarding humanoid social robots.

Quantitative studies focused on teacher's attitudes toward social robotic technology identified mixed feelings. Kennedy, Lemaignan, & Belpaeme's study (2016) comparing teachers with the general public, identified teachers' caution and concerns about the robot's social skills. In contrast to this, some studies found teachers' affection and acceptance of social robot affordance, predicting its application in the classroom (Fridin & Belkopytov, 2014) with some issues about the accessibility of expensive technology (Conti, Di Nuovo, Buono, & Di Nuovo, 2017).

Educational technology contributes to the construction of authentic learning environments (Istenic, 2021) and the type of technology has been established as an important area that patterns teachers' beliefs (Tondeur, van Braak, Ertmer, & Ottenbreit-Leftwich, 2017). In our study, we apply a qualitative methodology to examine pre-service teachers' attitudes to social robotic educational technology and underlying beliefs.

Teachers' attitudes and beliefs about social robotic technology

Beliefs are seen as an interplay of a variety of opinions and values (Hermans, Tondeur, van Braak, & Valcke, 2008). An opinion is regarded as an unemotional statement, while attitude is an emotional statement about something (Bergman, 1998). Teachers' attitudes towards behavior and actual behavior are underpinned by their beliefs about the use of technology facilitating favorable outcomes (Sadaf, Newby, & Ertmer, 2012 citing Ajzen, 1991) and in turn guide their pedagogical practice. Innovation in education technology causes polarized views with emotional responses and diversified opinions. Thus, attitudinal studies are essential for understanding and addressing technology integration.

The critical success factors for acceptance are the beliefs that influence a person's attitudes (Ajzen, 2001). These are formed during pre-service preparation and influence technology adoption in schools (Drent & Mellison, 2008). Teacher educators provide role-modelling in technology integration (Istenic Starcic & Lebenicnik, 2020).

The synthesis of qualitative research by Tondeur et al. (2017) advanced the understanding of how teachers' beliefs influence technology integration. This does not depend merely on technology-related factors, but on patterns of the multiple beliefs that teachers hold when they select their teaching strategies. Beliefs refer to a bi-directional relationship between pedagogical beliefs and technology integration, the perceived barriers, types of technology, the role of professional development and the importance of school context (ibid.).

The pedagogical beliefs refer to epistemic (the nature of knowledge and knowing) and reveal two main orientations - the teacher-centered and the student-centered. The teacher-centered considers teacher's roles and functions as an authoritative supervising learning process, while the student-centered corresponds with constructivism or social constructivism and prioritizing learning according to students' needs (ibid.).

With the rise of constructivism, educational technology was recognized as a facilitator of constructivist student-centered learning (Means & Olson, 1995) and educational technology scholarship, indicating educational technologists' beliefs and capturing educational technology as a potential force for improving educational processes (Selwyn, 2011). The spread of constructivism coexisted with the spread of computer-assisted

learning in the 1990s. The 21st century is becoming an era in which robots receive attention from researchers. However, the teachers' attitudes and underlying beliefs in social robotic educational technology have not been extensively explored. An examination of teachers' attitudes and beliefs needs to address issues raised by Selwyn (2011) and Spector (2014). Selwyn (2011) argued for a critical discussion of the educational technology as an enabler and force for a positive change and Spector (2014) claimed that implementing technology in education has been opportunistic following technological affordance and not instructional design requirements.

Student-centered beliefs underpin the qualitative studies of concerns of social robot integration. It focuses on a child and developmental needs including the ethical concerns (Serholt, Barendregt, Leite, Hastie, Jones, Paiva, Vasalou, & Castellano, 2014; Serholt, Barendregt, Vasalou, Alves-Oliveira, Jones, Petisca, & Paiva, 2017; Van Ewijk, Smakman, & Konijn, 2020) and an affordance for learning domains (Crompton, Gregory, & Burke, 2018). The student-centered beliefs are in line with discussions of human nature uniqueness that is associated with negative attitudes (Giger, Moura, Almeida, & Piçarra, 2017; Giger, Piçarra, Alves-Oliveira, Oliveira, & Arriaga, 2019).

Some qualitative studies of teachers' perceptions of social robot classroom integration focused on robot integration in specific domains, such as special education (Diep, Cabibihan, & Wolbring, 2015) or language learning (Ahmad, Mubin, & Orlando, 2016) and are aligned with the framework of the teacher-centered belief. They explore social robotic potential, focusing on learning content and its delivery with a teacher as an authority in the classroom (Rosanda & Istenic Starcic, 2019; 2020). Such qualitative studies (Diep, Cabibihan, & Wolbring, 2015; Ahmad, Mubin, & Orlando, 2016) as for most of the quantitative studies (Fridin & Belkopytov, 2014; Kennedy, Lemaignan, & Belpaem, 2016; Conti et al., 2017), are in line with teacher-centered beliefs underpinning educational technology integration. They are connected with the subject matter and the teacher's authority supervising the process of learning acquisition, serving as an expert in the highly structured learning environment (Tondeur et al., 2017). Teachers perceive robots more from a teacher-centered view, with a greater focus on the possibilities of integration, use by teachers, placement of the robot in the classroom and pedagogical framework, teaching, and less on children wellbeing. This might be explained by the fact that before the actual introduction of the robot in the classroom, the focus is on implementation and direct practical aspects. Less thought is given to the long-term consequences and effects in line with the education concept. Based on the review of indicated studies, teachers perceive the robots' role in terms of efficiency and effectiveness of lower-level cognitive routine tasks.

Social robots in education

There is no formal definition of a social robot. For this study, we developed a working definition, drawn from Dautenhahn and Billard (1999), Fong, Nourbakhsh and Dautenhahn (2002), Bartneck and Forlizzi (2004), Yan, Ang and Poo (2014), Edwards, Edwards, Spence, Harris and Gambino (2016), Jung and Won (2018), Hegel, Muhl, Wrede, Hielscher-Fastabend and Sagerer (2009), Tsiakas, Kyrarini, Karkaletsis, Makedon and Korn (2018), Beer, Fisk and Rogers (2014). Social robots are physically embodied autonomous robotic technology equipped with AI and social skills, developed to become a human-equivalent partner in social relations, and capable of human-like and situation- and role-appropriate interaction.

AI-enabled social robots are not yet truly intelligent machines. Their important characteristic is the capability of natural interaction with humans (Fong et al., 2002; Kanda, Sato, Saiwaki, & Ishiguro, 2007), based on the robots' anthropomorphic

appearance and coherence of appropriate verbal interactions with non-verbal cues, such as eye gaze, gestures, bodily orientation, body posture, and similar cues (Van den Berghe, Verhagen, Paz, Van der Ven, & Leseman, 2019). Social robots are being designed with the intention that, through interaction, form intimate social bonds with a human in the same way humans form attachment bonds to others (Serholt et al., 2017). The robots also go beyond the role of interaction mediator, on which previous types of technologies have focused, and raise entirely new issues in classrooms. The social robot physical embodiment in the classroom space is examined from perspectives of all socio-emotional cognitive and psycho- learning domain (Crompton, Gregory, & Burke, 2018). In education, robots are most often used in robotics classrooms and for related subjects, mostly as a goal or means of learning activity (Benitti, 2012; Cheng, Sun, & Chen, 2018; Mubin, Stevens, Shahid, Al Mahmud, & Dong, 2013); in STEM (Mubin et al., 2013); for language learning (Van der Berghe et al., 2018; Mubin et al., 2013; Cheng et al., 2018); in special education (Cheng et al., 2018), primarily for working with children with autism spectrum disorder (Cheng et al., 2018; Fong et al., 2002); and for the development of cognitive abilities among children and adolescents (Mubin et al., 2013). There is a growing interest in humanoid social robotics in early learning for all domains of learning (Crompton, Gregory, & Burke, 2018). At this stage, robots are used in education in a small number of curricular areas, and researchers' and teachers' expertise about the use of robots in education to date remains relatively nascent (Cheng et al., 2018).

