Understanding the Value Co-creation Potential of Social Robots in Primary School Education

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Abstract

While social robotics have great value creation potential in education, their fit remains unclear, and usage limited. We utilize the lens of Service-dominant (S-D) logic in investigating how value co-creation (and co-destruction) may occur among actors in the educational use of social robots. Our thematic analysis of 10 qualitative interviews with primary school teachers underscores that social robotics herald value co-creation potential by complementing traditional classroom teaching, enabling student engagement and motivation, and supporting teachers in their work. In addition, we identify value co-destruction dimensions relating to teachers' earlier experiences, attitudes and prejudices towards social robots which could lead to resistance to change and inequalities between teachers and students. This study extends previous understandings of educational social robot use and offers practical guidance to educators and authorities on the matter.

Keywords: Social robot, Education, Service-Dominant Logic, Value Co-creation, Value Co-destruction

1. Introduction

Technological developments and the increasing importance of digital literacy require educators and students to learn and transform at an unprecedented rate (OECD, 2015). Such developments increase the responsibility of schools to act as facilitators of change (Tanhua-Piiroinen et al., 2019). Utilizing school-provided educational technologies in primary education has substantial benefits such as the potential to improve students' digital literacy and increase equity, as well as address the increasing demand for teachers and reduce administrative costs (OECD, 2015). At the forefront of emerging educational technologies are social robots i.e., "physical entities that operate in complex, dynamic and social environments, behaving according to their own and others' goals (Duffy, 2000)". Social robots offer vast value creation potential providing personalized and relentless learning experiences unlike other educational technologies (e.g., Belpaeme et al., 2018). As the physical and social nature of the robot can be combined with the benefits of technology, such as customization, scalability, and ease of adding educational content (Kory Westlund et al., 2017), social robots may enable effective exchange of resources and value co-creation between the involved teachers and students (Vargo & Lusch, 2016). For instance, social robots can promote peer collaboration and teamwork among students, leading to value creation in terms of improved learning outcomes and social skills (Tanaka et al., 2012).

However, teachers' personal features such as skills, preferences, and attitudes impact the application of technologies in schools (e.g., Blackwell, Lauricella & Wartella, 2014), putting a strain on the evolving teacher roles, long-term routines, and the balancing between personal preferences and governmental requirements (e.g., OECD, 2015). Therefore, to realize the value co-creation potential of social robots more effectively in the classroom, it is of utmost importance to attain an in-depth understanding of teachers' attitudes, opinions, and visions on their usage. Such insights could be harnessed in the design of social robotics for enabling value co-creation in teacher-robot-student interactions (cf. Tuunanen et al., 2023).

Service-dominant (S-D) logic is a meta-theoretical framework for viewing any interactions between social or economic actors as exchange, wherein resources, such as knowledge, skills, and other assets, are being integrated for mutual co-creation of value (Vargo & Lusch, 2004, 2008). Here, value is considered as an emergent improvement in the well-being of the actors involved in such service exchange (Vargo, Maglio & Akaka 2008). However, as artificial intelligence (AI) and robot-based service functions are increasingly common across contexts, a shift emerges in the way value is co-created and derived by the human and non-human actors involved (Kaartemo & Helkkula, 2018; Lumivalo et al., 2022). Recent studies have examined value co-creation in the use of social robotics in tourism

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(e.g., Ivanov & Webster, 2019), elderly care (Čaić, Odekerken-Schröder & Mahr, 2018), and higher education (e.g., Dollinger, Lodge & Coates, 2018), but more research is called for on the phenomenon (Ostrom et al., 2021). Especially within primary school education, a research area that has remained relatively understudied, social robotics assumes a pivotal role as a context for investigation. It harbors numerous potential advantages that, despite their promise, are hindered by evident frictions and challenges perceived by users.

Motivated by this background, this study addresses the research question "*How can social robots co-create or co-destruct value in primary school education from the perspective of the teaching staff?*". Accordingly, semi-structured interviews (Myers, 2019) (n = 10) and thematic analysis (Braun & Clarke, 2006) were conducted with the aim of identifying and understanding the dimensions of value co-creation and co-destruction in the service exchange between teachers and students utilizing social robots. We discuss the emerging value co-creation and co-destruction potential of social robots in terms of three complementary themes, i.e., 1) perceptions of and attitudes toward social robots in education, 2) fit of social robots in education, and 3) hedonic and utilitarian aspects of the use of social robots in education. The insights gained from this study can be valuable to researchers and practitioners in the field of education, as well as authorities who are interested in introducing social robots in primary schools.

