The case of classroom robots: Teachers' deliberations on the ethical tensions

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Abstract

Robots are increasingly being studied for use in education. It is expected that robots will have the potential to facilitate children's learning and function autonomously within real classrooms in the near future. Previous research has raised the importance of designing acceptable robots for different practices. In parallel, scholars have raised ethical concerns surrounding children interacting with robots. Drawing on a Responsible Research and Innovation perspective, our goal is to move away from research concerned with designing features that will render robots more socially acceptable by end users toward a reflective dialogue whose goal is to consider the key ethical issues and long-term consequences of implementing classroom robots for teachers and children in primary education. This paper presents the results from several focus groups conducted with teachers in three European countries. Through a thematic analysis, we provide a theoretical account of teachers' perspectives on classroom robots pertaining to privacy, robot role, effects on children and responsibility. Implications for the field of educational robotics are discussed.

Keywords

Educational robots, Social implications, Ethics, Teachers' perspectives, Thematic analysis, Focus group

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1 Introduction

Encouraged by indications that robots in education can facilitate positive learning outcomes and enjoyment in learning (Kennedy et al. 2015; Leyzberg et al. 2012), researchers are increasingly considering the use of robots in educational contexts (Han 2012; Kanda et al. 2007; Movellan et al. 2005). Although different applications of robots can foster different ways of learning (e.g. learning through programming), the focus of the current paper is on humanoid *classroom robots* aimed at primary education that have computational fidelity functioning autonomously in varying degrees. We use autonomy to refer to "the extent to which a robot can sense its environment, plan based on that environment, and act upon that environment with the intent of reaching some task-specific goal (either given to or created by the robot) without external control" (Beer et al. 2014). Porayska-Pomsta et al. (2013) have argued that this genre of technology must not only recognize what the learner knows but must also have knowledge about the learner's affective characteristics in order to deliver appropriate pedagogical responses. Thus, seeking to emulate the conduct of charismatic teachers, drawing on an understanding of the learning sciences, classroom robots are designed to recognize and adapt to children's emotional or affective states within educational scenarios (Castellano et al. 2013).

In what could be critiqued as a largely techno-centric design process, some researchers have suggested that socially acceptable robots can only be developed provided that stakeholders are involved during design processes (Belpaeme et al. 2013; Jones et al. 2015; Šabanović 2010). In education, teachers, students and their parents constitute the most critical stakeholder groups. In this paper, we will focus on the teachers. Teachers constitute a primary stakeholder in the design of educational technology, particularly so since technology has the power to change existing educational practices for which teachers are responsible (Nordkvelle and Olson 2005). Teachers orchestrate students' learning, act in accordance to a duty of care toward their students, and should ultimately serve as gatekeepers deciding if and how technology is used in the classroom. In previous research that has considered the adoption of classroom robots in schools, Fridin and Belokopytov (2014) showed that teachers' perceptions of a robot's usefulness predicted their intention to use it. In a different study, Lee et al. (2008) found that teachers defined usefulness in terms of robots possessing instrumental as opposed to relational roles. Confirming these findings in a small scale interview study with teachers, Serholt et al. (2014) found that robots needed to fit within the social dynamics of the classroom while serving operational roles to optimize the teacher's time.

While this previous research has yielded some strategies on how robots might be designed (Jones et al. 2015), it has not deeply engaged with the ethical and moral implications of a technology that seeks to intentionally provoke emotional and social bonding with children. In the words of van Oost and Reed (2011), "While Information Communication Technologies (ICTs) have, in the past, primarily mediated or facilitated emotional bonding between humans, contemporary robot technologies are increasingly making the bond between human and robots the *core issue*". To provide an illustrative example of ethics, Kanda et al. (2007) equipped their classroom robot with a principle that allowed it to share fictive personal information such as, "I like our class teacher" in order to encourage more long-term interactions with the students. They also implemented a pseudo-development mechanism which meant that the longer the child interacted with the robot, the more behaviors the robot displayed, and the more personal information it shared. As this example attests, robots do not simply fulfill instrumental functions, nor do they mediate interaction among humans through technological means, but instead they are intentionally designed to evoke social bonding and fulfill the need for social interaction (see e.g. Belpaeme et al. 2012).

The present work addresses the need to better understand the ethical implications of classroom robots by adopting a Responsible Research and Innovation (RRI) perspective. RRI applies a non-deterministic perspective taking "into account the concerns and expectations of a broader set of stakeholders including the general public through the facilitation of public participation in research strategy and the equipping of a more reflective research culture" (Eden et al. 2013). It has been argued that the use of RRI processes during technology design is especially critical for more vulnerable groups in society such as children and the elderly (Sharkey and Sharkey 2011; Sparrow 2015; Stahl et al. 2013). As Schomberg (2007) explains, public deliberations surrounding future technologies should also entail discussing their possible applications. In our case, this should involve deliberations with teachers about what potential roles for robots are desirable in education, so that teachers' voices can influence these socio-technical developments (Nordkvelle and Olson 2005). In line with this view, our study moves away from research concerned with designing features that will render robots more socially acceptable by end users toward a reflective dialogue whose goal is to consider the key ethical issues and long-term consequences of implementing classroom robots for both teachers and students. The next section reviews and distills the key ethical and social concerns raised by scholars working in the field of robotics. We go on to use this conceptual work as a guiding lens to conduct a series of focus groups with both pre-service and practicing teachers in three European countries.

2 Background

A literature review on ethics aiming to explore the areas relevant to classroom robots yielded four ethical themes: (1) privacy, (2) robot role in relation to replacing humans, (3) interactional effects on children, and (4) responsibility. These themes were initially informed by work undertaken in the European project ETICA (Ethical Issues of Emerging ICT Applications[1]). ETICA aimed to identify ethical issues pertaining to emerging ICTs through desk reviews and empirical work in the form of focus groups with the general public. Whilst focusing on the issues identified in this previous work as they relate to robotics, artificial intelligence (AI) and affective computing (Heersmink et al. 2014), additional ethical perspectives were consulted pertaining to specific emerging technologies such as a digital dieting support system (Mancini et al. 2010), assistive technologies (Dorsten et al. 2009) and robots for long-term elder care (Sparrow 2015; Wu et al. 2012), as well as robot companions for children (Kahn et al. 2013; Turkle 2006). The following subsections detail these issues and the research questions they informed.

2.1 *Privacy*

Personalization and adaptive tutoring plays a very important part in effective education (Bloom 1984). In the field of robotic tutors it has been suggested that personalized feedback or problem selection leads to greater learning gains (Leyzberg et al. 2014). Lee et al. (2012) found that personalization furthermore increased participant rapport, cooperation, and engagement with a service robot in the longer term. Additionally, Kanda et al. (2004) equipped a classroom robot with the ability to adapt to individual children by recalling previous interactions. Although the researchers do not provide details about the nature of the robot's memory, their findings show that this intervention facilitated children's relationship formation with the robot and subsequently their learning outcome. After reviewing how robot designers have previously promoted long-term interaction, Leite et al. (2013) devised recommendations for future robot design, wherein they suggested the importance of fostering affective interactions and empathy as well as memory and adaptation. Conceptually speaking, this work would suggest that a robot needs to "get to know" a person by collecting data about him or her, while also being able to adapt to that information in a humanlike empathic fashion. Thus, to be able to offer personalization and to engage children in long-term interactions, classroom robots need to store an extensive amount of data on individuals in order to create personal profiles that can take into account previous interactions (Belpaeme et al. 2012; Porayska-Pomsta et al. 2013). Although there is no uniform approach when it comes to the data collection required to develop adaptive systems that model the learner, previous research has collected video captures, facial expression capturing, speech recognition, or other physiological data such as galvanic skin response (Jones et al. 2015). Kahn et al. (2007) ask whether this type of data collection has the potential to infringe on people's privacy *in itself*, i.e. if a robot "understands" a person, whilst highlighting the potential of these technologies to turn into a surveillance system where others may access the data.