In terms of intervention duration and number of participants, the activities of social robots in classrooms are well-prepared in advance with different levels of human assistance. Short robot-assisted activities for small groups, however, are not implemented in regular teaching and are rarely aligned with the school curriculum. Robots are mostly employed in one-to-one interactions with students (Belpaeme, Kennedy, Ramachandran, Scassellati, & Tanaka, 2018; Rosanda & Istenic Starcic, 2019; 2020) and less frequently "in a one-to-many teaching scenario" (Belpaeme et al., 2018) with real classroom learning dynamics (Rosanda & Istenic Starcic, 2019; 2020). Overall, there is a lack of well-defined curriculum and learning material for teachers (Mubin et al., 2013). More attention is devoted to affective outcomes and human-robot interaction (HRI) than to efficiency and effectiveness in the teaching and learning process (Belpaeme et al., 2018; Cheng et al., 2018; Rosanda & Istenic Starcic, 2019; 2020). But in research experiments, robots perform a variety of teacher roles and tasks. Among these, for instance, robots can function as teacher assistants and care-receiving robots, tutors, peers, and classroom management tools (Rosanda & Istenic Starcic, 2019; 2020).

The potential of robots concerning high-order thinking has not yet been explored sufficiently (Tuna, Tuna, Ahmetoglu, & Kuscu, 2019); for example responses that cannot be pre-determined (Newton & Newton, 2019b); facilitating creativity (Ivanov, 2016; Rainie & Anderson, 2017; Tuna et al., 2019); collaboration, abstract and systems thinking, complex communication, deliberation, conflict resolution, the ability to thrive in diverse environments (Rainie & Anderson, 2017); leadership, design, and human meta-communication (Rainie & Anderson, 2017) and indeterminate open-ended answers (Newton & Newton, 2019a). Open-ended answers seem impossible to handle by robots due to limitations in natural language understanding by computers.

This paper is not intended to assess the state-of-the-art of AI technology regarding its readiness for robot-based teaching in the classroom. It is nevertheless appropriate to mention some serious deficiencies of the current AI methods in this respect. One major problem is the inability to really understand natural language.

There has recently been considerable success in applying deep learning (LeCun, Bengio, Hinton 2015) to some natural language tasks. One relevant example is fast

progress in machine translation between natural languages. Another, more recent example is the development of the GPT-3 system by OpenAI (Brown et al., 2020). GPT-3 has learned to generate text that often looks like being very cleverly written by a human. Syntactically and stylistically, it is practically impossible to distinguish machine-written text from the perfect human-written text. Many example results by GPT-3 have produced an impression frequently reported in the media that GPT-3 is a significant step towards artificial general intelligence, that is towards a technology that is also required for really convincing robot-based education. However, the problem with GPT-3 is in the meaning of a generated text, which may or may not be true. It is very hard for the user of the system to ensure that the meaning of what is generated does make sense. The next generation is completely syntactic, without any consideration of the semantics. So, the meaning of the generated text is more or less random. One consequence of ignoring the semantics is that GPT-3 is not capable of reasoning (for example, inferring the logical consequences of a sequence of sentences). Therefore, this technological breakthrough does not seem to be very relevant to solving the fundamental problem of natural language understanding in robot-based teaching. But it might still be useful for improving the robot's social skill through clever, although essentially uninformative natural language interaction.

Another relevant problem of many machine learning methods, much discussed recently, is the inability to adequately explain their decisions (the problem of black boxes, Rudin 2019). Although the importance of transparency in machine learning has been known for a long time (Bratko, 1997; Michie, 1988), progress in this respect has been rather slow. This is particularly problematic in deep learning, which is otherwise achieving generally best learning results and therefore attracting the most attention.

Current thinking of social robot-based education as teacher-centered and a need for student-centeredness

Studies discussing the testing of social robots in a classroom are mostly conducted in the context of a teacher and ask how a robot would perform teaching roles and communicate with students. The teacher's role in social robot-based education is examined by two main groups:

a) The first group comprises advocates of introducing intensive robot integration and highlighting its advantages, in the belief that social robots will, in the long term, replace teachers to some extent (Ivanov, 2016). Edwards and Cheok (2018) anticipate a teacher shortage in the near future that would create a need for independent robot teachers in some fields of education capable of performing some teacher roles, such as classroom management, delivering subject knowledge, lesson planning, and summative assessments.

b) The second group consists of proponents of the belief that social robots cannot pedagogically replace the teacher at an acceptable level. They argue that human uniqueness and human-to-human interaction in the educational process are of irreplaceable value for child development (Newton & Newton, 2019a; Newton & Newton, 2019b; Sharkey, 2016; Singh, 2018). The group allows for the possibility of a future division of tasks between teacher and robot with the consequent reorganization of teacher roles and functions in classrooms (Edwards, Edwards, Spencer, & Lin, 2018; Mubin et al., 2013; Newton & Newton, 2019a; Sumakul, 2019). They anticipate that, in the event of a division of tasks with a robot, a teacher will be dominant in some phases of the pedagogical process but be a controller in others. In such a role, the teacher would control social robotic educational technology via the design and selection of machine-led instruction while monitoring student progress and robotic support to students (Edwards et al., 2018).

The robotic educational technology in the early-years classroom needs to be considered from a student-centered framework and to address the robot-child interaction.

Research suggests that a robot's social capabilities can affect children's behavior in the following ways: children interact with robots similar to the way they interact with people, attributing a human form, characteristics, or behavior to non-human things and perceiving a robot being "human" when they compare it to a machine (Van Straten, Peter, & Kühne, 2019). In interaction, children attribute to a robot mental states similar to human states (Di Dio, Manzi, Peretti, Cangelosi, Harris, Massaro, & Marchetti, 2020b) ascribing psychological and perceptual properties and social cues establishing trust relationships (Di Dio, Manzi, Peretti, Cangelosi, Harris, Massaro, & Marchetti, 2020a). In a robot design, a teacher should be a partner in designing robots that interact with children (Ahmad, Mubin, & Orlando, 2016) and be responsible for making decisions about how to fit robots in the learning process and effectively manage them. AI-enabled robots looking and acting as apparently alive human beings raise concerns. The focus of the next section, is the concerns model we propose for our study and support it with discussions of findings from related studies.

Designing Concerns model for humanoid social robot integration in a classroom

As the concrete possibility of introducing social robots with pedagogical roles in classrooms approaches, it becomes important to know not only the benefits but also the concerns raised by such integration *(*Sharkey*,* 2016*;* Serholt et al., 2017*;* Smakman & Konijn, 2020).

Sharkey (2016) identified the following main ethical concerns associated with robot teachers: privacy; attachment, deception, loss of human contact, and control and accountability. She discussed these concerns in terms of four identified scenarios (robot as a classroom teacher, robot as companion and peer, robot as a care-eliciting companion, and telepresence robot teacher).