2. Theoretical background

In this section, we take a closer look at the related work on S-D logic, value co-creation and user-based values, as well as social robots in educational use.

2.1. Service-dominant (S-D) Logic lens for Value Co-creation

Traditionally, value has been seen as embedded in a product and created in the manufacturing process, i.e., as value-in-exchange. Vargo and Lusch (2004) introduced an alternative framework, the S-D logic, for explaining value creation as an interactional value co-creation process between actors, such as customers and providers, or teachers and students, involved in mutual service exchange. The S-D logic view considers that value, which in general terms is an improvement in wellbeing, emerges as 'value-in-use' in service exchange between actors (Vargo, Maglio & Akaka, 2008). Accordingly, S-D logic refers to value co-creation as the process where multiple involved actors integrate possessed resources, acting as value co-creators in service networks and ecosystems (Vargo & Lusch, 2008). For example, value can be created through specific activities such as co-design and collaborative problem solving, customer self-service, or generally through any interaction such as dialogue between actors (e.g., Minkiewicz, Evans, & Bridson, 2014).

While the value and the use of technology-enabled services have been traditionally investigated from the perspective of perceived benefits, such as efficiency, more recent studies show that the service exchange may be driven by divergent utilitarian (i.e., benefit-driven), or hedonic (i.e., pleasure-driven) personal drivers (e.g., Van der Heijden, 2004) and/or their hybrid combinations (Tuunanen, Lintula & Auvinen, 2019). While technology has typically been considered a resource, an enabler, of such services, recent technological advancements have started to shift machines and technologies closer to the role of actors in service exchange (e.g., Lumivalo, Tiilikainen & Elo, 2022). In other words, it is established that non-human actors, such as social robots, may obtain agency in service exchange (Čaić et al., 2018; Kaartemo & Helkkula, 2018.). Additionally, suboptimal outcomes may emerge from such interactions. Such a *value co-destruction* process may be intentional or unintentional, and occur for instance, through lack, misuse, or loss of resources in service exchange (Lumivalo, Tuunanen & Salo, 2023; Plé and Chumpitaz Cáceres 2010).

2.2. Social Robots in Education: Fit and Challenges

Technology-integrated education has a key role in the 21st century classrooms (Weisberg, 2011). Various technology-integrated educational approaches are used in the classrooms like flipped classroom (Bergman & Sam's, 2012), blended learning (Graham, 2006), inquiry-based learning (Harwell & LeBeau (2010), personalized learning (Pane et al., 2015) and mobile learning (Sharples et al., 2009). Social robots, which are "physical entities that operate in complex, dynamic and social environments, behaving according to their own and others' goals (Duffy, 2000)", are at the vanguard of the most recent educational technologies and can offer value such as personalized and consistent learning experiences that other educational technologies cannot (e.g., Belpaeme et al., 2018). For instance, new, gamified perspectives on traditional technology-integrated approaches such as flipped classroom and blended learning have been implemented with social robots (Kennedy et al., 2015). According to Fong et al. (2003), social robots must be able to 1) express and perceive emotions, 2) engage in high-level dialogue, 3) form social relationships, 4) use natural cues such as looks and gestures, 5) exhibit personality and character, and 6) learn from others. Social robots are typically designed with an anthropomorphic appearance to facilitate symmetrical social communication and experience (Breazeal, 2003; Duffy, 2003).

The impact of social robotics on human interactions and distorted expectations about robot capabilities, as well as their privacy and security may create ethical challenges (Fridin, 2014; Smakman et al., 2021). Historically, as robots became more widespread it was necessary to establish ethical code for the discipline, so Asimov (1976) defined the Three Laws of Robotics: 1) A robot may not injure a human being, or, through inaction, allow a human being to come to harm, 2) A robot must obey orders given it by human beings, except where such orders would conflict with the First Law, 3) A robot must protect its own existence as long as such protection does not conflict with the First or Second Law. Today, ethical challenges emerge for example, as regular interaction with an artificial, social robot may lead to reduced social interaction or stunted social and emotional development (Smakman et al., 2021). Social robots may also create an ethical dilemma from the perspective of Asimov´s (1976) Second Law, as in the role of teacher or tutor, the robot acts in an authoritative position in relation to the human (Fridin, 2014).