Within elderly care, research suggests that older adults in need of care are not positive toward being monitored by robots or other technologies. For example, in their focus group studies on emerging assistive technologies for long-term care, Dorsten et al. (2009) found that elderly participants were concerned about being directly observed in their everyday private routines. The possibility of such observations led them to express "feelings of intrusion, vulnerability, and confinement". They furthermore feared negative consequences if their behavior caused a concern in others, e.g. forgetting things, or activities disapproved of by care givers. Another focus group study carried out by Pino et al. (2015) with a specific focus on socially assistive robots revealed a similar trend. Older adults with mild cognitive impairments perceived robots to threaten their privacy with particular concerns noted about human independence and freedom. In contrast to Dorsten et al. (2009), however, about half of the participants expressed an interest in services that could promote their safety, e.g. fall detection and subsequent emergency contact systems, as long as no video capturing was allowed. Foucault's (1975) discussion of Bentham's model of the ideal prison, the Panopticon, presents a possible explanation on the elderly's responses to privacy and technological monitoring. The Panopticon's design consisted of a central guarding tower with windows on all sides overlooking a surrounding ring of cells on several levels, enabling the constant surveillance and control of prison inmates. The inmates could never see into the tower themselves, which meant that they did not know whether they were being observed or not. Echoing the participant responses captured in these empirical studies, Foucault (1975) argued that this feeling of uncertainty can create a psychological prison where one has to constantly regulate their behavior.

Similar to the elderly, children constitute a vulnerable group in society. The implementation of robots in both education and elder care is often not ultimately decided or controlled neither by the children nor the elderly,

[1] www.etica-project.eu

but is instead dictated by a third party who has a duty of care. Not much research has been devoted to exploring if and how robots might infringe on children's privacy. Turning to teachers who act as technology gatekeepers, in part enacting their duty of care toward their students, our first research question asks: What are teachers' perceived privacy risks to children that arise from the design and presence of classroom robots? (RQ1)

2.2 The role of robots and human replacement

As Nordkvelle and Olson (2005) argue there has been a vision by certain technologically deterministic proponents to automate schooling, i.e. where students are taught by machines rather than teachers. Even though previous work shows that teachers have subtle fears regarding whether a robot could replace them (Serholt et al. 2014), Benedikt Frey and Osborne (2013) challenges the presence of this threat. Although they find that about 47 percent of current job occupations in the US are susceptible to computerization, teacher replacement is deemed to be unlikely. This is possibly attributed to the fact that "human capabilities such as creativity, empathy and understanding are not likely to emerge in robots for decades" (Heersmink et al. 2014). Yet, it's not clear whether this vision of education will be desirable once the technological barriers have been overcome.

Such extreme perspectives have led researchers to argue that social contact with other human beings is valuable in itself (Aiken and Epstein 2000; Heersmink et al. 2014; Nordkvelle and Olson 2005; Turkle 2006) in turn suggesting a shift from considering what is possible or probable, to what is desirable or ethical. Applying such an ethical lens, Sharkey and Sharkey (2011) argue that robots are perhaps best used to facilitate "robotic" literacy, i.e. to teach students about robots' underlying mechanisms, how they are manufactured, in addition to understanding the human tendency to perceive robots as humanlike in order to manage the vulnerability that arises from this. Beer et al. (2014) argue that "a scientific base of empirical research can guide designers in identifying appropriate tradeoffs to determine which functions and tasks to allocate to either a human or a robot", wherein similar to other scholars they emphasize the importance of considering what a robot *should* rather than *can* do. Not much empirical study has been devoted to what roles robots should play in education from an ethical perspective, although the research carried out in elder care indicates that some older adults are concerned about the possibility of their care providers being replaced by robots (Pino et al. 2015; Wu et al. 2012). Grounded in a view that technology must be desirable and ethical, our second research question aims to unpack the goal of robots in education: In what capacity do teachers believe robots can benefit learning and fit in the learning context? (RQ2)

2.3 Developmental effects on children

Zhao (2006) argues that agency is negotiated now that robots are making their way into society. Takayama (2012) speculates that people ascribe agency to robots behaviorally even though they reflexively acknowledge that a robot is a machine. Other research suggests that people ascribe agency to robots believing or acting as though robots operate on their own behalf (Kahn et al. 2004). This tendency has been referred to as anthropomorphism, i.e. people's tendency to "attribute human characteristics to inanimate objects, animals and others", and based on observation, "rationalise an entity's behaviour in a given social environment" by attributing emotional and cognitive states onto that entity (Duffy 2003). Epley et al. (2007) consider this to be a process of induction, which starts "with highly accessible knowledge structures as an anchor or inductive base that may be subsequently corrected and applied to a nonhuman target".

Anthropomorphism, or ascription of agency, have consequences for relationships. Previous research has shown that children can perceive robots as friends (Fior et al. 2010; Hyun et al. 2010; Kanda et al. 2004; Tanaka et al. 2007), although robots are also seen as a separate ontological entity or "hybrid being" (Eunja et al. 2012; Kahn et al. 2013). Thus, although robots are not perceived to be completely human (Eunja et al. 2012), children nevertheless seem to project their understanding of humans onto robots, allowing friendships to form (Beran and Ramirez-Serrano 2011). As argued by Kahn et al. (2007), there could be psychological benchmarks at play where people for instance begin to imitate robotic behaviors or afford intrinsic moral value to a robot, raising concerns on whether these effects might also manifest in children.

In a related line, Turkle (2006) has argued that social robots are becoming relational artifacts that evoke feelings of attachment in people. Falsely thinking that human-robot interaction measures up to human-human interaction (Sharkey and Sharkey 2011), as well as becoming attracted to a robot's constant adaptation and individualization, there is a concern that children may start to prefer interacting with robots (Bryson 2010). Sharkey and Sharkey (2011) point out that this could impede children's development in terms of how to understand and interact with humans, linguistic ability, and understanding of reciprocity in human relationships, whereby they might not fully develop empathy and understanding of the ambivalence of human nature (Turkle 2006). Bryson (2010) also addresses the concern that AI may foster different types of behaviors. In contrast to Sharkey and Sharkey (2011) she argues that even though there may be a correlation between engagement with robots and introversion, the consistent behavior of robots may still provide children with stability in their lives, and increase their sense of self-worth.

In contrast to concerns over how children might bond with robots, Kahn et al. (2013) ask whether extensive interaction with adaptive robots could foster a master-servant relationship in which robots are objectified by children. In their view, such behaviors could subsequently carry over to human relationships. Providing some support to this view, Nomura et al. (2015) found that children engaged in abusive behaviors toward a robot. This was either motivated by other children's behavior, or was done for the sake of children's enjoyment and curiosity. Even though some of the children described the robot to be a human-like entity, they still engaged in the abusive behavior. Kahn et al. (2007) suggested the possibility to work towards a more reciprocal relationship where a robot expresses opposing desires or perspectives from the child it interacts with in order to mitigate a master-servant relationship. However, the study by Nomura et al. (2015) showed that despite the robot crying out to stop the abuse, the children persisted.

There is much conceptual and empirical work that has aimed to foresee and understand the potential effects of robots on children. Our study seeks to inform and advance this work by additionally introducing the perspective of teachers: What social implications and effects on children who interact with a classroom robot do teachers anticipate? (RQ3)

2.4 Responsibility

Concerns over how robots may negatively impact on children's development and behavior also introduces questions of responsibility. Whether these effects can be attributed to errors in programming or unforeseen consequences stemming from the robot's autonomy or learning, a responsibility ascription problem arises (Marino and Tamburrini 2006). For example, it has been argued that predicting any situation that may arise is unreasonable to expect from a developer (Gill 2008; Matthias 2004). From a legal perspective, manufacturers and/or developers can only warn potential consumers of possible risks associated with using a product, perhaps avoiding responsibility by arguing that they develop robots in accordance with industry standards (Asaro 2007). It is therefore not clear who, if anyone, can be considered responsible for unforeseen implications of using robots (Matthias 2004); "the causal chain leading to a damage is not clearly recognizable, and no one is clearly identifiable as blameworthy" (Marino and Tamburrini 2006). This creates a responsibility gap wherein neither user nor developer is able to exert the necessary level of control over the robot to be able to assume responsibility for negative consequences (Matthias 2004).