In the review study, Smakman and Konijn (2020) identified how robot tutors in education impact (both positively and negatively) multiple values of children and teachers. Based on the review they raised concerns related to friendship and attachment, human contact, deception and trust, privacy, security, safety, and accountability. It is noted that robots can negatively impact positive values related to robot tutors, namely psychological welfare and happiness, efficiency, freedom from bias, and usability.

Serholt et al. (2017) explored teachers' deliberations regarding various aspects of social robot integration in classrooms. They list a set of issues such as integration impact on children regarding issues like type of data to be stored, data access and usage, robots' intimate privacy invasion, responsibility for the damage caused by robots, emotions and emotional intelligence, empathy, "robotisation" of children, children pseudo-relationship formed with the robot, attachment bonds between children and robot and dehumanization. Such concerns, analyzed by Serholt et al. (2017) are relevant for our concerns model.

From the review of related literature, we identified that researchers mostly refer to concerns that can be connected with legal aspects, however, the legal aspect as an umbrella term is not mentioned explicitly. Researchers also referred to concerns in social and affective aspects and the least represented were concerns in instructional aspects. For social robot integration in the classroom, we designed a model of concerns drawn from a conceptual paper by Sharkey (2016) and a review paper by Smakman and Konijn (2020). We propose a model of concerns that arise from three main aspects: instructional, social and affective, and legal (Figure 1).

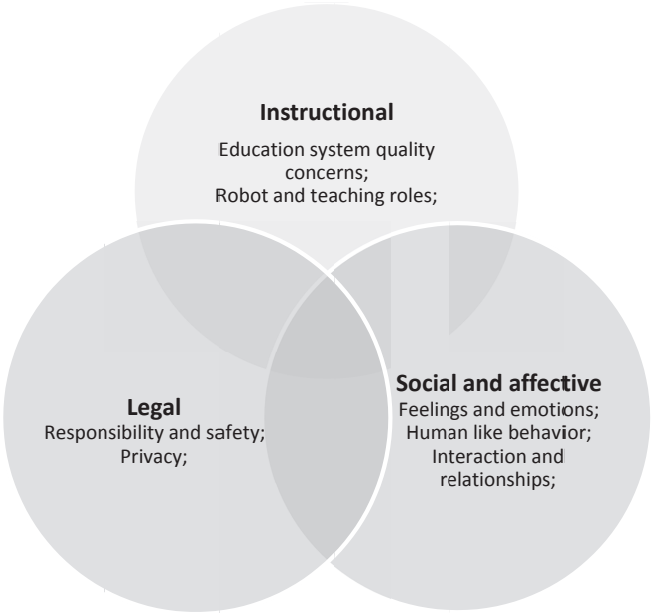

Figure 1. A concerns model for social robot integration in the classroom.

Instructional aspects

Studies have predicted that the introduction of social robots into education will affect the instructional setting and the teacher roles and functions (Edwards et al., 2018; Ivanov, 2016; Newton & Newton, 2019a; Sharkey, 2016; Smakman & Konijn, 2020; Sumakul, 2019; Istenic Starcic, 2019). We summarize the instructional aspects within the two main issues: (i) education system quality concerns and (ii) robot and teaching roles.

(i) Education system quality concerns

The focus of research is the quality of education and how new technologies affect the quality of teaching and learning. Concerns may be summarized under three main areas.

a) *Trivialization of the education system*: The introduction of social robots in classrooms without an appropriate pedagogical framework can lead to excitement due to an interesting technological innovation without learning gains (Sharkey, 2016). Students might get used to leaving their thinking to AI (Newton & Newton, 2019a). Uncritical integration of social robots might lead to an education system relying on pre-recorded courses performed by robots (Tuna et al., 2019).

b) *The efficiency of the learning process*: Breakdowns in child-robot interaction (CRI) (Serholt, 2018) and a robot's inability to respond appropriately to social context may cause a decline in efficiency in the learning process (Smakman & Konijn, 2020). Robots can also be a source of distraction in the classroom (Kennedy, Lemaignan, & Belpaeme, 2016).

c) *Student engagement and motivation*: After students' initial enthusiasm, they may lose interest in the robot (Serholt et al., 2014) and consequently in learning.

(ii) Robot and teaching roles

Researchers discussed sharing the teaching role in the classroom. Some authors predicted that the integration of social robots in classrooms will influence the teachers'

role and functions in the classroom (Edwards et al., 2018; Ivanov, 2016; Sumakul, 2019). Issues of teachers' roles can be summarized in four areas.

a) *Teacher replacement*: When using social robots for pedagogical functions, teachers fear being replaced by robots (Serholt et al., 2014; Serholt et al., 2017; Smakman & Konijn, 2020).

b) *Division of tasks between teacher and robot*: The basic question is whether, in robot-based education, the tasks between robot and teacher will be divided according to the criterion of what a robot can do, or according to the criterion of what is more appropriate for a teacher to perform (Sharkey, 2016; Sumakul, 2019).

c) *Robots allowed to function as classroom teachers*: Research questions the ability of the robot to handle the variety of situations a teacher faces daily and which cannot be fully foreseen and properly programmed in advance (Alves-Oliveira, Sequeira, & Paiva, 2016).

d) Credibility: Concerns may exist regarding the possibility that children and parents consider a robot more credible in a situation when a robot and a teacher do not agree. (Sharkey, 2016). Giger et al. (2019), among other negative aspects of humanizing social robots, mentioned over-trust, unrealistic perceptions of a robots' autonomy and capabilities of mimicking human appearance and behavior, including cognitive and emotional states. A teacher can fascinate and inspire students, robots not so much (Newton & Newton, 2019a, Singh, 2018).

Social and affective bonds with robots

In CRI, there is a problematic transition from the phase in which a robot is a short-lived novelty, to the phase of permanent CRI (Kanda et al., 2007; Van der Berghe et al., 2018). Important factors in long-term CRI are a robot's appearance, behaviors, affect, memory, and adaptation (Van der Berghe et al., 2018); social skills, socially interactive behavior, and human-like rather than machine-like interaction (Van Straten et al., 2019); establishing a relationship with the child and the child's sense of being important to the robot (Van der Berghe et al., 2018).

Social robots cannot form genuine attachment contacts. However, they are designed to stimulate the formation of social bonds with humans (Serholt et al., 2017; Sharkey, 2016), which may have negative effects on humans' concept of friendship and attachment (Smakman & Konijn, 2020). Drawing from related studies, we summarized the concerns raised within three issues: (i) feelings and emotions, (ii) human-like behavior, (iii) interaction and relationships.

(i) Feelings and emotions

As Newton & Newton (2019a) stated, teaching is a kind of emotional engagement with effects on students' cognitive, personal, and emotional growth, providing the feeling of closeness and trust (Van Straten et al., 2019). Concerns within this category include five areas.

a) *Reciprocity*: Robots do not have real emotions, true intellectual abilities, or the capacity to have real bidirectional emotion exchanges and empathy (Serholt et al., 2017; Tanaka & Kimura, 2009; Sharkey, 2016); however, a robot can stimulate child's emotions, empathy, and attachment to the robot, or create reciprocity expectations in users that a robot cannot meet (Hrastinski, et al., 2019; Sharkey, 2016). The robot can understand the student to a certain extent, but the student cannot sufficiently understand what the robot is (Serholt et al., 2017) and how the robot interacts.

b) *Intimidation*: Children might get intimidated by the robotic expression of emotions (Ahmad, Mubin, & Orlando, 2016), appearance, or movements (Smakman & Konijn, 2020).

c) *Emotional intelligence*: A robot's lack of emotional intelligence could result in not only a child lacking appropriate emotional development and emotional intelligence (Serholt et al., 2017) but also the robot being unable to adapt the teaching to the student's needs (Ivanov, 2016).

d) *Sense of psychological imprisonment*: A robot can permanently note children's behaviors, feelings and relationships, which can cause children to feel a sense of psychological imprisonment with the consequence of having their feelings regulated within this situation (Serholt et al., 2017).

e) *Trust*: Children's trust in their educators might be impacted if CRI is not aligned with curricular activities (Tolksdorf, Siebert, Zorn, Horwath, & Rohlfing, 2020).