Social robots, as any technology-enabled services, have been explored by comparing baseline and end-of-course tests, and their use has been found to be beneficial for students' learning. Further, social robots may increase student engagement and motivation, help students to develop their problem-solving skills, and improve their language and critical thinking skills (e.g., Alemi et al., 2014; Köse et al., 2015; Mubin et al., 2019). However, the fit of social robots in classroom use remains unclear as they are preferred in repetitive and simple tasks (Smakman, Vogt & Konijn, 2021). Subsequently, further research is called for into social robots' use in education.

2.3. Educational Value Co-creation and Co-destruction with the Use of Social Robots

Social robotics is a relatively new domain with enormous value co-creation potential in various types of service ecosystems, such as healthcare (e.g., Čaić et al., 2018), hospitality (e.g., Ivanov & Webster, 2019), and education (e.g., Belpaeme et al., 2018). Social robot users derive value based on subjective and contextual experiences (e.g., Vargo & Lusch, 2008) and expectations that users have before the service encounter occurs (Oliver, 2006). As any technology-enabled services, social robots have certain system features, to which users project their personal goals and values for consideration to produce desired outcomes (e.g., Tuunanen & Peffers, 2018). Therefore, to realize the value co-creation potential of social robotics (e.g., increasing student engagement and motivation, helping students to develop their problem-solving, language and critical thinking skills), obtaining an in-depth understanding of users and their perceptions becomes essential for system design and development (Elo et al., 2022; Tuunanen et al., 2023).

Previous literature has discussed the educational use of social robotics, but not specifically with the S-D logic lens and the perspective of value co-creation. The literature showcases that social robots mostly adapt to the roles of a teacher (e.g., Alemi et al., 2014; Eimler et al., 2010) or a learning partner (e.g., Serholt, 2017) in language studies (e.g., Köse et al, 2015; Kanda et al., 2004), mathematics (e.g., Mubin et al., 2019) and geography (Serholt, 2017) to name a few examples where social robots ask multiple-choice questions on particular subjects and record the answers given by students. The robots then confirm if the answers are correct. Social robots can personalize the lessons through non-verbal behavior, such as precision and timeliness of movements, and eye contact (Baxter, de Greeff & Belpaeme, 2013), and verbal behavior, like addressing the learner by name (Tanaka & Matsuzoe, 2012) and providing feedback and guidance. To better engage children in different learning situations, other resources, such as playfulness and gamification, are often integrated into lessons (Alemi et al., 2014). For example, in a study by Serholt (2017), elementary school children engaged with a social robot for 3.5 months in different learning scenarios, including a collaborative game where they, along with the robot, constructed a sustainable city. The game involved building structures, making upgrades for energy efficiency, and implementing city policies.

S-D logic provides a suitable lens for viewing all the involved actors as potential co-creators of value and beneficiaries of social robot-enabled service exchange (Vargo & Lusch, 2016). Drawing from the S-D logic approach, such service exchange requires resource integration from the students, teachers, and social robots alike (e.g., time, effort, and learning materials), and enables the derivation of positive (and/or negative) value (such as learning, efficacy, enjoyment, and data acquisition) for each of the involved human and non-human actors (Kaartemo & Helkkula, 2018). We consider the lack of previous S-D logic research on the educational use of social robotics a shortcoming, especially in terms of the potential inertia identified in the adoption of such technologies in classrooms. Also, technology-enabled value co-creation (Breidbach & Maglio, 2016; Tuunanen et al., 2023), and particularly service exchange mediated or enabled by AI applications and robotics (Ostrom et al., 2021), has been under-researched. This study aims to address both research gaps.