Kahn et al. (2007) question whether people will consider robots morally accountable for their own actions, arguing that it becomes increasingly likely when robots take on more "sophisticated humanoid forms". Moral wrongdoings are usually dealt with through criminal rather than civil law. However, as long as robots are not moral agents, any type of punishment is not likely to have the desired effect. It would not serve traditional means of justice (i.e. the robot pays its debt to society), reform (i.e. so that the robot does not repeat the offense), or deterrence (i.e. to deter other robots from making a similar offense) (Asaro 2007). Asaro (2007) instead suggests that robots be legally viewed as quasi-agents not fully responsible for their actions, yet raises the issue that this might "place a too heavy burden on the owners of robots, preventing the adoption of robots due to risk, or unfairly protecting manufacturers who might share in the responsibility of misbehaving robots due to poor designs".

Marino and Tamburrini (2006) argue that scientists and roboticists play important roles in identifying risks and benefits with using robots, but that we also have to include a broader set of stakeholders "to evaluate costs and benefits of learning robots in society, and to identify suitable liability and responsibility policies". Understanding the issue of responsibility has wide reaching implications from informing school decisions to adopt such technology, to conversing with legal frameworks and their assumptions. This concern grounds our final research question: Who do teachers consider responsible and accountable for any negative consequences that arise from the use of classroom robots? (RQ4)

3 Methodology

This qualitative study seeks to explore teachers' views on the ethical implications of classroom robots in primary education. The goal is to develop a broad theoretical account of how robots can impact individual children and the socio-cultural environment they are introduced in. This is achieved by involving, on the one hand, both pre-service and practicing teachers, and on the other hand, teachers from different European countries. Whereas in our previous work we only targeted practicing teachers (Serholt et al. 2014), the views of pre-service teachers should also be considered important as they are on the brink of becoming professionally active in education. They constitute what Fluck and Dowden (2013) have referred to as the 'cusp generation'. Given the futuristic technology considered in this work, pre-service teachers are also more likely to face a reality with classroom robots in the future.

Furthermore, educational systems and experiences therein differ cross-culturally as well. By targeting three European countries in which educational systems have been shown to be culturally diverse (Chiu and Chow 2011), namely Sweden, Portugal and the UK, we seek to acquire a more versatile and valuable account of the phenomena under study.

Our research questions are tackled through a series of focus groups with the goal "to create a candid, normal conversation that addresses, in depth, the selected topic" (Vaughn et al. 1996). Unlike individual interviews where participants are engaged in discussion with a researcher, focus groups allow participants to govern the discussion and interact more with each other (Cohen et al. 2013). This was deemed important in ensuring that discussions are led by teachers and formed on the basis of their common practice and theoretical background. Our approach is not concerned with generalizing across populations, but rather aimed at providing a rich theoretical account of the phenomena under study from the basis of our four research questions:

1. What are teachers' perceived privacy risks to children that arise from the design and presence of classroom robots?
2. In what capacity do teachers believe robots can benefit learning and fit in the learning context?
3. What social implications and effects on children who interact with a classroom robot do teachers anticipate?
4. Who do teachers consider responsible and accountable for any negative consequences that arise from the use of classroom robots?

3.1 Participants

Practicing teachers and students with teaching backgrounds currently pursuing a Master's degree in education were recruited for the study. In total 77 participants in Sweden, Portugal and the UK took part in the study. Participant demographics are presented in Table 1. Most participants had teaching experience and a teaching degree at the time of the study (which took place in mid-late 2014). There were twelve focus groups, four in each country. The focus groups lasted approximately one hour each. In the UK, all groups comprised students who were recruited through an ongoing teacher training Master course in ICT and Computing. In Portugal, the groups consisted of practicing primary school teachers who responded to an invitation in an online educational database. In Sweden, two of the groups were recruited from an ongoing Master course in IT and Learning[2], and two of the groups consisted of practicing teachers from a primary school. In addition to informed consent and demographic information, we collected data about participants' technology experiences based on a previously validated questionnaire developed and reported by Little et al. (2008), consisting of six yes/no questions pertaining to their current use and perception of mainstream technology, such as Internet and mobile phones. Table 2 presents the response frequencies to the measure's items suggesting that a majority of the participants enjoyed technology and valued access to it, but that they may have perceived issues related to over-dependence on technology.

Demographics		**No. of Participants (N = 77)**
Category	**Subcategory**	(% of N per Category)
Country	Sweden	35,1%
	UK	28,6%
	Portugal	36,4%
Age	18-24	11,7%
	25-34	18,2%
	35-44	22,1%
	45-54	31,2%
	55-64	16,9%
Gender	Male	37,7%
	Female	62,3%
Occupation	Practicing teachers	54,5%
	Pre-service teachers	45,5%

Table 1: Participant demographics (% per Category are based on N = 77)

[2] These discussions were held in English as not all participants were Swedish-speakers.

Questionnaire Items 1-6 (Response options: “yes” or “no”)	**Responses** (% of N responding “yes”)
If your personal devices (e.g. mobile telephone or computer) were taken away from you tomorrow, would it bother you?	84,4%
Do you think that we rely too much on technology?	70,1%
Do you enjoy exploring the possibilities of new technology?	96,1%
Do you think technologies create more problems than they solve?	14,7%
Is Internet access important to you?	94,8%
Do you like to use innovative technology as opposed to tried and tested technology?	72,7%

Table 2: Participant responses on current technology usage questionnaire (N = 77)

3.2 Procedure

Participants were first given a short introduction about the purpose of the study in accordance with ethical standards on both National and Institutional levels. Following this they signed an informed consent form, provided demographic information and filled out the technology usage questionnaire described in 3.1 and presented in Table 2. The goal of the focus groups was then to elicit participants’ perspectives on ethical issues of introducing classroom robots in primary education, and their general thoughts and concerns with regards to emergent issues. Previous studies have shown that people struggle to envision potential scenarios associated with unfamiliar and particular technologies (Mancini et al. 2010), which was also evident in our previous work (Serholt et al. 2014). The use of fictive scenarios has been shown to mitigate these issues and provide a common point of reference for participants (Little et al. 2008; Stahl et al. 2013). Moreover, it has been suggested by Mancini et al. (2010) that including both positive and negative scenarios can encourage a wider spectrum of voiced concerns. Informed by this methodological work, we used the following procedure to introduce participants to the topic across the different sites:

Participants first viewed a 5-min video about current developments in social robotics. The video showed how external sensors and software programs can be used in order to interpret children’s emotional states. The video also presented several robots (both tele-presence and autonomous humanoids) currently in use in primary education in various countries. It ended with two short segments of some futuristic possibilities of robots depicted in two science fiction movies (*I, Robot* and *Robot and Frank*) in order to raise ethical issues to their attention and inspire participants to think beyond their current experiences with technology. Drawing from Mancini et al. (2010) the videos were intentionally edited so that *I, Robot* was deemed to be perceived in a more negative light, and *Robot and Frank* in a more positive light. The ordering of the segments were counterbalanced for half of the groups. Participants were then requested to read through a short fictive vignette about a 12-year-old student’s interaction with a classroom robot with guidance by the researcher present. The aim of the vignette was to provide a concrete case of one application area for robots in education, depicting a robot that could interpret a child’s emotional state and subsequently adapt a learning task accordingly. The vignette was written to illustrate practices that could be associated with the four ethical perspectives presented in the background (see Table 3).

Sue, the principal of Eventon school, decides she wants to start using an empathic robotic tutor in her school. She orders one for each of her 15 teachers. Each teacher receives a personal robotic tutor, which he/she can give a name that the robot will respond to when switched on. All teachers receive a one-day long course in which it is explained how the robot works, who to contact in case of technical problems, and the kinds of work the robot can support. It is explained that the robotic tutor can be used to assist individual students as well as small groups when doing assignments. Each robot is connected to a table-sized touch screen in order to display task-related information, such as maps, pictures, movies, and texts. All 15 robots in the school can communicate with each other and all data from the robots is stored on the school’s protected server. The robots will be able to recognize all the students in the different classes.