(ii) Human-like behavior

The presence of robots causes changes in human behavior and interaction (Salah, Ruiz-del-Solar, Mericli, & Oudeyer, 2012). Concerns in this category consist of:

a) *Behavior understanding*: Children expect human-like behavior from an anthropomorphic robot (Tolksdorf et al., 2020), but robots lack an understanding of child behavior (Sharkey, 2016).

b) *Robot embedded in a social context*: Robot cannot respond appropriately to social contexts (Smakman & Konijn, 2020).

c) *Robotization of humans*: Children might imitate robotic behaviors (Serholt et al., 2017), social skills, interaction styles, and speech (see 1.5 Social and affective bonds with robots) and become "mechanical".

d) *Abusive behaviors*: Children sometimes engage in abusive behaviors toward robots (Sharkey, 2016). This pattern might be transferred to human-human relationships (Serholt et al., 2017).

(iii) Interaction and Relationships

The intensive integration of robots in classrooms with, or instead of teachers (i.e., "r-learning"; Han & Kim, 2009) affects human interaction possibilities and capacities, and may cause a reduction, loss, and changes in human contact and relationships Concerns in this category cover:

a) *Relationships understanding and attachment*: The pseudo-relationship formed with the robot could affect the child's understanding of how relationships work (Serholt et al., 2017; Sharkey, 2016). The understanding of empathy that a robot cannot provide reciprocity could be misunderstood (Sharkey, 2016). A robot cannot properly care for children, ensure their safety, or exert authority (Sharkey, 2016) and empathy (Hrastinski et al., 2019; Serholt et al., 2014; Serholt et al., 2017; Sharkey, 2016) like a teacher. According to Sharkey (2016), the central question remains whether social robots can be a suitable attachment figure for children which is deceiving from several aspects, providing the illusion of being responsive, sentient beings capable of understanding, forming intimate social bonds and offering emotional support.

b) *A child's conception of a living being*: Children tend to attribute living characteristics and intentional action to non-living objects (animism and intentionality) (Piaget & Inhelder, 1969).

c) *Robots replacing human-human interaction*: Humans might prefer the interaction with the robot (Serholt et al., 2014; Serholt et al., 2017; Sharkey, 2016) to interaction with humans. This may cause several risks: child isolation (Kennedy, Lemaignan, & Belpaeme, 2016), a child failing to develop human interaction sensitivities and social skills (Newton & Newton, 2019a), and the degradation of human-human interaction (Kennedy, Lemaignan, & Belpaeme, 2016; Newton & Newton, 2019a). Intensive CRI might cause a

reduction of human-to-human contact (Smakman & Konijn, 2020) and dehumanization (Serholt et al., 2017).

d) *Robots restricted social skills and interaction styles*: Upon realizing that robot has restricted social skills, users may feel deceived (Sharkey, 2016; Smakman & Konijn, 2020; Tolksdorf et al., 2020). In children, such feelings could lead to frustration and mistrust (Sharkey, 2016). Students may adopt robot-like simplistic interaction styles (Kennedy, Lemaignan, & Belpaeme, 2016; Newton & Newton, 2019a), speech (Newton & Newton, 2019a), and mannerisms (Serholt et al., 2017). Communication might become impoverished (Hrastinski et al., 2019).

e) *Impaired relationships*: In CRI, a robot might display a dominant role (Ahmad, Mubin, & Orlando, 2016) or a servant relationship with the child (Serholt et al., 2017; Sharkey, 2016), which could influence children's behavior and understanding of human relationships (Serholt et al., 2017). CRI often under-considers children's communicative behavior (Tolksdorf et al., 2020).

Legal aspects

Legal aspects largely relate to the robot's ability to detect, categorize, and record information, which raises legal concerns (Serholt et al., 2017; Sharkey, 2016; Smakman & Konijn, 2020). We summarized these concerns in the framework as two issues: (i) responsibility and safety and (ii) privacy.

(i) Responsibility and safety

Some studies discussed the application of robotic technology in the roles of teacher assistant or teacher and raised concerns regarding robots' decision-making, for which robots do not have the capacity for the necessary moral and situational understanding. Among the main limitations are robot's failure to meet requirements in terms of common sense, contextualization within the larger picture and capacity to grasp a person's intentions, values and anticipations (Heyns, 2013). We summarized these concerns in the framework as four issues.

a) *Decision-making and moral and situational judgement* is significant for pedagogical decision-making. Teachers make decisions about social classroom management regarding children's behavior, when/how to teach specific learning content and how/when to adjust lesson delivery and adapt the curriculum according to students' progress (Sharkey, 2016). Researchers raised the question of whether robots can be equipped with appropriate pre-programmed rules to decide on the many and unpredictable situations that arise in classrooms (Sharkey, 2016). Because robots' intelligence is loaded into their operating systems (Newton & Newton, 2019a), concerns exist regarding who will set or choose these rules, and whether it will be clear to all students that a robot's decisions are not the result of human-equivalent decision-making (Sharkey, 2016). Further concerns include the question of whether the robot will be placed in a situation where it is expected to decide what humans should do (Sharkey, 2016).

b) *Duty of care* poses a similar problem since a robot cannot properly understand all personal and contextual dimensions perform the duty of care for children, ensure their safety, or exert authority (Sharkey, 2016).

c) *Responsibility for harm*: Someone in robot-based classrooms will have to ensure the safety of students, the robot, and teachers (Serholt et al., 2017; Sharkey, 2016; Tolksdorf et al., 2020). Questions are raised about responsibility for possible physical and emotional damage (Serholt et al., 2017) caused by robots and their use in harmful ways to children and their learning (Hrastinski et al., 2019).

d) *Exclusion and discrimination*: A robot's technological biases (Sharkey, 2016; Smakman & Konijn, 2020) might lead to new forms of student discrimination. For example, robotic speech recognition systems do not allow for appropriate interaction with students with strong regional accents, students who speak dialect languages (Sharkey, 2016). A robot cannot respond in terms of inclusion of children with disabilities and special learning needs (i.e., children with phonological and phonetic disorders (Tolksdorf et al., 2020)).

