Designerly Processes with Robots as a Framework for Children's Perspective-Taking

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Abstract. The use of robotics technology in school is renowned for providing children with opportunities to interact and collaborate in various school subjects, which raise questions of how to design learning activities that include robot technology in education. In this paper we explore how a designerly approach can foster children's perspective-taking while creatively collaborating in mixed analogue and digital learning environments including robots, creative material and classical fairytales. Based on a social semiotics analytical framework, the study draws from workshops carried out with third grade classes of Danish school children, aged 9–10 years old. Using video recordings and a thematic analysis, the unit of analysis focuses on the activities with a special interest on children's interactions with robots, creative materials, classical fairytales and with each other. The results of this study imply that by using a designerly approach with robotics in programming activities, conditions were created for children to engage in interactions and reasoning with each other, where the mixed learning environment reinforced children's abilities of perspective-taking.

Keywords: Designerly · Child-robot interaction · Fairytales · Creative material · Mixed learning environments · Video observation · Linking · School children

1 Introduction

The use of robotics technology in classroom settings is at the present time renowned for providing children with opportunities to interact and collaborate in non-technical subjects as well as technical including programming, and science, technology, engineering and mathematics (STEM) oriented activities (Benitti, 2012; Bertel et al., 2020; Bruni & Nisdeo, 2017; Mubin et al., 2013). In this regard, artefacts and a playful approach towards STEM are considered as vital (Ackerman, 2004; Fisher et al., 2011), in particular highlighting how robots by offering tactile manipulation can promote self-exploration (Lupetti et al., 2017) as well as social and cognitive processes (Yadollahi et al., 2020). When children are involved in playfully framed programming activities

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with robots, they are encouraged to reason and practice perspective-taking (Sjöberg & Brooks, 2022; Brooks & Sjöberg, 2021). Yadollahi et al. (2020) argue that perspective-taking is important when it comes to designing meaningful interaction and collaboration. In this regard, a key quality of a robot is that it is equipped with perception abilities, which means that the robot should be able to extract information to achieve its task, which is termed perception-action loop (Milliez et al. 2014). In order to integrate a perspective-taking model in a robotic platform, Yaddolahi et al. (2019) investigated how a robot's cognitive-affective state influenced children's actions, emotions and perceptions of the robot. Perspective-taking thus can be considered as a sociocognitive process enabling a person to be aware of and perceive others' point of view (Healey & Grossman, 2018) in perceptual, cognitive and affective dimensions (Yadollahi, 2020). Surtee et al. (2013) describe perspective-taking tasks to consist of three components, namely a perspective taker (self), a target perspective (other) and an object or circumstance (object). Perspective-taking can also be described in relation to domain-specific skills such as spatial ability, which are considered as an important educational target for instruction in the K-12 curriculum (Eilam & Alon, 2019). These matters are mostly dealt with from a cognitive perspective and/or technical (Healey & Grossman, 2018; Yadollahi et al. 2019; Yadollahi, 2020; Eilam & Alon, 2019) based on Piaget's terminology (Piaget & Inhelder, 1956; Piaget, 1997), or focusing on robots' capabilities to uphold reasoning and spatial interactive components (Healey & Grossman, 2018; Milliex et al., 2014; Trafton et al., 2005) in relation to people in general and not necessarily having primary school children as the target group. However, several aspects of robotics and perspective-taking are still underexplored.

Tangible digital tools such as robots have a potential to offer perspectives, concepts and ideas involved in designerly processes concrete and possible to transform into practicable forms (Brooks & Sjöberg, 2021; Sjöberg & Brooks, 2022b). By means of digital tools such as robots and children's own physical designs, children can simplify their creation of ideas and thus on perspective-taking. It is in this intersection between such concrete and abstract processes involved in design activities that we are interested in facilitating, to explore children's perspective-taking. In this study, we have used a combination of analogue material (e.g. foam clay, crayons, markers, and LEGO) together with Ozobots as robotic characters (Ozobots are small robots that are either controlled using drawn colour combinations that they run over or via simple application-based block programming). When we investigate perspective-taking within this combinational context, we do this from a social semiotics analytical perspective focusing on how groups of primary school children (7–9 years of age) apply different strategies of perspective-taking. Since most studies in this field of research primarily focus on robots' perspective-taking, we apply a reverse perspective, namely to investigate how a robot-child interaction can facilitate and/or challenge children's perspective-taking. In doing so, we consider the child's perspective and how a child can influence the interaction with the robot as a core aspect of it, rather than the other way around. In other words, it is our assumption that it is not so important that the robot delivers correct feedback, it is more crucial that it can invite children to different kinds of reasoning and perspective-takings. Based on this, we explore how designerly processes, i.e. using a combination of creative material and robotics, can support primary school children's perspective-taking. With such an approach, this study can contribute to improving robotic tasks, such as programming, by means of designerly processes in primary school teaching and learning, but also contribute to the area of technology design targeting this age group of children.