3. Research Methodology

3.1. Data Collection: Preliminary survey and semi-structured interview

This study uses a qualitative approach to explore teachers' perceptions of social robotics in primary schools. The aim is to identify and describe the value co-creation and co-destruction potential of social robotics-enabled service exchange in primary education. To ensure the selection of participants with an interest in technology and robotics, a preliminary survey was conducted. This survey aimed to identify lead users who are interested in technological innovations and can express their ideas regarding potential use of technologies creatively. Identifying lead users helps mitigate risks associated with data collection, such as participants' lack of experience with new technologies or motivation (Tuunanen & Peffers, 2018).

Thereafter, we employed semi-structured interviews, an intermediate form of structured and unstructured interviews based on the focused interview of Merton, Fiske, and Kendall (1990). The semi-structured interview frame follows the recurring themes in the literature and consists of an open-ended set of questions which are not tied to predefined answer options (Myers, 2019). The interview frame was formed based on the literature review and the responses of the preliminary survey. The frame comprehended four main themes: users' perceptions of and attitudes toward social robots in education, fit of social robots in education, hedonic aspects of the use of social robots in education, and utilitarian aspects of the use of social robots in education. One of the authors interviewed 10 primary school teachers via the Zoom video conferencing tool. The conducted interviews averaged 54 minutes, and they were recorded and transcribed. Among the interviewees, 50% were classroom teachers, 30% were craft teachers, and 20% were foreign language teachers. All interviewees had a minimum of 5 years of teaching experience, with an average of 11-15 years.

3.2. Thematic analysis

Thematic analysis was chosen as the method of analysis since it provides a flexible way understand focal contents emerging in a set of qualitative data (Braun & Clarke, 2006). The purpose of thematic analysis is to interpret the data and the emergent themes to facilitate an in-depth understanding of the phenomenon under study. Thematic analysis generally aims to illustrate themes and issues that are relevant to the research topic and questions (Braun & Clarke, 2006). The process of identifying focal contents and their connections in the data involved the following steps. First, the transcripts were carefully read and analyzed to gain familiarity with the data. Second, a coding process was employed to label and categorize relevant portions of the transcripts. This involved assigning descriptive codes to specific statements or passages that captured key concepts related to the research and research question. These categories were assigned with labels indicating potential for value co-creation (i.e., reported positive perceptions related to the use of social robotics) or value co-destruction (i.e., reported negative perceptions related to the use of social robotics). The coding process led to the identification of altogether 13 value co-creation dimensions and 12 value co-destruction dimensions. Subsequently, in the final step, the developed codes were assessed and grouped with the lenses of the conducted literature review into three themes, namely perceptions of and attitudes toward social robots in education, fit of social robots in education, and hedonic and utilitarian aspects of the use of social robots in education.

While the first theme focused on primary school teachers' perspectives and experiences, including their roles and responsibilities, and perceptions of varied and individualized teaching, the second theme explored the fit of social robots in the teaching environment including challenges associated with their implementation. The third theme integrated highlighted the intersection of hedonic and utilitarian aspects of using social robots in education. By assessing these three thematic areas, a comprehensive understanding of the studied phenomenon was formed.

4. Findings

We present the findings of the study in sub-sections complying with the themes emerging in the thematic analysis. Within each sub-section, the identified value co-creation and value co-destruction dimensions are discussed (cf. Table 1 and Table 2).

4.1. Perceptions of and Attitudes toward Social Robots in Education

One value co-creation dimension, namely *diversifying teaching*, and three value co-destruction dimensions, namely *lack of pedagogical purpose, lack of resources*, and *attitudes and prejudices,* were identified in the first theme. The interviewed teachers reported to not being expected to merely possess and disseminate information to students, but rather to facilitate value co-creation by engaging with students in a diverse, guiding and learner-centered manner to support the development of learning skills. For varied teaching, the appropriate activities and contents needed to be chosen so that they supported the learning objectives. The informants reported that technology, such as computers, tablets, 3D-printers, as well as