(ii) Privacy

A robot's infallible memory exceeds the memory of a teacher. The robot can note, store, and recall all (Newton & Newton, 2019b). We summarized privacy concerns in four issues.

a) *Concerns regarding types of data* that are allowed to be stored (Serholt et al., 2017; Sharkey, 2016) and the purpose of collecting and storing data. A robot has the capabilities to recognize individuals, and to categorize, monitor, and store their behavior and emotional states (Sharkey, 2016). These data much more thoroughly define the intimate essence of the observed than the data collected in education by previous types of technology. Robots store data continuously and can do so undetected. In this way, a robot continuously invades the private sphere of all those present in the classroom and occasionally also the intimate sphere of students' families (Sharkey, 2016; Smakman & Konijn, 2020; Tolksdorf et al., 2020). A robot's intimate privacy invasion exceeds the ability and capacity of a teacher and may cause the effect of psychological imprisonment (Serholt et al., 2017).

b) *Data access concerns* address who is permitted to access the stored information (Sharkey, 2016), especially in terms of access by unauthorized persons and/or institutions (Serholt et al., 2017; Sharkey, 2016; Smakman & Konijn, 2020), and the purpose of the data storage, access, and use. Data could be used, for example, as an indication of a student's interests, as a basis for educational decisions about students (Sharkey, 2016), for governmental surveillance of citizens (Serholt et al., 2017), or socially labelling mistakes students made during schooling (Serholt et al., 2017).

c) *Duration of data storage* concerns refer to questions about whether the personal info about a student will be deleted at the end of the schooling (Sharkey, 2016).

d) A special problem is *consent given for the CRI* by parents on behalf of underage children. Underage children cannot decide independently on the interaction with the robot, or its course, duration, or possible termination (Tolksdorf et al., 2020), or anything regarding storing the collected data (Serholt et al., 2017; Tolksdorf et al., 2020). Because not all parents agree with CRI occurring, CRI can lead to class community division and new forms of discrimination (Tolksdorf et al., 2020), impacting the educational process and students' development.

Objectives

The objectives of our study are as follows: We examine pre-service teachers' concerns expressed in their reflections and the underpinning beliefs about social robotic educational technology. By capturing pre-service teachers' reflections about social robots being integrated into classrooms, we explore the following research question: What are pre-primary school and primary classroom pre-service teachers' concerns regarding the integration of social robots in preschool and classroom instruction and what are beliefs that underpin them?

Method

Research design, participants, and procedure

This qualitative study supports quantitative Unified Theory of Acceptance and Use of Technology (UTAUT) study among pre-service teachers in pre-primary school teaching and primary classroom teaching in Slovenia in 2019. The convenience sample of students at the University of Primorska (one of three Slovene universities educating teachers) represents about one-third of the pre-service teacher generation enrolled in the first year in 2019/20. Before the study, participants were informed about the study, their free choice to take part in the study and that participation in the study did not affect course grades in any way. They were offered a written consent explaining confidentiality, data protection and explicit information regarding a study and reporting of study findings. Participants were 121 pre-service teachers in pre-primary school teaching and primary classroom teaching. Females represented 90.1% of the sample. The age mean was 19.47 (SD = 1.45).

In this paper, we examine students' reflections. During the first round of reflections analyses, the predominant topic was identified. Students were asked to reflect their perception on social robotic educational technology in which they would highlight the positive, neutral and negative aspects at their own discretion. The students' reflections predominantly expressed concerns. They were contemplating their concerns about social robotic educational technology and regarded three aspects, the instructional, social-emotional, and legal concerns related to the integration of humanoid social robots in the classroom. This qualitative study further explores the results of a quantitative study of data based on the unified theory of acceptance and use of technology (Istenic, Bratko, Rosanda, 2021), which identified students' negative attitudes and non-acceptance.

We used videos to present social robots in pre-primary school and primary classroom lessons. Belpaeme (2020) discusses the benefits of an on-screen presentation of a robot in research studies comparing it to a situation with a real robot. Studies about teachers' attitudes, opinions, views on the topic established that video intervention presenting social robots on the screen is appropriate (Ahmed, Mubin, & Orlando, 2016; Serholt et al., 2017; Van Ewijk, Smakman, & Konijn, 2020). Three videos were shown:

- a five minutes video (https://www.youtube.com/watch?v=NLaDE4OsjQI) Robots For Early Childhood Education, followed by
- a fifty-second video (https://www.youtube.com/watch?v=qGR4G91y5dQ) The iPal Robot goes to Kindergarten and
- a five–minutes video (https://www.youtube.com/watch?v=vlmjvKgWtmU) Social robot helps to teach toddlers a second language.

After viewing the videos, students filled out the questionnaire for attitudes assessment and wrote their reflections. The topic of reflections was: *How do you perceive the social robot educational technology and anticipate its application in the classroom? Please reason and comprehensively discuss your perceptions of demonstrated applications.* The topic of the reflections was intended for their in-depth and broad reflection in which students would, at their own discretion, highlight the positive, negative and neutral aspects of social robots in the classroom. By doing so, we avoided the conditioning or guidance that would result in priming.

Data analysis

Students were encouraged to reflect the positive, neutral and negative aspects. In the preliminary analysis of participants' reflections, we found that all participants shared concerns as the main topic of their reflections.

Therefore, the analysis was conducted based on the concerns model (Figure 1). In further stages of the analysis, we classified the reflections into the three types of our

concerns model: (a) legal aspects (i.e., privacy; responsibility and safety); (b) social and affective bonds with robots (i.e., feelings and emotions; human behavior, interaction, and relationships; human contact, attachment, deception); and (c) instructional aspects (e.g., education system quality concerns; robot and teaching roles).

The qualitative data obtained from written reflections were coded and categorized into two steps. We analyzed and grouped similar statements, before giving these groups of statements assigned codes (Appendix Tables 1-8). Cross-checks and peer debriefing were performed during the processes of planning, data gathering, and analyzing. Therefore, we ensured validity and reliability. The coding process involved discussion and cross-checking by two researchers. We conducted several rounds of coding and categorizing the data involving cross-checking. The data is presented within codes and categories. In the results section, we have summarized the data within categories and illustrated important aspects with quotations. Given that some statements could be classified into several groups as they overlap between them (see Figure 1). When compiling the concerns model, we decided to deal with each issue in a single group and subgroup while also referring to the implications for topics in other groups and subgroups. In the results section, we report on the data within categories. Fragmentation by subcategory would preclude a meaningful and coherent review of the results. Their comprehensive explanation is possible only by interpreting the entire content of the statements.

Findings

The results are presented in a narrative form following the categories of our concerns model. We examine topics that were raised by our participants. Participants' deliberations are presented in italics and marked in parenthesis with the letter P ("participant") followed by the participant's unique number. All participants were assigned numbers to guarantee their anonymity.

Instructional aspects

Education system quality concerns

Some pre-service teachers predicted that children would perceive the robot more like a toy rather than in a pedagogical role:

> "*Children could misunderstand a robot, not as a person, but as a toy, and therefore not take it seriously*." (P16)

Some participants predicted also that children would get tired of the robot's long presence in the classroom.

[Robots would be]… *"very popular and effective at learning in the beginning, but eventually, like any new thing, they would become part of everyday life and no longer be interesting."* (P63*)*

After the initial excitement, the robot could represent a source of distraction:

> *"I also know from experience that a robot in kindergarten will be interesting in the beginning, but they will not listen to it for a long time. The children will be more interested in its structure and everything else, rather than sitting and listening to what it is saying."* (P23)

One participant in contrast to the majority of students' deliberations indicating robots losing attractively in a while, envisages the possibility that children would start to get bored when taught by a teacher using teaching methods different to those of robots':

[The robot]… *"should not overshadow the teacher, in the sense that children would want to learn something new just by using a robot."* (P47)

Some participants anticipate that interacting with the robot might be uncomfortable and intimidating for some children:

"… Children will be surprised, some scared." (P13, P27, P34, P48, P51)

CRI could affect children's behavior:

"Children need human learning because if they listen to robots, they would become like robots." (P34)

A comprehensive interpretation of all the statements shows pre-service teachers' belief that robot-based education would fail to maintain the current quality of the education system.