Nathan, the geography teacher in grade 6, receives his robot, which he names Gwen. Nathan explains to his class that Gwen will be used in the classroom for doing individual assignments related to map-reading as well as small-group assignments around urban planning and sustainable development. This can be done in parallel with the ordinary classwork in a corner of the classroom, alternatively as part of a class project. He tells them that the robot will use its perceptive capabilities, such as tone of voice, facial expression, and proximity sensors in combination with its knowledge of the task to provide them with support to fulfil the assignments.

While the teacher is doing an activity with the class, the 12-year old pupil Sandra is working with Gwen on a map-reading task. Gwen and Sandra have done some assignments before and Gwen has stored information about Sandra's usual expressions, tone of voice and proximity. Today, Sandra is behaving differently. While usually being able to answer quickly she now takes a lot more time. Her voice has a somewhat higher pitch and she does not lean as closely to the interactive table as usual. Gwen uses this information to determine that Sandra is not doing well. It seems that Sandra is especially distressed when she needs to transform distances given in miles/kilometres to a distance on the map in front of her. Since nothing seems out of the ordinary in the classroom environment (e.g. lights and sounds), Gwen suspects that Sandra needs an extra tutorial in order to solve the assignment. Gwen suggests that Sandra may be having some trouble with converting distances. She asks Sandra whether this is the case, and Sandra responds by pressing a confirmation button on the touch-table. Gwen indicates to Sandra that she does not need to worry: there is nothing wrong with not understanding scales.

After giving the tutorial Gwen adapts the level of the task gradually for Sandra to catch up. When Sandra is now able to do the assignment and has returned to displaying her normal behaviour, Gwen praises her and says that she should be proud of having learnt so much today.

Table 3: Vignette of classroom robot use

During each focus group, participants were encouraged to discuss their attitudes about robots in education freely, while researchers prompted them with questions relating to the critical lenses identified in our literature: privacy, effects on children, responsibility, and roles. To avoid leading the discussion, the questions were designed to be intentionally broad and open to participants' interpretation.

3.3 Analytic approach

Audio recordings from the sessions were transcribed verbatim and translated to English where applicable. They were then imported into the software QSR NVivo 10, where a thematic analysis as described by Braun and Clarke (2006) was conducted. Thematic analysis is a qualitative analysis method which seeks to extend theoretical knowledge rather than focusing on frequencies of expressed viewpoints or representativeness over populations. This method of inquiry allowed us to explore each ethical viewpoint in depth and the complex interactions that might describe it.

Initially, each author produced a written summary of key points and interpretations from the focus group to which they acted as facilitators. These summaries served as sources of reference to aid the analysis process. Following this, the first author interpreted the material by means of thematic analysis. First, a low-level coding of the whole material was conducted, in order to maintain the details of the transcriptions. Codes were then refined, where the ethical implications identified in the literature review served as analytical lenses. Thus, participant statements were assigned to the following overarching themes where possible: privacy, effects on children, responsibility, and negotiated robot role. Alongside being directed by the themes identified in our literature, an inductive approach was taken to identify categories not covered by those uncovered during the literature review. Given the scope of the paper, participant statements pertaining to suggested robot design and detailed applications were discarded during the final analysis unless they were used by participants to express an ethical issue. Researchers undertaking interpretive analysis must aim at attaining confirmability and neutrality (Shenton 2004). Whilst the authors were guided by the literature, they were also in part influenced by their social and cultural contexts. To avoid bias, predispositions were openly discussed and negotiated between the first author and the remaining authors during the entire process of coding.

4 Results

Our findings will be presented in a narrative form organized in accordance to the themes that emerged for each respective research question during the interpretive analysis. The narrative is based on participants' voices even when this is not specified in the text. When quotes[3] are used, references to speaker demographics will be

[3] Note that the pre-service teacher focus groups in Sweden were held in English as there were some non-Swedish speakers present. As they were not fluent English speakers, this sometimes resulted in errors. To preserve a verbatim account, however, grammatical and linguistic errors produced in quotes were not corrected.

abbreviated in parenthesis to denote occupation (T=Teacher; P=Pre-service teacher), gender (M=Male; F=Female) and country (UK=United Kingdom; SE=Sweden; PT=Portugal).

4.1 Privacy

In this section, we present our findings pertaining to the themes associated with our first research question: What are teachers' perceived privacy risks to children that arise from the design and presence of classroom robots? The first theme regards participants' expressed expectations and views of privacy and privacy control as it exists today. The second theme pertains to participant discussions on the accuracy of a classroom robot's data collection and accompanying interpretations, whereas the third theme concerns perceived risks, costs and benefits of collecting different kinds of data on children.

4.1.1 Expectations of privacy and privacy control

Privacy concerns raised by classroom robots were compared to existing expectations of privacy. Participants explained that privacy was already compromised, for example in the UK, where many schools have closed-circuit television (CCTV) recordings within their classrooms. In addition to this, teachers across all three countries already stored information about their students electronically. As one participant explained, *"Let's get this clear: in relation to data privacy, that does not seem to be a big issue for us, because we spend our lives working with sensitive data, such as evaluation meetings, students' private cases that are shared with us"* (T, F, PT). Moreover, it was argued that children already share personal and sensitive information on social media highlighting the changing nature of privacy. Participants drew a nuanced distinction between classroom robots and these existing technologies or practices. Although they recognized that students' information was already held by the educational institutions, what distinguished these practices from classroom robots was the fine-grained data and data on affective signals which was perceived to be more intrusive. In the words of one participant, *"Because I mean there's already that collecting data about your achievements and your levels. But the level of detail would be the concern"* (P, F, UK). Another participant pointed out the sensitive nature of affective data, *"I think it's a very big issue actually to have all this data on all the students. It would include like facial recognition, emotions, everything"* (P, F, SE).

Across all focus groups, privacy was thought to be a sensitive issue particularly because children do not have control and legal authority over the data stored about them while in school. Taking a normative stance, teachers believed that children should have freedom of choice, especially when it comes to data that is stored about them while in school. One participant explained this, *"It's the difference between choice. Because I am choosing to give my stuff to Google. But, they're not. The choice is being made for them"* (P, M, UK). One teacher speculated about the emotional harms that would be incurred once children realize that their school held an emotional profile of them: *"Actually, they would find that if they knew that their data would have been stored; their emotions would have been stored. They would be really upset about it"* (P, F, UK).

Considering possible responses and forms of control, some suggested that parents and children should have the right to delete data and that strict legal policies had to be put in place. Others questioned whether it was necessary to store such data at all, where online storage was considered even more risky. For example: *"Yeah, the only thing you could possibly do is something that is just not linked to any sort of upload-able system. If it (robot) is programmed to sort of react according to things it sees"* (P, F, UK). A few participants considered the practice of storing digital performance assessments online acceptable as long as it was anonymized.

Parental consent was recognized to be critical, yet described by a tension in fairness. Some participants believed that parents would make the appropriate decision for their child, provided that proper legislation was put in place beforehand, e.g. *"In this case the students' caregivers should be included in this project, right? This does not seem to constitute an issue"* (T, F, PT). Other participants argued that particularly parents of a lower socio-economic status would not understand the sensitivity of affective data, accentuating existing patterns of social exclusion: *"And what about the people who are going to sign their children's rights away without having any understanding of what they're doing? You know, it's going to be the uneducated people that once again suffer most. Because, when you get these checklists: I allow my child's data this, this and this; you're going to get people that have not got a clue what they are signing their kids up to"* (P, F, UK). This was attributed to the complex legal terms and conditions which made it often too difficult to comprehend by those responsible for providing consent (e.g. school authorities, teachers and parents).