Table 1. Value co-creation dimensions and descriptions across themes

Theme	Co-creation Dimension	Description	Evidence
Perceptions of and Attitudes toward Social Robots in Education	Diversifying teaching	A social robot enhances learning by promoting student engagement and skill development through trial and error, complementing traditional teaching	Informants 3,4,5,6,10
Fit of Social Robots in Education	Simple task assistance	A social robot helps students learn and practice simple tasks like multiplication tables and language vocabulary, building on their prior knowledge	Informants 3,4,5,6,7,9
	Supervision and support	A social robot facilitates and complements the teacher's work by supervising students and helping those who need assistance	Informants 1,3,8,9
	Individualizing teaching	A social robot adjusts the difficulty of a learning task according to the student's performance and current skills	Informants 4,6,9
	Instructions and feedback provision	A social robot provides instructions and feedback on learning tasks which enables students to start the task and monitor their progress	Informants 1,2,3,4,5,7,9
	Enabling longer periods of work	A social robot enables longer study sessions to students when needed which increases the effectiveness of learning	Informants 3,7
	Scalability of education	A social robot promotes equal learning experiences across different ages and subjects, enhancing efficiency of use and student equality	Informants 2,3,8,9
Hedonic and Utilitarian Aspects of the Use of Social Robots in Education	Equal and sensitive treatment	A social robot treats everyone equally, fostering comfort, trust, and equality among students	Informant 3
	Fun and excitement	A social robot is fun and exciting for students, integrating movement, color, music, and playfulness	Informants 2,3,4,5,6,7
	Motivation and engagement	A social robot motivates and engages students to participate in doing learning tasks and learn skills	Informants 1,3,7,10
	Peer-tutoring	A social robot enables student peer-tutoring, promoting student-centered teaching and equal learning opportunities	Informants 3,9
	Fostering self-regulation of learning	A social robot monitors, documents, and reflects on learning tasks, enabling students to self-regulate, track progress, and receive encouragement	Informant 2
	Downward and upward differentiation	A social robot can provide support and encouragement to students at different levels and facilitate learning and motivation	Informants 2,3,8

different learning environments and games, and streaming services, were commonly used in classrooms, affording students to learn important skills quickly.

However, students' interest and motivation were severely affected if lessons were fixed/repetitive. Therefore, more advanced technology, such as social robots, was considered not only a necessary or fun addition, but also pedagogically purposeful.

> *Money is such a big brake -many just think that "Okay, that is the cheapest package, let's take that", so not necessarily the best pedagogical solution (Informant 6).*

The interviewees considered that teachers' attitudes and prejudices influenced social robots' adoption. However, among the informants, previous familiarity with robotics did not have a major impact on attitudes. While the interviewees personally considered robots as a positive addition to teaching practices, they reported to witnessing mostly opposite opinions from their peers. The teachers considered that courage and willingness was needed to adopting social robotics. The introduction of robots could create inequalities between teachers, as not all would want or have access to robots.

> *The biggest threshold why there are not more robots in classrooms is teachers' fear of not knowing how to use them (Informant 3).*

4.2. Fit of Social Robots in Education

In the second theme, six value co-creation dimensions were identified, namely *simple task assistance*, *supervision and support*, *individualizing teaching*, *instructions and feedback provision*, *enabling longer periods of work*, and *scalability of education*. However, also five value co-destruction dimensions emerged within the theme, namely *complex and explanation-intense tasks, lack of personalization,* *summative assessment style, battery life, expenses, and inequal distribution,* and *privacy and security challenges*. Many interviewees saw the introduction and use of robotics in education as resting on the shoulders of a few interested teachers, often a digital tutor. It is important to note that just two out of ten interviewees had used a social robot that offers learning experiences through social interaction, and in only two of the schools, robotics was offered among the optional studies. The main aim of the use of robotics was identified as teaching students skills such as planning, documentation, teamwork, and information retrieval. The respondents did not see a need to remove or add extra items (e.g., robotics classes) in the curriculum, but rather to integrate robotics into suitable subjects such as mathematics and environmental studies. Subjects and tasks that require repetition, such as multiplication tables or foreign language vocabulary training, were regarded as one of the strongest application areas for social robots.

> *You can drill pronunciation and words with it for hours, so from a learning perspective, the robot is ideal (Informant 3).*

Some of the informants would have preferred for the robot to be present with all students at the same time, while others would have divided the students into smaller groups of 3-4 or even individually with the robot. However, the evenly distributed and regular presence of the robot was considered essential, ensuring that the robot would serve a useful purpose on a daily, weekly, or monthly basis. Robots were considered best suited as students' learning buddies, i.e., as engaging co-learners, or as a teachers' assistants.