"… By using robots in school, we raise children into narrow-minded robots, which means setbacks because the robot is not able to understand the child." (P57, P34)

"Genuine human contact is more important and teaches and educates children more than a robot could perform." (P20)

Robot and teaching roles

The majority of participants touched on the issue of social robots being allowed to function as classroom teachers. Their reasoning was mainly within the teacher-centered mindset, they were reasoning about a robot taking teaching roles.

"[Robots]…should not replace the teacher's work and interaction with children..."(P21)

"Genuine human contact is more important and teaches and educates children more than a robot could perform." (P20)

"[Robots]… cannot offer what the teacher's word offers…" (P65)

"[Robots]… cannot replace a teacher's genuine contact with children. A child needs a person who will actually understand, help and encourage him/her." (P15)

All were of the attitude that this would not be appropriate or should not be allowed, which they justified by the reasons given in the results under the item for social and affective bonds with robots, and via the justification that, from an early age, today's children live in a technologically saturated world.

"Children spend too much time with electronic devices, so it is necessary to encourage other activities, such as spending time in nature. Contact with others (teacher) is also important for the child's development." (P30)

Some participants pointed out that this reality is already affecting the impoverishment of human-to-human interaction in the family environment. Only a handful mentioned a concern about their jobs. However, they expressed awareness that their profession and professional role could change:

"Robots inhibit the innovation and creativity of teachers, the role of the teacher as a person raising children is diminishing." (P13)

In particular, participants highlighted that the teacher is required to do much more than just imparting knowledge. They believe that social robot-based education at these stages would not primarily ensure adequate emotive growth of children or socialization into human society with human interaction and behavior.

For some participants, social robot integration remains, in its essence, contrary to professional ethics:

"… I want to become a teacher so that I will teach the children, not that the robot will do it for me." (P23)

Social and affective aspects

Our pre-service teachers' concerns about humanoid social robot integration in classrooms focus largely on issues from this category. Directly or indirectly, the participants perceive, in a problematic way, all subgroups' issues.

Participants did not perceive the robot's operation in the classroom only from the perspective of transferring learning contents, which was the least interesting for them. The fact that they recognize social robots as a useful tool in the classroom showed that they viewed robots holistically. However, they paid special attention to the aspects that, in their attitude, are the most important in education, that is children harmonious cognitive, personal and emotional development and well-being. It is clear from some of the statements that they are familiar with these aspects of pre-service education for their future profession.

Emotions, empathy, interaction, attachment, and human contact

Participants stressed that the robot has no emotions of its own and cannot properly address children's emotions. They doubt that emotions can be learned through a robot. Therefore, according to participants', the possible emotional attachment of the child to the robot is worrying:

> *"… Because the robot is similar to a human, it can trigger an 'unhealthy' attachment to it (it becomes a child's imaginary friend)."* (P51)
>
> *"Children could become emotionally attached to robots after a while, which could become a problem."* (P51, P32)

This would have harmed the child's development, socialization, and interpersonal relationships.

> *"Using a robot would contribute to poorer socialization, as people would get used to communicating with an inanimate being and lose touch with reality."* (P14)

Some answers were particularly emotive:

> *"… It used to be weird if a person was attached to something/object excessively ... But now we encourage kids to talk to robots. I find that sad."* (P42)

Robots also do not enable the proper upbringing and socialization of children in human society, which a credible teacher does while serving as a child's role model.

> *" Since a child finds a person in his life as a role model, it would be wrong to attach to a robot similarly. "* (P30)
>
> *"We live in a society where we interact, communicate with others and create social bond[s] and relationships. Computers and phones will not help a child understand what it means to live, adapt, and change or shape society."* (P71)

Some also suggest that intense contact with robots in children could lead to identity confusion:

> *"Young children might not be able to understand that a robot is not a real person."* (P51)
>
> *"… They may start to think that a robot is equal to a human."* (P49)

Participants believe that successful socialization requires intensive contact and relationships with people:

> "*… Children in early childhood need a lot of contact with people to socialize and to be brought up by them.*" (P51, P57) and *also to "learn compassion, empathy and communication with a person in general."* (P10, P56)
>
> *"… Human communication and the teacher-child relationship are important in establishing relationships with other people and for the socialization of children."* (P63)

They also emphasized that genuine and not pre-programmed human emotions, facial expressions, non-verbal communication play an important role in the school environment, and therefore human contact and communication are irreplaceable.

> "*The teacher understands the child's feelings and can comfort him/her."* (P42)

While:

"*A robot cannot establish human contacts and emotions"* (P69)

True, the robot cannot feel, properly perceive a child's emotions, feel empathy, and/or form genuine human relationships prevents them from functioning in pedagogical classroom roles. But they could be programmed to stimulate feelings. Also, they can learn to correctly perceive a child's emotions. So, it could be argued differently: namely that the robots may function in pedagogical classroom roles. Our participants expressed regarding this: *"I don't see a robot in an independent role (e.g., a teacher) because the robot has no empathy for people."* (P6)

> *"… Children should be taught by parents and teachers. By doing so, they form relationships. Parents should spend more time with their children rather than giving the child a robot and let them learn on their own. A robot cannot replace a human."* (P38)

The participating students hold the belief that a robot cannot replace a human being in any way.

> "*A robot cannot process a child's emotional needs the way as a human being."* (P9)
>
> *"… I don't feel good if a robot replaces a human. Technology is already almost too much present in our daily lives today."* (P28)

They also highlight the addiction problem and the weakening of human-human relationships:

> *"… Among children, there is a frequent addiction to digital gadgets, … which are mostly individual games, and when playing them, children sit. It is important to play with peers as much as possible and be physically active."* (P69)
>
> *"If children were to spend too much time with robots, they could take those children away from the realm of human relationships, because as they grow up, they'd be constantly looking for some contact with technology and maybe putting it ahead of interpersonal relationships."* (P32)

When they are thinking of a robot and human capability are arguing for a robot not to be compared to a human and not to be in a position to replace a teacher.

> *"Perhaps children would be more motivated to learn with robots because they are interesting, but it is still better if children are taught by teachers and parents and robots are used for play in which children learn."* (P38)
>
> *"The teacher is required to do much more than just impart knowledge. The emotional connection with the child is very important."* (P16)

And as P51 stated, a robot is completely unsuitable for

> *"… raising, comforting, caring for a child, learning culture, behavior, life and emotions."*

Some participants share P40's view:

> *"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."*

They are also convinced that the robot is not suitable for class management:

> *"Wouldn't one rather invest money in hiring one teacher instead of a robot? A teacher, compared to a robot, could act quickly on a problem, a fight between children, and above all, a teacher would understand the child's feelings and therefore be able to comfort him. The robot doesn't know that. "* (P42)

"Genuine human, contact is more important and teaches and educates children more than a robot could perform." (P20)

One participant also wondered why robots have a human appearance at all:

> *"I don't see the need to be shaped like a human being."* (P19)

Nobody mentioned explicitly deception.

Legal aspects

Participants did not focus explicitly on the legal aspects and legislation. Implicitly students' concerns regarding robots' decision-making and moral and situational concerns, the duty of care, responsibility for harm and exclusion and discrimination is expressed through underlining student-centered beliefs.