4.1.2 Accuracy of measurement and affective data interpretation

Some participants argued that collecting data about children was acceptable provided the data was accurate and analyzed with valid and reliable techniques to ensure the appropriate interpretation of a child's data. Yet, drawing on their knowledge of children, participants offered several arguments to suggest that this would not be easily accomplished in technical terms. They mentioned cultural and inter-individual in how emotions might be expressed introducing measurement challenges that could require individualized approaches to machine interpretations. One participant briefly described this: *"the robot is working on perceptions and perception is a very subjective thing*" (P, M, UK). In addition to highlighting inter-individual differences, participants recognized developmental changes. As children develop and mature, their behaviors and emotional expressions also change. Whilst teachers are able to adapt to these changes to maintain dynamic interaction and understanding with their students, participants were skeptical as to how a robot might 'learn' about an individual child leading them to consider robotic perception in static terms. Furthermore, our participants questioned whether technology can diagnose internal states, disambiguating moods (e.g. children having a bad day or problems at home) from cognitive responses to a learning task. As expressed by another participant: *"So you know, kids go through stages in their life and they're having different emotions and different reactions to things and a computer is just going to be storing, not understanding"* (P, F, UK). Pointing out that teachers would typically inquire about such aspects to interpret the student's response to a task, one participant voiced doubts about the ability of technology to undertake this dialogic interpretation: *"(it) depends on the student that we are facing, depends on the environment that we have, how students are doing on that day at that school. It depends on everything. There are multiple factors that I think make it impossible to program a robot that takes into consideration all these variables"* (T, F, PT). Casting doubt over the validity of measurement more broadly, some participants challenged the domains that this kind of technology may be applicable to asking for example whether children's creativity could be analyzed and interpreted by this technology. Whereas biases to human perception were also recognized, the risks were perceived to be particularly heightened with technology given the permanence and access to data by unanticipated third parties, which we will explore next.

4.1.3 Risks, costs and benefits

During the focus groups there were tensions in how participants perceived the costs and benefits of using student data to support pedagogical goals. Some participants considered certain advantages if 'responsible' teachers could access children's affective data, e.g. *"if a student care team checks the data, we could maybe see a period of time where a student does not feel well, and we could act upon that"* (T, M, SE). This view was refuted by another participant who argued that such exercises might reinforce children's difficulties through teachers ascribing traits onto students based on this data. Relatedly, whereas some participants believed that children's knowledge of their monitoring would cause a breach in trust, others considered data to the teacher to be a prerequisite in informing teaching practice. One participant was particularly emotive about the importance of data: *"I don't see the point of having a robot there and it's thinking 'this student seems really agitated', but then it doesn't report it to anyone. So what's the point in that? Like who does that benefit in class if it's not being recorded and fed back to the teacher?"* (P, F, UK).

It was generally considered important that children be allowed to make mistakes throughout their childhood without the risk of a social label. With this in mind, participants' privacy concerns of classroom robots were shaped by their understanding of current complex political and social systems describing risks instigated by the government, police, commercial, institutional, or criminal parties. There was a general feeling of disempowerment in how technological decisions were made in education whereby participants perceived economic and political powers to set the agenda: *"It would not be up to us to decide whether or not they keep the children's data. We can register and protest somewhere but it is not going to be up to us"* (P, F, UK).

Some privacy concerns that teachers described echoed risks arising from unauthorized or secondary uses of the data as they would occur with any technology deployed in education: e.g. hackers accessing the data, secondary uses by unauthorized school staff members, children harnessing data against their peers. Other concerns were more pertinent to the affective nature of the data. Participants were concerned about governmental surveillance of citizens, expressing concerns over the increasing control affective data afforded over citizens, while also describing a lack of trust in the government. One participant described this in emotive terms: *"If we thought we live in a society where you could actually trust the government, and trust the agencies and everything... Of course it would be different; but we don't live in that kind of society. We'll be forced to trust them. To trust them with your children's every emotional response. It's just frightening to the point of making me feel sick"* (P, F, UK). Focusing on the police, a few participants worried that children's affective data profiles would encourage new interpretations during police interrogations. One participant explained how this could give the police more power: *"Imagine having these data during questioning in the police. They would know how you would react when there's something wrong with you"* (P, M, SE). Yet another perceived risk were commercial organizations who might capitalize on the scope of the data collected and seek to purchase children's data. In noting this, participants did not seem to consider the legal measures that would typically prohibit such data sharing: *"But there is also the risk that we have too much information in one place, and then someone realizes that they can sell that information to someone else"* (T, F, SE). One participant connected this to a personal experience during which she had realized her personal information had been sold and bought across different agencies arguing that *"we perfectly know that nowadays any product is negotiable"* (T, F, PT).

4.2 Robot role

In the two following subsections, we target our second research question: In what capacity do teachers believe robots can benefit learning and fit in the learning context? First, discussions surrounding the nature of role distribution between classroom robot and teacher is presented, wherein issues of teacher replacement is raised coupled with normative discussions on what sort of role a robot should have. The second theme focuses on teachers' experienced limitations concerning contemporary education; how they balance the different aspects of their roles as teachers, and how the introduction of a classroom robot may affect this.

4.2.1 Distribution and nature of roles

The humanoid robot design, where one robot was able to interact with many students at once, introduced fear that teachers could be replaced. Some participants responded with anxiety, e.g. *"Until now I was not afraid of teachers' replacement, but in this case it really replaces the teacher, the teacher is not there, right? It is just the toy!"* (T, F, PT). Others questioned whether robots were part of an insidious plan to replace teachers in education. As expressed by one participant: *"I think the goal is to replace teachers in the end. No seriously, I think the goal is… Because, I mean, what you say is that an AI learns, that's the whole point, it learns. It deals with the kid, the kid gives a response, it learns from the response. It learns about it for a period of time and then slowly it gets better and better at teaching that child, like a teacher would. That's the whole point of it. What else, I mean?"* (P, M, UK). This led some to speculate that as teachers start using classroom robots, systematic changes to the teaching profession will occur to deliver mass education in turn reducing the teacher to a mechanical role. One of our participants explained this: *"Someday, they are going to put the teacher in a central room, right, controlling all the robots that are in the class… Commanding the system instead of giving a class, instead of having a class one at a time, gives three or four!"* (T, M, PT). Others conceived teachers' replacement to be an unintended consequence of innovation: *"The fear that the teachers would be substituted. Because, actually those are problems, scientists invest in a certain area and get to certain results with a specific practical objective of that knowledge that built it. And after what happens is that the society takes advantage a lot of times with a different objective from the one it was initially created by the scientist, right? And normally it is a direction that ends up being harmful to us, to the planet, right?"* (T, M, PT).

While participants recognized that robots could be endowed with human capabilities, they questioned whether such capabilities could match those of a human tutor: *"but also it will be frightening imagining... They will… They are better than human beings because they never get ill… They are better in so many respects, but when it comes to like teaching and stuff…"* (P, F, UK) also echoing the findings reported in Section 4.1.2. This encouraged participants to draw a distinction between 'what teachers do' and 'what robots do', paying particular attention to the need for less robot autonomy compared to that of a human teacher. As argued by one participant: *"All the films and materials around us is telling us: Yes, robots can help us. They can facilitate our development, but ultimately they shouldn't be allowed to make choices"* (P, M, UK). Thus, classroom robots were viewed in instrumental terms as an additional teaching tool subject to the teacher's scrutiny as to how it fits in the learning process. In accordance with this view, some participants suggested that robots should not teach novel concepts which were the realm of the teacher, but rather act in a capacity of reinforcement. In the words of one teacher, *"if a student really has difficulty to read and write, I should be the one that first assists the student, helping him to unblock that difficulty or situation, and I envision the robot to train"* (T, F, PT). Moreover, in considering how such robots might fit in a pedagogical context, a few participants envisioned robots as supportive tools for small groups or individual students e.g. *"I think it's just good for small groups and individuals, but I wouldn't ever give it to a whole class"* (P, F, UK) with teachers acting as facilitators on the side to manage the learning process and any disruptions.

Despite the impetus of the data mining and learning analytics community to design digital assessment tools that aim to make teachers' work easier, this research found a sense of distrust to this approach. Focusing on summative and formative assessment it was argued that robots could not carry out the holistic evaluations necessary for assessing more qualitative skills such as writing or complex reasoning which is more relevant for education than factual knowledge. As one participant expressed: "*For example, if I want to check if a student has capacities to write a narrative, or a letter, the robot cannot evaluate this by any means"* (T, F, PT). Thus, overall, classroom robots were subjugated to roles that support existing practice.