2 Related Work

2.1 Robots in Education

Robot technology is evolving at an ever faster pace with the emergence of Artificial Intelligence (AI) and the improvement of hardware features, advances that have contributed to that robots have become increasingly independent and efficient at performing tasks (e.g. Lytridis et al., 2019). This has in turn led to the introduction of robots in different areas in society, such as the educational field. In recent years, robot technology of various kinds has become an increasingly common feature in formal education, ranging from the early school years up to higher education (e.g. Benitti, 2012; Anwar et al., 2019; Athanasiou et al., 2019). Not least social robots have become popular to use as teachers or teaching assistants, where research shows several benefits with students interacting with the robot to achieve a specific pedagogical purpose (e.g. Vrochidou et al., 2018; Kaburlasos & Vrochidou, 2019). One of the advantages that is highlighted with social robots in particular is that they seem to create an increased engagement among the students, which have positive effects on learning (e.g. Lytridis et al., 2019). The most common area of use for robots in teaching however is in so-called STEM subjects (Science, Technology, Engineering and Mathematics) and more specifically in programming activities (e.g. Zhang et al, 2021; Çetin & Demircan, 2020). Various studies have shown that cooperation and problem-solving are promoted in the introduction of robots in pedagogical practice (e.g. Bers, 2018; Durak et al., 2019; Silva et al., 2020; Brooks & Sjöberg, 2021). One possible downside is that a lot of focus is placed on the technical aspects of the robot, rather than an extended learning. This often has its origins in how the actual teaching situation with the robot has been framed. Even though robots have become an integral educational technology in learning situations, robots in education are primarily used to provide STEM education and proposing how robots can be used as a tutor or peer in learning activities. Thus, there is a need for research focusing on learning implications of robots in education rather than investigating how the technology works.

2.2 Child-Robot Interaction

When it comes to research on children and robot interaction, it has often focused on specific groups of children, such as children with autism and children diagnosed with cognitive impairment (e.g. Ismail et al., 2020; Katsanis, & Moulianitis, 2021). Other areas of interest have been to explore various kinds of trust in interactions between children and robots (e.g. van Straten et al., 2018; Di Dio et al., 2020). In several of these studies, robots have successfully been used as teachers or teacher assistants, focusing on activities of child-robot interaction in order to achieve a certain educational or therapeutic goal (Belpaeme et. al., 2018). The main reason for the observed positive effect of robots in education is that when a robot is involved in the educational process children seem to be more engaged (Belpaeme et. al., 2018). Recently, more attention has been paid to how child-robot interaction can be studied in relation to children's playfulness and sense of exploration (Sjöberg & Brooks, 2022a), as well as their designerly ability (Brooks & Sjöberg, 2021). In these cases, the interaction between the children and the robots becomes part of the children's exploratory and creative activities, where the robot fulfils an important function for the children's knowledge making and learning. However, this is still an unexplored area of research.

In a literature review on the use of robotics construction kits in K-12 learning, Sullivan and Heffernan (2016) identified that children could learn programming concepts and engineering content while interacting with robotic construction kits. It was also identified that in child-robotic interaction, children improved their problem solving abilities; moving from trial-and-error to more sophisticated modelling approaches. The literature review concluded that robotics construction kits appeared to provide rich opportunities to learn STEM disciplines from direct hands-on learning as well as from analogical/modelling application. However, research about how children reason and use technologies to position themselves is limited. In the present study, we use a kit of analogue and digital material to explore how this can spark children's reasoning about perspective-taking. By combining the analogue and creative material with digital and robotic material in a design process, we address learning processes as designerly-framed (Cross, 1982).