> *"… how robots could resolve disputes between children, judge in contentious situations, and understand children's intentions."* (P39)

Students did not refer to data management (privacy, liability and data collection). This may be explained in that data management is more of a concern to teachers who are already in the service facing data management daily. Pre-service teachers, however, do not yet face this problem and devoted less thought to it. To maintain a comprehensive concerns model, we have kept the legal aspect in the model even though our students did not focus on these concerns.

Discussion

The findings showed a clear rejection of social robot integration in classrooms by pre-service teachers. In the view of the results of our study, the statement by Serholt et al. (2017) about social robots' affordance (e.g., being designed for bonding with humans) does not seem realistic. The analysis revealed that their rejection stems from their predominantly student-centered beliefs. They hold strong beliefs of students' well-being, personal, emotional and cognitive development which may be jeopardized by social robot integration. Participants do not address the practical aspects and did not anticipated technological developments. The analysis shows their attitudes with affective component eliciting feelings of unease towards social robots and rejection of social robots at the present state of development or in the future, which may bring more advanced social robots. Participants' critical reflections identified their desirable future (Jasanoff, 2015; Williamson, 2016) and "fears of harms that might be incurred" (Jasanoff, 2015, p. 6) by social robot integration. In discussions on the future of education, teachers produce and promote their imaginaries, "including their potential meaning, affordances and constraints in various educational settings" (Hrastinski et al., 2019, p. 429). The reflection process is important as "human actions are based on anticipated futures…," which humans can imagine based on their current knowledge and what they strive to achieve (Tuomi, 2018, p. 5).

In line with the concerns model, participants discuss the instructional, social-emotional and legal aspects. We identified four main points that participants expressed which we discuss in light of related literature:

1. They perceive the humanoid social robot as an unknown inanimate machine, without feelings, emotions, and thoughts (Newton & Newton, 2019a), merely as a further stage in the development of technology. They do not assign to a robot status of quasi-human (Suchman, 2011). Participants' reflections clearly expressed their belief in human nature uniqueness (Giger et al., 2019; Piçarra, 2014), which they capture based on the uniqueness of human emotions, bonds, and relationships. Consistent with the findings of Giger, Moura, Almeida, & Piçarra (2017) and Giger, Piçarra, Alves-Oliveira, Oliveira, & Arriaga, (2019), our participants' strong belief in the uniqueness of human nature leads to less positive attitudes toward humanoid social robots, to be placed in the context of working with students and the classroom environment. Our pre-service teachers felt uncomfortable, especially with the idea of children having social interactions with robots who presented themselves as humanly socially competent; however, a robotic image of the human appearance bothers them less. They also expressed feeling uncomfortable with the idea of a humanoid social robot as their professional collaborator/partner. The

possible benefits of having a robot in education, in the participants' view, do not outweigh a robot's disruptive social effects. Robots with pedagogical roles were rejected as a concept because of unsatisfactory social skills, for which they may be assigned they cannot replace human contact.

2. They believe that exclusively humans should provide children's education and, consistent with Serholt et al., (2017) they hold a belief that children need teachers for their socio-emotional development. While Kennedy, Baxter, Senft, and Belpaeme's (2016) findings show that human social cues may be responsible for some of the learning differences that resulted from the comparison of robots and humans in terms of children learning outcomes, our participants express an attitude about the essential importance of human social cues in achieving learning outcomes. Consistent with Tanaka & Kimura, (2009), participants highlighted the unknown impact of CRI upon children's personal development. Aligning with Edwards et al. (2018, p 2), participants expressed doubts regarding the possibility of "for humans and machines to communicate with (and thereby educate) one another." They perceive the use of autonomous humanoid social robots in children education as threats to human identity (Złotowski, Yogeeswaran, & Bartneck, 2017) or human nature uniqueness, values, and distinctiveness (Giger et al., 2019; Złotowski et al., 2017), focusing mainly on the importance of human emotions, bonds, and relationships for children. For some participants, social robot integration remains, in its essence, contrary to professional ethics.

3. They see the robots more as socially incompetent competitors than allies do.

4. Social robots which are designed to support education through social interactions and "deliver the learning experience through social interaction with learners" (Belpaeme et al., 2018, p.1), are seen by our participants as a predominantly socially disruptive technology that could jeopardize the entire current course of upbringing and education.

In a review about the AI in education, Zhai et al. (2021) identified that the ethics of AI are relevant in education. However, our participants' concerns focused more on social skills and related ethical concerns and not so much on practical solutions. This is consistent with teachers' views in the study by Kennedy, Lemaignan, and Belpaeme (2016).

Our participants demonstrate a student-centered belief. They argue that a robot cannot properly teach a child and therefore should not be allowed to do so. Like the teachers in Serholt et al's (2017) study, our participants agreed with Sharkey's conceptual study (2016) arguing for robot deceptively acting as an attachment figure while only the teacher can act as an attachment figure providing empathy and role modelling. Our participants were aligned with Sharkey's (2016) argument for children need to be taught by a teacher who understands them, cares for them, and is a role model and attachment figures. They pointed out that, robots' performing human social skills and human-like interaction does not mean robots are able to build humanely equal social bonds too. Therefore, assigning a teacher's roles to a robot can harm children's personal, emotional and cognitive growth.

Besides, participants emphasized the importance of genuine human emotions, empathy, and human relationships, which are also recognized by social robot designers and researchers who study teachers' perceptions of robots (Ahmad, Mubin, & Orlando, 2016) intending to introduce those aspects to educational robots. That approach is very complex since the whole range of feelings and emotions, with all its nuances, plays an important role in the classrooms. Consistent with findings among teachers in Ahmad, Mubin, and Orlando's (2016) study and Tanaka & Kimura's (2009) paper, our participants

focused on the lack of true reciprocity of feelings, empathy, and attachment between children and a robot teacher.

Consistent with findings among teachers by Serholt et al., (2017), our participants considered teacher's human contact in education as irreplaceable and something that cannot be compared with robotic interaction with a child. Participants believe that a child needs a teacher's understanding, encouragement, support, and leadership.

Participants ultimately believe that robot-based education lacks the emotional side and upbringing styles used by teachers in traditional didactics. Consistent with Kennedy, Lemaignan, and Belpaeme (2016), participants highlighted that the robot might be a source of distraction in a classroom. Consistent with Ahmad, Mubin, and Orlando (2016) and Smakman and Konijn (2020), they stressed the possibility of children intimidation and loss of contact with reality. Consistent with Kanda et al., (2007), Sharkey (2016), and Tanaka & Kimura (2009), our participants envision the undesirable possibility of emotional attachment between human and robot, defined as a pseudo-relationship by Sharkey (2016).

Participants reasoned about children attachment to robot teacher consistent with Sharkey's (2016) within two possible scenarios; the first children lose emotional security when not developing attachment, and the second when perceiving a robot as an attachment figure interacting with a machine and basing their social skills and speech on the robot's appearance and speech.

They added that robots could create uncertainty about the roles assigned to some children, leading to the robotization of behavior, which might profoundly impact human interaction.