4.2.2 The impact of contextual constraints on the perceived benefit

Participants explained the lack of time they faced in carrying out their teaching duties. Demands on teachers were increasing at a pace with student numbers. As one participant argued *"we are unable to meet all the different needs* *that exist in the classroom and this worsens because we now have more students in class. And in some types of classes, like educational arts, the class was lectured by two teachers and now we only have one"* (T, F, PT). These concerns resonated with responses of participants from other countries who claimed they were not given the resources or necessary conditions to perform their jobs efficiently. Thus, futuristic technology such as classroom robots were perceived by some to constitute an extra burden for teachers. As a response to this, our participants postulated they would require technical support and maintenance onsite. Moreover, in order to negotiate the new roles introduced due to the humanoid nature of robots, participants expressed the need for appropriate education so that they themselves could understand a robots' underlying mechanisms.

Some participants took a different perspective and recognized the cost incurred in purchasing this technology as threatening other more basic needs: *"Keeping all the equipment up to date, costs a lot. It is not so costly acquiring, but maintaining it. The maintenance has brutal costs, and there is no money. There is really no money. Because when we think about children that cannot eat, there are priorities. To me it's much worse that there's someone in a school that does not eat, compared to a computer that is not working. I don't really care if it does not work, but at least I fed someone"* (T, F, PT). The same participant further suggested an ethical tension in investing time and money in a piece of technology when these resources could be put to better use within an educational system in strain.

4.3 How interactions with robots may affect children

This section presents the themes surrounding our second research question: What social implications and effects on children who interact with a classroom robot do teachers anticipate? Here, discussions on de-humanization of children is presented first, i.e. how children may come to be influenced by the presence of a classroom robot in the long term. This includes both potential changes to children's own demeanour, but also their outlook on others. The second theme pertains to participants' envisioned child-robot relationships, and the moral implications thereof. The third theme regards children's level of trust in robots and participants' discussions on children's credibility affordance to robots.

4.3.1 De-humanizing

Participants expressed concerns that children would be de-humanized through their interactions with robots. There were several speculations as to how and why this could happen. Firstly, a commonly held view was that robots cannot interact on the same emotional plane as humans. As a result of their interactions with robots, it was argued that children would start to struggle understanding human facial expressions leading to impaired emotional intelligence. As one participant explained: *"You learn from other people's emotions. So will there be a lack in learning, in learning emotions from facial expressions? Because the robot has no facial expressions"* (P, M, UK). According to our participants, this could lead to children becoming "mechanical" in how they express emotions, or causing profound confusion in their emotional intelligence: *"You could possibly turn a child into an emotional wreck"* (P, M, UK). Taking a similar perspective, some participants argued that people's use of language is highly affected by technology, whereby they speculated that children might mimic robots and increasingly adopt new ways of speaking. Nonetheless one participant suggested that certain linguistic skills could be enhanced with the use of robots: *"With the robot you can actually program it to really speak so clearly that it would actually accommodate good language"* (P, M, UK).

Participants considered classroom robots against broader technological and societal trends which do not often encourage the visibility and tangibility of consequences. One participant explained: *"I think we already feel this in the kids, the human relation has stepped to second place. Everything is so virtual now and that is not good for, I do not know, aggressiveness. And also the lack of consequences, they can do everything, like they hit a friend in a game or in some virtual thing, and as people do not exist there, there are no consequences or effects on the other. I think we feel this. Kids are growing aggressive, it's like they do not see the consequences of their actions in terms of the human side, they can say everything, they can abuse, they can hit, they can hurt, because that will recover"* (T, F, PT). Given the humanoid characteristics of robots, our participants voiced a concern that if children were to engage in destructive physical actions, such as for example pulling off the robot's arms or piercing its eyes, these could ultimately legitimize and encourage violence in human interactions.

4.3.2 Changing relationships and their moral implications

Our participants argued that children could have asymmetrical power relationships with robots. They conceived of a future where robots would be subservient to children: *"I think there's a risk, a problem, if the robots become like these butlers and that they're everywhere. Of course that's gonna change our behavior if we have a butler that's over there all the time that we can ask questions, and that we can tell to do things"* (P, M, SE). In accordance with this view, it was argued that children could develop an authoritarian attitude and behavior that transcends their human relationships, and ultimately abandon human-human relationships in favor of the more "gratifying" ones with the robot. Conversely, some participants considered the opposite scenario in which children's interests and desires might come under the robot's control even if this contravened their interests. Taking this even further, several of them pointed out the possibility of robots being used to manipulate children and carry out disciplinary measures if deployed with sinister motives, e.g. in a country governed by dictatorship.

In defining the possible relationships between children and robots and the effects thereof, participants also focused on the affective qualities of child-robot interactions arguing that children could come to ascribe agency to robots leading to intimate social bonds where for example children shared their secrets. Similar to the implications anticipated for the asymmetrical power relationships described above, most participants worried that students might prefer robots over human contact. To mitigate this some participants argued that children should be allowed to learn *about* or *through* rather than *with* robots echoing also the findings reported in 4.1.2. In contrast to those arguing that affective interactions with robots would be credulous, some participants believed that whilst robots can 'interpret' children's emotions, ontological differences would lead to the absence of a bidirectional emotion exchange. This lack of emotion reciprocity was seen as particularly problematic: *"But there is no reciprocity! The relation must be univocal, it has to be from here to there and from there to here. Because if the robot can understand the person, but the person is unable to understand what that robot is… Because a robot is projected to be something, and should be that"* (T, F, PT). They predicted that this could result in children feeling deceived, unfairly treated, concealing their emotions, and responding in adversarial or even aggressive ways towards robots.

4.3.3 Credibility and trust affordance

Our participants problematized the ability of classroom robots, and related AI technologies that adapt to learners, to foster opportunities for growth and independence. It was argued that classroom robots were predictable and consistent: children receive answers to their questions instantaneously (due to the technology's connectivity) and benefit from constant assistance when solving tasks. The danger of this, they argued, was that robots might be perceived to be too credible. One participant explained, *"they would see it [the robot] as a source that knows everything and they do not question the answers"* (T, F, PT). Participants postulated that children could become over-reliant on robots and lose their capacity to be critical, even encouraging them to envision a future where students who might trust a robotic tutor more than a teacher if the two disagreed.

Finally, one of the focus groups explained that students were often reluctant to share with their teachers their gaps in understanding due to fear of judgement. Inhibiting their own learning, it was said that students claimed to "know it all". Some participants speculated that students might come to feel more comfortable expressing their doubts to robots without fearing judgment. Through this, they proposed that students could become more comfortable about their own shortcomings, a process that would eventually help them share uncertainties with their teacher. Others took the view that sharing their vulnerabilities outside human interaction would only reinforce children's conviction of their privacy: *"maybe the fact that they would expose their doubts only to a robot, would reinforce this even more, it would only help them to hide more the things they do not know"* (T, F, PT).

4.4 *Responsibility*

This section on responsibility of using classroom robots presents the themes related to our final research question: Who do teachers consider responsible and accountable for any negative consequences that arise from the use of classroom robots? When discussing the issue of responsibility, participants construed this along both instrumental and ethical dimensions. The first theme therefore raises instrumental responsibilities in the immediate classroom environment, whereas the second theme digs more deeply into ethical responsibilities associated with long-term consequences of using classroom robots.

4.4.1 Instrumental responsibilities

Taking an instrumental perspective, participants considered the technical failures that might occur in relation to children's safety. In such cases, most participants assumed that the teacher should be responsible for managing safety suggesting the inclusion of an alarm that might alert teachers to possible malfunctions. A second issue raised was in relation to keeping the technological equipment intact from children who might vandalize the robot intentionally or unintentionally. One participant drew on existing experiences to explain this: *"There could even be, you know, issues of students putting graffiti on this robot. I mean, it happens in textbooks all the time when they're growing up. Um, they could purposely try to sabotage it, make it slip, spill their drink, water, whatever. Spill water on it. It's always a possibility"* (P, M, SE). Whilst participants had accepted their responsibility to upkeep students' safety, when it came to the robot's safety, they did not view themselves as responsible. In the words of one participant, *"I mean, a teacher… that's taking resources away from the school itself if they're dedicating a teacher to follow the robot. I mean, isn't the purpose of it to be independent aid to the teacher?"* (P, M, SE). Drawing from findings reported in other sections, whereas teachers wanted to control the use of classroom robots, when it came to being responsible for the robot's wellbeing they relinquished this control. Despite this, most participants argued that they would only consider leaving mature students whom they trusted to be alone with the robot in line with their institutional expectations: *"It depends also on how much you can trust the kids as well. Because it is always going to be your fault if something goes wrong"* (P, F, UK). Some did not consider primary school students mature enough to handle a robot on their own at all, e.g. *"if they are primary school students, it's a different kettle of fish, isn't it? They're just learning for the first time. They've got no idea what to do. You need to outline and structure things for them. I mean honestly you need to manage it. You can't just be like: here's a robot"* (P, M, UK).