3 Theoretical Framework

In this section we present the theoretical framework on which this study is based. The theories emerged from the empirical material and are thus inductively chosen. First, we introduce a theoretical framing to designerly-framed learning processes which is followed by a social semiotics approach to perspective-taking by linking.

3.1 Designerly-Framed Learning Processes

Designerly processes with robots play an important role in developing children's learning. When children design, they not only acquisite knowledge by materialising ideas, they also experiment with possible futures by confronting these ideas with the world (Stappers, 2007). Such confrontations lead to an exploration of different outcomes and perspectives as well as negotiating their meanings with others, which can widen people's sense of participation (Rogers, 2000). Exploration, i.e. the ways people make sense of what they are doing contributes to how design and learning develop and are sustained (Brooks & Sjöberg, 2019; Pramling Samuelsson & Carlsson, 2008). The traditional way of considering design as based on form and function as well as on aesthetics and usability of a product is challenged by contemporary collaborative and process-oriented perspectives focusing on meaning and function (Dorst, 2015). Thus, design can offer opportunities for children to practise perspective-taking, to process abstract concepts, and to make meaning between these different ideas. Inspired by Cross (1982; 2006), we term such processes as designerly.

In designerly-framed learning processes, materials and technology (tools) are central features. The activity as such and the social world of which these tools are part of can be reflected in different ways in their design and use. So, the use of these tools exist with respect to some purposes that are tied to cultural practices and social organisation with which they are meant to function (Lave & Wenger, 1991). Expressed differently and in relation to the context of the present study, creative material and robots cannot be considered as having features in themselves, but as a process that involves specific forms of participation by schoolchildren, where creative material and robots fulfil a mediating function when it comes to children's perspective-taking. Thus, there exists an interesting interplay between mediating tools and learning activities, where mediating tools in their non-transparent way are necessary for allowing focus on, and thus supporting transparency of the subject matter (e.g. perspective-taking). Conversely, transparency or salience of how the tools can be used is important for allowing its non-transparent use (Lave & Wenger, 1991). This makes the design of mediating tools key to provide a balance between transparency and non-transparency, in particular when it comes to their role in communicating social processes.

A designerly perspective to perspective-taking allows children to be able to link their ideas by producing their own signs as new combinations of form and meaning (Kress, 2003). By allowing children themselves to be part of a designerly activity, their engagement in the learning process will be strengthened and they will be more inclined to take active participation (Brooks & Sjöberg, 2020).

3.2 Perspective-Taking and Verbal Linking

In the present study children should use both analogue material and digital technology, which can be seen as offering 'bits' of perspectives (van Leeuwen, 2005). Each of these 'bits' has values in themselves. The goal of the study is to explore how the children link those items of perspectives and pack them into a reasoning about perspectives. Different communicative situations require different understanding and use of perspectives. For example, in this study the children should link materials such as foam clay, LEGO, cardboard, glue, and sharpies together with a classical fairytale and Ozobot robots - each of these items have some meaning of their own but this meaning only becomes relevant if they are linked in terms of the needs of the children who want to find out how to do something (in this case to create a representation of a fairytale by means of material and Ozobots). In order to explore how the children link these items and perspective, the category of verbal linking (van Leeuwen, 2005) becomes central. Van Leeuwen (2005) identifies elaboration or extension as concepts that make verbal linkings explicit (see Table 1). Elaboration as a type of verbal linking includes subtypes such as explanations, examples, specifications and corrections. Extension as another type of verbal linking can be an addition, temporal, spatial and/or logical link. An addition linking exists when an item introduces new perspectives or information which can be adversative or alternative. Temporal linking exists when something is, has or will occur. Logical linking occurs when perspectives give reason for a comparison of or condition of another item. Spatial linking forms a category where proximity and co-presence of items occur. (Table 1).

A designerly perspective to perspective-taking allows children to be able to link their ideas by producing their own signs as new combinations of form and meaning

Table 1. Overview of verbal linking (van Leeuwen, 2005, p. 225).