While social robots can give simple instructions and feedback to students, some interviewees questioned whether the summative assessment style used by social robots really promotes learning. Based on the completion of the learning task, the robot could potentially personalize the teaching by adapting its own activities to the learner's abilities, i.e., by adjusting the

Table 2. Value co-destruction dimensions and descriptions across themes

Theme	Co-destruction Dimension	Description	Evidence
Perceptions of and Attitudes toward Social Robots in Education	Lack of pedagogical purpose	Some teachers may not believe in the ability of social robots to teach students and enable them to learn new skills, which hinders the use of social robots and creates inequalities between teachers and students	Informants 2,3,8
	Lack of resources	A social robot may remain unpurchased due to limited resources which creates a complete barrier to value co-creation	Informants 6,8
	Attitudes and prejudices	A social robot can be associated with negative attitudes from teachers, preventing the use of social robots and creating inequalities between teachers and students who are able to learn with social robots	Informants 1,2,7
Fit of Social Robots in Education	Complex and explanation-intense tasks	A social robot is unable to teach complex and explanation-intense learning tasks to students, which limits the intended use of social robotics across subjects and learning tasks	Informants 4,9,10
	Lack of personalization	A social robot's lack of ability to recognize students' individual traits or external factors limits the personalization of the service, resulting in reduced trust and empathy	Informants 1,2,4,5,6,8
	Summative assessment style	A social robot's binary and short-term feedback encourages harmful learning patterns like brute force, hindering students from developing a deeper understanding of the subject or task	Informants 2,8
	Battery life, expenses, and inequal distribution	Limited battery life, expenses and inequal distribution between schools and municipalities creates barriers to perceived value co-creation potential	Informants 3,8,9
	Privacy and security challenges	A social robot's sensitive data collection exposes teachers and students to potential harm through security breaches and system attacks	Informants 2,4,6,7,8,9
Hedonic and Utilitarian Aspects of the Use of Social Robots in Education	Uncertain long-term effects	Teachers are unsure whether social robots can have a positive long-term impact in the school environment	Informants 2,7,8
	Ethical and emotional challenges	Interacting with a social robot can lead to ethical and emotional challenges, such as attachment that damages students' relationships with others	Informants 1,2,7
	Inequal learning opportunities	The lack of resources or reluctance of teachers to use social robots in the classroom can lead to inequalities in learning opportunities for students	Informant 3
	Technical problems	Technical issues with a social robot, like speech recognition problems, can frustrate students and impede their learning progress, compromising the lesson quality	Informants 1,3,4,6

level of difficulty of the tasks. However, it is not able to recognize the individual characteristics of the learner or factors outside the learning task.

> *[Educational games] only let you go ahead when you've answered perfectly right — in the worst case, you go through in brute-force, so you answer differently until you get through, and then you might not learn the relevant content (Informant 8).*

> *Acknowledging individuality or personal features, I think that's a human trait, is it even possible for a robot to learn that? (Informant 4).*

4.3. Hedonic and Utilitarian Aspects of the Use of Social Robots in Education

The third theme focused particularly in potential hedonic and utilitarian outcomes of social robotics use, wherein six value co-creation dimensions were identified, namely *equal and sensitive treatment, fun and excitement, motivation and engagement, peer-tutoring, fostering self-regulation of learning,* and *downward and upward differentiation.* However, also five value co-destruction dimensions emerged, namely *uncertain long-term effects, ethical and emotional challenges, inequal learning opportunities,* and *technical problems.* The hedonic and utilitarian aspects of the use of robots in education were considered to depend on the subject and level taught, and the way the robot was used. Most considered robots to be equal and sensitive tools that create curiosity and excitement.

> *The robot never laughs if it [learning task] goes wrong, it's always kind to the child. It's really fair and equal, it doesn't see gender, age or anything. (Informant 3).*

However, robots would need a longer period of use in school settings to ascertain positive long-term effects, for instance, whether the presence of a robot would affect comfort, enthusiasm, and motivation in a classroom. When teachers were hesitant about taking the initiative to use robots, the familiarization was also regarded as a keen tutoring activity for students, whereby students would teach their peers what they have learned earlier themselves.