4.4.2 Ethical responsibilities

Besides these instrumental issues, participants considered the ethical dimensions of responsibility. Whilst they wanted classroom robots to function as teacher aids, some participants questioned whether teachers would ultimately become passive and afford a robot too much responsibility, as in the following excerpt: *"I think that teachers should be more involved, definitely. Because otherwise you just slacker, so they (students) can do whatever they like. They are children, they need restrictions, and they need guidance, as well"* (P, F, UK). This was negotiated in some of the focus groups such as for example, in Portugal. Even though some of the participants were intrigued by the idea of allocating responsibility to a robot and engaging in a reciprocal long-term companionship, they concluded this technology was not trustworthy and they could come to depend on the robot's (inaccurate) judgment. Moreover, our participants grappled with their responsibilities toward the students. There was uncertainty as to who would be held accountable if classroom robots were designed or used in ways that were harmful to children. As one participant exclaimed: *"What if they actually have caused emotional damage to a whole generation of children? Then what do you do? Who puts that right?"* (P, F, UK). Another participant considered the same issue highlighting that assigning robots with moral accountability was not possible: *"I think it's strange, because you can't tell the robot: why you call my students stupid? Whereas with a person you would be able to say that is inappropriate behavior"* (P, F, UK). A few participants believed that educational harms would be easier to trace back to particular actors: *"I mean, it depends. Unless it is bad programming and the robot is teaching everything upside down… In this situation maybe the responsible is the person that has programmed the robot. It depends on the damage it causes"* (T, F, PT). In the case of avoiding harms to learning, some participants were confident that teachers (who advocate the use of robots) could assume some authoring responsibility to avoid missing an important pedagogical perspective. Broadly, in not feeling confident in the harms that could occur (see Section 4.3), participants pointed out the importance of investigating the possible consequences of using classroom robots in their local, situated contexts before scaling up to the level of classes and schools.

5 Discussion

In this study, we conducted focus groups with 77 pre-service and practicing teachers in Sweden, the UK and Portugal concerning their perspectives on social and ethical implications of classroom robots. Rather than exploring ways to facilitate greater stakeholder acceptance, this study aimed to "contribute to debates about how research outputs may lead to unintended future consequences" (Eden et al. 2013) through discussions with teachers, who serve as one of the primary stakeholder groups for classroom robots, and indeed any classroom technology. The participants were probed through the use of video and a vignette. Broadly formulated, open-ended questions asking about privacy, effects on children, responsibility, and roles were posed to elicit their ideas and perspectives. Through an interpretative thematic analysis, it was found that teachers' views on ethical implications of classroom robots draw on both moral and practical reasoning.

Not much research had been devoted to the ethical and moral perspectives on classroom robots prior to this study. Shortly before we submitted this paper, however, Sharkey (2016) published a conceptual paper analyzing the ethical implications of robot teachers. Substantiating the goals of the current study she argues that "[r]obotics has progressed to a point where there is a real possibility of robots taking on social roles in our lives, and it has become crucial to look at the ethical issues raised by such developments. We need to think about where robots can and should be used, and where they would be best avoided, before we travel too far along a path towards complete automation" (Sharkey 2016). She raises important ideas surrounding issues of privacy, attachment, deception and loss of human contact, as well as control and accountability. However, what she was unable to address was the practical context of the classroom in which the teachers operate, such as the teachers' struggles with a strained educational system in which a classroom robot would be perceived as yet another burden. As has been argued earlier, roles and applications of robots should also be based on empirical data and the views of stakeholders (Beer et al. 2014; Schomberg 2007). This strengthens our belief that teachers and other stakeholders can and should indeed be invited to take on a more active role in the type of research presented here. As our study shows, whilst teachers are concerned about making teaching and learning efficient, first and foremost, they exercise a duty of care where the well-being of children is their most prominent concern.

Focusing on teachers' professional context, participants felt unable to exercise both their duty of care as well as their teaching responsibilities to their fullest due to limitations imposed on their teaching role in contemporary society. While this led them to consider robots as a possibility for time alleviation, it also caused fears that teachers would come to be replaced, similar to perceptions reported in previous studies (Serholt et al. 2014; Wu et al. 2012). Although recent empirical work has indicated that current robots do not measure up to human tutors in terms of students' learning outcomes (Kennedy et al. 2016), the effectiveness of the technology may improve as the technology becomes more advanced. From this perspective, our participants exhibited a need to defend their roles, emphasizing that children need their human teachers for their socio-emotional development. This could be seen to draw on the moral conviction that human contact is preferable even if it becomes less efficient (Heersmink et al. 2014; Nordkvelle and Olson 2005; Turkle 2006) resonating with the conclusions drawn by Sharkey (2016), namely that "[f]irst and foremost, children need to be taught by fellow human beings who understand them, care for them, and who form appropriate role models and attachment figures".

Although Sharkey's (2016) paper was not based on empirical data, her analysis was very similar to what we have interpreted here, albeit some variations in the use of terms. She, too, raises the issue of privacy, drawing attention to who might access children's sensory data as well as the potential infringement following emotion detection. Personalization of learning has been become increasingly applied in recent years. Whether this be pedagogically (Leyzberg et al. 2014) or emotionally (Castellano et al. 2013) it requires collection of data. Sharkey (2016) points out that legal frameworks are not yet able to guarantee the security of this data, and asks whether it is "too farfetched to imagine that, in the future, robots might be used to categorise and monitor children's behaviours; keeping a record of disruptive behaviour, or alerting the teacher?" As Foucault (1975) argued, such practices could potentially have devastating consequences wherein the monitored party experiences a sense of psychological imprisonment. Taking this further, if children feel that their emotions are under scrutiny, they might not only regulate what they *do*, but also how they *feel*. Indeed, our participants were concerned about ensuring children's privacy when discussed in relation to data on emotions, as this kind of data could provide insights into students' sensitivities that could be interpreted and exploited by third parties in new ways. At the same time, most participants considered it important that teachers are granted access to their students' data in one way or another, while recognizing that students would likely be upset about it (if they became aware of this). Thus, it seemed contradictive in the sense that students had a right to their privacy in the face of third parties (which was clearly their expressed standpoint), but not in the face of the educational institution. This study therefore provides a possible answer to Sharkey's question, namely that there might be a temptation for the institution to take part in children's data when such practices become possible. It was only when the discussion was framed from a moral standpoint that our participants argued that students should have control and the right to decide what kind of data is kept about them in school. From a design perspective, this requires understanding of what data a robot actually stores so that teachers and students are able to make informed choices, making transparency a pressing need if robots are embedded in classrooms.

Furthermore, our participants questioned a robot's ability to discern children's emotions, creativity, intentions, etc. It was considered unlikely that affect recognition could account for the complexity of human nature, whereby the chance of a robot truly understanding students' feelings was considered unfeasible. In line with this view, they raised a number of factors that could come to make this problematic, such as cultural and inter-individual differences among children, creativity, children's development as well as the uniqueness of the sociocultural context itself. Extending this view, the purpose of a robot is not simply to understand a situation, but rather to respond to it. Sharkey (2016) argues that this requires a sense of morality, which itself is biologically based. Although Sharkey recognizes that a robot could act in accordance with pre-programmed rules, it would nevertheless depend on the anticipatory work carried out by the programmers who are not immersed in the particular context. Our participants also exhibited a distrust toward such rule-based approaches, especially since they as teachers would not be able to "look under the hood" to understand how the robot determined its specific actions. It might therefore be worth considering how to design algorithms in such a way that they can be scrutinized by end users so that for example teachers are confident in judging the underlying mechanisms of a robot's interpretations. Once again, the need for transparency is highlighted.