Type of connection	Subtypes	Typical explicit verbalisations	Typical environmental condition
Elaboration	Explanation Example Specification Summary Correction	'that is', 'in other words', 'example', 'to illustrate', 'in particular', 'more specifically', 'in fact', 'actually'	Argumentation Persuasion
Extension: addition	Addition Adversative Alternative	'and', 'moreover', 'but', 'however', 'or'	Description Argumentation Persuasion
Extension: temporal	Next event Simultaneous event Previous event Conclusive event	'then', 'next', 'finally', 'in the end', 'meanwhile'	Narrative Procedure
Extension: spatial	Proximity Co-presence	'behind', 'in front', 'there' etc	Description
Extension: logical	Similarity Contrast Reason Result Purpose Condition (positive) Condition (negative)	'likewise', 'similarly', 'conversely' 'therefore', 'as a result', 'in consequence' 'in that case', 'if', 'otherwise', 'if not'	Argumentation Persuasion

(Kress, 2003). By allowing children themselves to be part of the designerly activity, their engagement in the learning process will be strengthened and they will be more inclined to take active participation (Brooks & Sjöberg, 2020).

4 Methodology

Following a designerly approach, we have applied a workshop methodology (Ørngreen & Levinsen, 2017) to investigate children's perspective-taking, while programming robots in combination with representing a fairytale using creative material. Overall, this approach offers a structure and flexibility to plan and monitor an activity including complex challenges. Workshops based on a designerly approach adopt a range of tools to support participants' group activities and energise a sense of ownership, especially when children are included (Fails, Guha, Druin, 2012). The empirical study consists of schoolchildren from a primary school in Denmark, including one 3-grade class with children between the ages of 9 to 10, in total 26 children. The children were divided into groups of four to five children resulting in a total of six groups. The group division was carried out by the teachers beforehand. By dividing the children in groups, we targeted a participative and negotiating character of meaning making to take place in the workshop activity (Lave & Wenger, 1991). This kind of condition implied a rich, interactive, and divergent environment (Brown et al., 1993), where the workshop context provided a dynamic participation among the children with an inherent integration of perspectives and negotiations.

Our team comprised four people: the main researcher (first author) and three research assistants from the same university as the main researcher. Our role was to facilitate the workshop structure (see below) and to promote children's collaboration and dialogue during the workshop activity. In addition, the teachers of each class participated to support their children throughout the workshop process (in average two teachers per class). The teachers had been informed about the procedure beforehand and were also supported during the workshop if they had questions.

Data were generated by means of video observations, ethnographic note taking, and casual conversation with the children and the teachers. The six groups each had a designated design station (table) where they carried out the activity. A video camera was set up at each table to capture both the children and what was going on at each station table.

4.1 Setting and Procedure

The study was situated in a school setting. The researchers brought creative material and Ozobots robots and had planned for a design-oriented workshop setting based on a combination of digital and analogue materials (Fig. 1). The analogue material consisted of creative material and classical fairytales (see below).

In establishing a design-oriented workshop context, the children were introduced to coding by means of Ozobot robots. The coding activity was framed by a classic fairytale theme, which the children could elaborate on and transform to coding actions where Ozobot represented one or more of the main characters in a specific plot of the story. Each group had access to 2–4 Ozobots. The children used creative material, such as foam clay, LEGO, cardboard, glue, and sharpies/marker pens in combination with applying colour- and sequence coding of the Ozobots to move according to the fairytale plot. Ozobot is a versatile robot designed to enhance children's interest in programming and thus suitable for STEM (Science, Technology, Engineering, Mathematics) education. In the workshops the Ozobots were used to invite the participating children to re-enact a narrative composition by conceptualizing and reproducing the fairytale, using coding. The fairytales were selected by the researchers beforehand and included classical fairy tales, which were: (1) Crying wolf; (2) Little red riding hood; (3) What the old man does is always right; (4) The little match girl; and (5) There is no doubt about it. Through this, we targeted a digital component combined with analogue ones to foster children's participative engagement and perspective-taking (Fig. 2).

Our designerly take on the workshop methodology was based on a design development process (Sanders & Stappers, 2012, p. 26), which was divided into four different phases, each one with a specific purpose. The different phases unfolded sequentially. Table 2 illustrates the different phases and the activities that unfolded within each phase.

Fig. 1. Workshop setting in the school context.

Fig. 2. Children working with coding, Ozobot robots, creative material, and the fairytale

Table 2. Overview of workshop phases.