The classroom was considered susceptible to sudden changes, wherein the adult in charge needed to be able to react quickly. Therefore, the consensus was that robots could not act as teachers on their own, but they were considered as teachers' assistants engaging in helping students to focus on their learning tasks, for instance. Alternatively, the robot could provide additional tasks for more advanced students, allowing the teacher to spend more time with students needing more support. The robot could also act as a supervisor, using different colors to indicate the noise level in the classroom, i.e., showing a red light when too much noise was detected, monitoring reading tasks and providing immediate feedback on performance with potential implications on students' self-regulation of learning. Technical problems were also raised as concerns by the informants. In addition to electricity cuts, the teachers questioned the speech recognition skills of robots, as they are trained using adults' speech data. Therefore, they may face challenges in recognizing a child's voice and speech. Nevertheless, the informants believed that the learning quality could be restored, as the teacher must have the professional skills to deal with situations where technology has failed. However, some of the informants were relatively concerned about the robots' connectedness to the outside world, whether and where they stored information about their environment, who had access to that information, and if they were vulnerable to security breaches.

5. Discussion

The aim of the study was to utilize the S-D logic lens for obtaining an in-depth understanding of teachers' opinions, attitudes and, to varying degrees, their perceived potential of value co-creation and co-destruction with social robots in the primary school context. Our findings contribute to the current understanding of the phenomenon in a three-fold manner. First, the study supports the S-D logic-footed idea that non-human entities, such as social robots, can be viewed as value co-creating/co-destroying actors in value networks (e.g., Kaartemo & Helkkula, 2018). Our findings illustrate that teachers believe that social robots can engage in a socially rich and guiding manner with students, showcasing potential for value co-creation but also value co-destruction (Lumivalo et al., 2023; Čaić et al., 2018). Drawing from S-D logic (Vargo & Lusch, 2016) and our analysis, we conceptualize that value co-creation and co-destruction may emerge in educational networks through the resource integration occurring between teachers, students, and social robots, wherein each of these involved actors may derive positive or negative outcomes from the exchange. Thus, our conceptualization considers social robots as agentic stakeholders, contributing to the service exchange occurring in educational settings (Kaartemo & Helkkula, 2018; Lumivalo et al., 2022). We identified 13 dimensions wherein value co-creation may occur for the involved actors, and 12 value co-destruction dimensions showcasing potential for the emergence of negative value in terms of social robotics-enabled service exchange in the classroom. The teachers reported the potential of deriving positive value in terms of diversifying teaching, facilitating specifically designed learning tasks, and ultimately, various positive hedonic and utilitarian outcomes in the classroom. However, the data also reveals teachers' experiences of social robotics' conflictive, value co-destruction potential in terms of lack of resources and purpose for implementing and facilitating teaching, a misfit between social robots (i.e., their affordances) and educational/professional needs, and ultimately negative outcomes related to technical issues, learning outcomes, inequality, and ethical problems. The teachers regarded that the students may potentially derive learning efficiency, support, and enjoyment from engaging with social robots in the classroom, but at the same time, concerns emerge regarding students' inequal opportunities for social robot employment, and ethical concerns regarding privacy and learning. Simultaneously, social robot applications themselves were seen to potentially derive value from (successful) employment in the classroom in terms of training, and potentially, increased adoption. Our conceptualization contributes to the existing considerations of social robots in educational settings, as the S-D logic lens and social robots have previously only been viewed in the context of higher education, wherein the dynamics between actors differ from those in primary schools (e.g., Dollinger, Lodge & Coates, 2018).

Second, our findings suggest there are conflicts arising with the original purpose and definition of social robots and the current effective understanding of social robots in the primary school environment. These conflicts arise when we investigate the definition of a social robot which implies that its actions should be partially autonomous (e.g., Duffy, 2000; Fong et al., 2003). Also in previous studies, the role of the robot has most commonly been that of a teacher (e.g., Alemi et al., 2014; Eimler et al., 2010) who has autonomy in decision-making and authority in relation to the students. This contradicts Asimov's (1976) Second Law of the Three Laws of Robotics (Fridin, 2014). As a key finding in this study, none of the interviewees would allow a social robot to act as a teacher in the classroom, but more as a tutor or a co-learner. However, robots were also found to be able to act as supervisors in classrooms which strakes the question of autonomy and authority once again. Accordingly, our analysis indicates that an appropriate level of autonomy for social robots across these potential roles needs to be further investigated in future research endeavors. Challenging some of the previously accepted approaches (e.g., Alemi et al., 2014; Eimler et al., 2010), we argue that social robots are not to be considered as substitutes to teachers, but rather as complementary actors contributing to the resource integration among students and teachers in the classroom.