Pre-service teachers in our study touched an issue of teachers' replacement by a robot, also raised in Serholt et al. (2014; 207) sharing the attitude that robots should not function as classroom teachers. They perceived robots as a further stage in the development of technology. However, in their attitude the robot's affordance of social intelligence in performing teachers' roles is not desirable in a classroom. They would use social robots consistent with Tanaka & Kimura (2009) to assist and support the educational activities under the teacher's control, but only occasionally. Consistent with Serholt et al., (2017), they envision robots' role in supporting existing practice. Many would also use this technologically demanding technology to distribute material, wipe the blackboard, and clean the classroom. In other words, they see the robot as a potentially useful teacher's tool, but consistently with Sharkey (2016), they believe that robot interaction should not lead to a situation in which the children would want to learn something new just by using a robot and rejecting other ways of teaching. They agreed with teachers from the study by Ahmad, Mubin, and Orlando (2016) regarding the training need to equip teachers for robot integration

Limitations, practical implications and suggestions for further research

This study was limited to reflections of pre-service teachers from one faculty in one geographic region representing one-third of pre-service teachers of the Slovene generation enrolled in the first year in the academic year 2019/20. We followed the methodology of related studies and showed the participants videos with humanoid social robots on work in classrooms (Ahmed, Mubin, & Orlando, 2016; Serholt et al., 2017; Van Ewijk, Smakman, & Konijn, 2020).

This was an introductory phase which is to be followed by an empirical study, experimenting with a Nao robot in collaborative learning design with teacher practitioners and pre-service teachers.

Conclusions

A significant contribution of the article is in development of the concerns model, which comprehensively covers a wide range of issues. Instructional, socio-emotional, and legal aspects are especially important for education. Sharkey in her conceptual paper identified a range of problematic aspects, which we upgraded and supplemented into a model, supported by the literature.

A valuable contribution of the participants in this study is a reflection on the context of developmental psychological aspects. In this context, they allowed us to identify the basic reason for the non-acceptability of a robot with a pedagogical role in the classroom.

Our findings differ from related studies because they identified participants' negative attitudes and a clear rejection of robot technology with social intelligence in the classroom. Student-centered studies reported on single groups of concerns within specific contexts without developing a holistic view and relating diverse concerns in one picture. Findings in our study aim to provide a more comprehensive picture based on a threefold model distinguishing instructional, social-emotional, and legal concerns. Participants' reflections are focused on child wellbeing and development within student-centered beliefs. Participants are not rejecting social robots as such, but in their view, the robot should not be granted the status of a social entity capable of engaging in classroom teaching.

While others focus on robot affordance in addressing learning material and objectives more in terms of practical problems, our participants addressed the developmental aspects of the child, with the practical aspects of use being negligible. The study is important because it identifies the underlying reason for the possible non-acceptability of robots stemming from concerns about children's well-being and harmonious development.

The reflections of our pre-service teachers can be useful for education stakeholders, HRI researchers, and robot designers. It is not enough just to apply social robots' affordance in the classroom, innovation in instructional approaches for effects in the long run is also required.

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Appendix: Codes with example quotes for the concerns model

Table 1. Instructional aspects. Education system quality

Codes	*Example quotes*
Trivialization of the education system	[Robots]"… should not overshadow the teacher, in the sense that children would want to learn something new just by using a robot."
Delegation of thinking process	–
Pre-recorded courses	"Robots inhibit the innovation and creativity of teachers, the role of the teacher as a person raising children is diminishing."
The efficiency of the learning process	"I also know from experience that a robot in kindergarten will be interesting in the beginning, but they will not listen to it for a long time. The children will be more interested in its structure and everything else, rather than sitting and listening to what he is saying. "
Loss of interest	[Robots would be]… "very popular and effective at learning in the beginning, but eventually, like any new thing, they would become part of everyday life and no longer be interesting."

Table 2. Instructional aspects. A Robot and teaching roles

Codes	*Example quotes*
Teacher replacement	"[Robots]… should not replace the teacher's work and interaction with children ..."
Division of tasks between teacher and robot	" It is difficult to imagine that the robot and the teacher could teach and plan lessons together."
Robots allowed to function as classroom teachers	"[Robots]… cannot replace a teacher's genuine contact with children. A child needs a person who will actually understand, help and encourage him/her."
Trust	–
A teacher is able to fascinate and inspire students, robot not	"[Robots]… cannot offer what the teacher's word offers…"

Table 3. Social and affective bonds with robots. Feelings and emotions

Codes	*Example quotes*
Reciprocity	"Young children might not be able to understand that a robot is not a real person."
Intimidation	"… Children will be surprised, some scared."
Emotional intelligence	"… It is better for children to be taught by parents and teachers. By doing so, they form relationships. Parents should spend more time with their children than if they only gave the child a robot and let them learn on their own. A robot cannot replace a human."
Sense of psychological imprisonment	–
Trust	–

Table 4. Social and affective bonds with robots. Human behavior

Codes	*Example quotes*
Behavior understanding	"If children were to spend too much time with robots, they could take those children away from the realm of human relationships, because as they grow up, they'd be constantly looking for some contact with technology and maybe putting it ahead of interpersonal relationships."
Robots embedded in a social context	"I don't see a robot in an independent role (e.g., a teacher) because robot has no empathy for people."
“Robotisation” of humans) and become “mechanical”	“Children need human learning because if they listen to robots, they would become like robots."
Abusive behaviors	–

Table 5. Social and affective bonds with robots. Interaction and Relationships

Codes	*Example quotes*
Relationships understanding	"We live in a society where we interact, communicate with others and create social bond[s] and relationships. Computers and phones will not help a child understand what it means to live, adapt, and change or shape society."
Robots replacing human-human interaction	“A child who spends a lot of time with technology cannot establish bonds with his/her peers.”
Robot-like interaction styles and speech	“distorted speech”
Communication quality	[Robot]… “chats, … but it only chats about what it is programmed to chat about.”
A child's conception of a living being	"… They may start to think that a robot is equal to a human."
Impaired relationships	"If children were to spend too much time with robots, they could take those children away from the realm of human relationships, because as they grow up, they'd be constantly looking for some contact with technology and maybe putting it ahead of interpersonal relationships."
CRI	–

Table 6. Social and affective bonds with robots. Human contact, attachment, deception

Codes	*Example quotes*
The illusion of robot’s competency	"… Because the robot is similar to a human, it can trigger an 'unhealthy' attachment to it (it becomes a child's imaginary friend)."
Robots restricted social skills	"A robot cannot establish human contacts and emotions"
Attachment	“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.”

Students attachment to teachers	"But it would not be ideal to have the robot present during all school hours, or so I think. Otherwise the communication and the relationships between the teacher and the student would be diminished."
Human-to-human contact and dehumanization	"… People would get used to communicating with an inanimate being, but they would lose touch with reality."

Table 7. Legal aspects. Responsibility and safety

Codes	*Example quotes*
Decision-making based moral and situational judgement	"How robots could resolve disputes between children, judge in contentious situations, and understand children's intentions?"
Duty of care	"[Robots]… cannot replace a teacher's genuine contact with children. A child needs a person who will actually understand, help and encourage him/her." *(overlap with A Robot and teaching roles)*
Responsibility for harm	"A robot cannot process a child's emotional needs the way as a human being." *(overlap with Emotions, empathy, interaction, attachment, and human contact)*
Exclusion and discrimination	"[Robot is completely unsuitable for] … raising, comforting, caring for a child, learning culture, behavior, life and emotions." *(overlap with Emotions, empathy, interaction, attachment, and human contact)*

Table 8. Legal aspects. Privacy

Codes	*Example quotes*
Who is permitted to access to the stored information	–
Duration of data storage concerns	–
A consent given for the CRI by parents on behalf of underage children	–