As argued by Beer et al. (2014) an empirical base should be used to guide what roles robots should play in different settings. Our study suggests that certain tasks are not desirable for robots to carry out due to the implicit roles that accompany them. Making assessments about students' learning processes seems to be one such task. Apart from our participants' opinion that robots could not manage difficult assessments due to a lack in understanding, it was also argued that such practices could lead to students and teachers affording too much trust and responsibility to robots. As argued by Friedman and Kahn (1992) delegating decision-making to a computational system (in this case a robot) runs the risk of developing into a scenario wherein *questioning* the authority of a system is perceived as *questioning* the community as a whole. Indeed, our participants discussed the possibility of students affording more credibility to the robot over their teacher if the two disagreed. In line with the argument expressed by Sharkey and Sharkey (2011) about encouraging children's "robotic" literacy, our participants also recognized the value of this approach in mitigating such overconfidence in robots' capabilities. Robots were therefore seen as best put to use in instrumental roles wherein their autonomy would be limited.

There were a number of conflicting views expressed concerning anticipated social implications of using classroom robots. Some students might engage in a dominant relationship (Kahn et al. 2013), others might try to engage in a reciprocal relationship (Turkle 2006), while yet others might become avoidant or hostile towards robots, in some cases exhibiting aggressive behaviors as seen in (Nomura et al. 2015). This hostility could be rooted in a lack of reciprocity, i.e. that children felt their emotional borders violated by a machine that could interpret their emotions, while not having any itself. Unlike the study by Nomura et al. (2015), our participants thought of potential sabotage as a conscious act by students who were unwilling to be deceived by a robot; not a lack of empathy or an intrinsic moral compass. If, on the other hand, students felt that they had a reciprocal relationship with a robot, participants thought that students would respect it – not abuse it.

Participants also considered risks associated with students interacting with robots "too much" for their own emotional well-being, as well as the consequences thereof for their human relationships. Since robots can appear or behave as though they are "alive", there is a risk that this can come to influence children's definitions of "aliveness", and subsequently how they treat the people around them. This could be manifested by children not understanding the consequences of their actions on other people, or by a deficit in emotional intelligence wherein appropriate emotional understanding or emotional display would not be learned. In other words, interaction styles with robots could become prescriptive in terms of what is deemed to be acceptable human treatment and in that way carry over to human relationships (Kahn et al. 2013). Likewise, this was also considered to take on physical characteristics in the speech patterns of children, i.e. children becoming more "robotic" in their speech both vocally and linguistically. Robot mimicry has been observed previously (Kahn et al. 2007; Ros et al. 2014), so it would not be surprising if children adopt robotic mannerisms.

Unlike certain other technologies (e.g. laptops and tablets) that have been implemented in education, robots are not ubiquitous. When discussing potential benefits or problems of classroom robots, the participants explained that it was not simply a matter of anticipating effects but also about experimenting with robots and seeing the consequences. We can see a problem here that extends the case of classroom robots, namely that technologies are often designed and developed by corporations or research institutions and subsequently applied to education with ethical grounds lacking. Even if we look at examples of ubiquitous technologies, social implications have only been revealed after some time. For example, Turkle (2015) raises concerns surrounding how the modern use of smartphones has altered the way in which people communicate and has caused deficits in people's ability to recognize the importance of true conversation. She worries that empathy and communication skills will be impeded in coming generations, and argues that "this isn't a game in which we can cross our fingers and hope that the good will outweigh the bad". Indeed, once implications are acknowledged, it becomes more difficult to alter the use of technology on ethical grounds because it will have become culturally grounded. This problem has been referred to as the Collingridge dilemma which states that "at early development stages consequences are difficult to predict whereas at later stages where consequences become clearer the trajectory of the development becomes more difficult to change" (Stahl et al. 2013).

Assigning responsibility for negative consequences for children is not straightforward. Teachers may be willing to assume existing responsibilities to keep children safe but might not be willing to assume new ones that are imposed by the technology. On the one hand, the participants recognized that certain harms were easier to address than others, e.g. physical safety in the classroom. From this perspective it was assumed that they as teachers would have to manage student-robot interactions. Yet this made them question whether such practices would take resources in the form of teaching time away from the school that could be better spent elsewhere. On the other hand, social or emotional harms on children were more difficult to address in terms of who would be responsible for mitigating them or being held accountable if they occurred. Our participants suggested that developers should be responsible, which Gill (2008) argues is an unreasonable expectation. They did not consider the possibility of a robot being morally responsible as proposed by Kahn et al. (2007), suggesting that they were far away from ascribing agency onto robots. If, then, robots assume the status of a quasi-agent as described by Asaro (2007), there is a risk that teachers as consumers are held accountable for potential damages caused by a robot; a technology for which teachers currently have a limited understanding of. This illustrates the responsibility gap identified in previous literature (Marino and Tamburrini 2006; Matthias 2004) where neither teacher, nor robot, nor developer is able to assume the appropriate level of control in order to be considered responsible. Given the vulnerable nature of children and the precedence of a healthy upbringing within the educational system, the issue of responsibility from both a legal and ethical perspective needs to be properly addressed before classroom robots become a common occurrence in education.

5.1 Limitations and future work

This study aimed to facilitate participants' deliberations of ethical dimensions of classroom robots. However, the fact that the participants lacked personal experience with robots called for much speculation on their part, while perhaps also being influenced by popular media. It is possible that the participants would raise other issues if they had acquired experience with robots. Although we tried to address this problem by exposing participants to a video and a vignette, the technology as such is not commercially available so consequences may be difficult to predict and discuss. Indeed, it was sometimes difficult for participants to consider what was desirable if they did not believe it to be feasible. For example, if they did not believe that a robot could actually handle children's social and emotional expressions, it required some effort to get to the point where they could discuss whether they considered this desirable or not. Therefore, a suggestion for future research is to conduct deliberations with teachers following potential experiences of using classroom robots.

While this study tried to reveal a broad range of ethical dimensions by including both pre-service and practicing teachers, as well as participants from several countries, we need to acknowledge that the study was limited to countries in Europe. The inclusion of other countries with very different educational profiles and access to educational technologies could reveal additional ethical dimensions. Thus, we hope that more researchers will follow suit in conducting similar studies in their respective countries in order to broaden the spectrum of ethical dimensions of classroom robots.

6 Conclusion

The aim of this work has been to shed light on what *might* be expected based on the educational and professional experience of both pre-service and practicing teachers, who currently or in the future will spend their days devoted to children's life-long learning and socio-emotional development. From the perspective of Responsible Research and Innovation, it can be deduced that discussions with teachers have revealed a certain ambivalence in regards to classroom robots. This ambivalence seems to be rooted in teachers' care for children and their futures. The way in which they discussed different issues suggests that they felt an emotional obligation and moral responsibility to uphold children's rights to a healthy upbringing within the educational context. When our participants considered ethical perspectives and social implications of introducing robots in the classroom, they were willing to consider robots as a teaching tool to facilitate children's "robotic" literacy. Yet, when faced with the possible reality of autonomous classroom robots, several questions arose which need to be addressed by the field.

First, the privacy of children's data might become compromised following the implementation of classroom robots, especially in regards to the granularity of affective data. There need to be discussions on how to mitigate such risks. Second, robots could intentionally or unintentionally be afforded too much responsibility, whereby necessary boundaries between teachers and robots are lost. This needs to be addressed from the perspective of what level of autonomy a classroom robot should be given. Third, robots could potentially affect children in negative ways, whereby the risks are considered to outweigh the possible benefits. Here, it is important to explore classroom robots from a long-term perspective, where teachers need to be included and consulted. Fourth, it is not clear who should be responsible for a robot, or who could be held accountable if any negative consequences for children are realized. This needs to be debated legally and ethically so that responsibilities are made explicit for everyone involved. Even so, risks are not always worth taking simply because someone could be held accountable for negative consequences. It is therefore vital that researchers in the field of educational robotics move forward carefully while bearing the following question in mind: What responsibility do we have?

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