Finally, our findings provide in-depth insights on the perspective of primary school teachers in terms of facilitating educational services in collaboration with social robots. We depict a categorization illustrating social robots' potential of value co-creation and value co-destruction. Aligning with previous studies, we find that social robots in primary schools have value co-creation potential in terms of diversifying teaching, engaging, and motivating students, enabling monitoring and reflection, and supporting teachers (e.g., Alemi et al., 2014; Eimler et al., 2010). However, concerns emerge due to social robots' limited feedback abilities, their poor fit in complex learning tasks, lack of individualization, ethical dilemmas, technical issues, and potential inequalities. While our study confirms that teachers believe in the facilitation of equal learning opportunities in schools, and that social robots have potential to diversify education (e.g., Smakman, Vogt & Konijn, 2021), paradoxically, as a novel finding, social robots were also seen as prone to oversimplification of teaching. Furthermore, the pedagogical purpose of social robots sometimes remained unclear to teachers, leading to resistance to social robot adoption. As an interesting finding, student tutoring was suggested as a method for alleviating the pressure on teachers to integrate robots into their teaching. Further research is needed on the possibilities of students acting as tutors, potentially supporting teachers in what they found to be the most essential task of all: student engagement.

Further, our findings support previous literature in that robots are seen as most useful for simple learning tasks that require repetition and are previously familiar to students, as robots lack the ability to teach more complex, explanation-intense tasks (e.g., Smakman, Vogt & Konijn, 2021). In addition, we find that social robots may allow for long working hours, given the limitations of battery life. However, students actually engaging with social robots for hours on end was considered unlikely. Interestingly, social robots' ability to instruct and co-learn with students over prolonged periods of time was not considered a valuable feature, as interviewees repeatedly mentioned that students tend to get bored easily. Additionally, previous studies have suggested that social robots could enrich educational contents in the classroom (e.g., Alemi et al., 2014; Köse et al., 2015). Conflicting with these notions, our study suggests that social robots tend to offer binary and immediate feedback but lack the ability to explain the reasoning behind correct or incorrect answers, which could foster short-term thinking and reduced tolerance for boredom among students. Future research is needed on this important topic. In particular, we call for quantitative measures and mixed methods' approaches for the assessment of students' learning outcomes, engagement, and comfort when engaging in co-learning with social robotics in the classroom.

While previous studies have raised concerns of emotional challenges, such as over-attachment styles over extensive engagement periods with social robots (e.g., Fridin, 2014; Smakman et al., 2021), such concerns had not occurred to most of the respondents in our study. However, ethical dilemmas were discussed for instance with respect to excessive use of robotics and lack of teacher-student interaction in the classroom. On one hand, social robots were seen as equal and sensitive to everyone's needs and able to create new ways of achieving and reviewing teaching objectives, such as promoting self-regulation of learning through monitoring, documenting, and reflecting on learning tasks. On the other hand, excessive use of social robots and technical problems in their use were seen to reduce the quality of teaching and trust among actors. For example, the robot's difficulty in understanding a child's voice can cause frustration for the learner and even lead to abandonment of the learning task. While social robots have great potential for value co-creation, enabling hedonic and utilitarian outcomes, respondents were unsure whether they would have a positive long-term impact in the school environment, and whether their long-term use was socially and emotionally safe for students. Such uncertainty of the long-term effects and related social and ethical considerations of implementing social robots in the primary education context call for further research.

6. Conclusion

This study explored the value co-creation and co-destruction potential in interactions between social robots, teachers and students using interviews and thematic analysis. The findings suggest that social robots enhance teaching by increasing engagement, offering personalized feedback, and supporting teachers. However, teachers' prior experiences and attitudes can hinder value co-creation and create inequalities. These insights inform the design and integration of social robots in the classroom for pedagogical value and educational opportunities. Note that the study was conducted in the Finnish educational system, necessitating additional research in international contexts.

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