Phase 1: Setting the scene	The objective of the first phase is to introduce the children to the activity, their specific roles, the task definition, its purpose and different tools. This was done to all of the children and their teachers. By the end of this phase, the children were divided into groups. The teachers had done the group division beforehand. Each group was introduced to their specific fairytale. After this, the respective fairytale was read out loud, either by one of the group members, by a teacher/pedagogue, or by a research assistant. This was followed by a group discussion about the content of the fairytale to make sure that it made sense for the children. This included elaborations of, for example, the underlying moral message of the fairytale. Finally, the children were introduced to the Ozobots, including the coding possibilities, and the creative material. Setting the scene is about creating a climate of trust and empowering the children to act freely and creatively within the frame of the task
Phase 2: Discovery	Phase 2 takes place within each of the groups and aims to a shared understanding and definition of the task, including how to approach it. From a design perspective, this is about ideation, where ideas are generated as well as opportunity and challenge identified. This is also where the children start to translate the fairytale to coding, as well as how this could be represented by means of the creative material. This can be seen as a voyage of discovery where the children confront the knowledge embodied in the task, and begin to appropriate that knowledge to their own in an explorative and expansive way
Phase 3: Design and make	Phase 3 includes time for the children to iteratively reflect, explore and further develop their ideas from phase 2. This process is characterised by children's casual connections between their shared ideas, and preconditions relevant to the coding, design and materialisation of their visions and goals relative to the task. This is followed by hands-on initiatives of designing and making, where several discussions, reflections, and perspectives emerge. *Are the coding and creative representation of the fairytale relevant to convey our ideas and perspectives? How can we appropriately code Ozobot so that it in a trustworthy way represents the fairytale character's movement?*
Phase 4: Communication	The objective of phase 4 is to develop a conclusive scene for the children to present their solutions, choices, considerations, and perspectives for each other. This is followed by a plenary question and feedback moment from the audience including the groups of children, teachers, and research assistants. The phase ends with an evaluation, where the researcher and research assistants ask the children to give feedback on the activity

4.2 Ethical Considerations

The study was subject to common research-ethical principles of transparency in the research process and quality of documentation as well as the protection of sources and individuals (Danish Code of Conduct for Research Integrity, 2014; GDPR, 2016). Teachers and parents were informed about the study in writing. All parents confirmed that their child could participate in the study by signing informed consent forms, which included their approval for us to use videos and photos for scientific purposes. The United Nations convention on the rights of the child (1989) was fully respected and participating children were carefully informed before verbal consent was negotiated with them ahead and during every workshop.

4.3 Analytical Framework

The analysis was based on a thematic approach (Braun & Clarke, 2006; 2019) and comprised in total, 690 min (11,5 h) of video recordings. All video recordings were carefully scrutinised and selected samples were transcribed for further analysis. The transcripts were reviewed and coded by both authors to identify themes in verbal and non-verbal actions and interactions between the children and the digital and analogue activity. The initial themes were reviewed and defined by both authors. The performed analytical steps are illustrated in the below Table 3. This means that the paper's focus on perspective-taking emerged from an inductive approach to the data.

Table 3. Overview of the analysis process (based on Braun and Clarke, 2006).

Phases of the thematic analysis process	Description of the thematic analysis actions
Getting to know the data	Watching and re-watching the video data and field notes
Generating initial codes	Systematically coding interesting features of the data and identifying data relevant to each code
Searching for initial themes	Synthesising codes into initial themes and gathering relevant data to each initial theme
Reviewing themes	Checking if the themes work in relation to the coded data and the whole data set, generating a thematic map of the analysis
Defining themes	Iteration of the analysis to refine the details of each theme in relation to the research questions, generating definitions and names for each final theme

From this analysis we identified three overall themes: (1) Perspective-taking through elaboration spatial extensions; (2) Perspective-taking through elaboration, temporal and addition extensions; and (3) Perspective-taking through elaboration and logical extensions, which are presented in the next section.

5 Findings

The design-oriented activity was divided into four main phases: the setting of the scene phase; the discovery phase; the design and make phase; and the communication phase. Each phase of design activity included different types of perspective-takings that required some sort of choices to get closer to a solution. The groups approached the four phases in an engaged task-oriented way, and carefully wanted to accomplish the task. The analysis identified what the children considered as important and what was not when linking the materials and the different perspectives they offered. The analysis also showed that the content of the fairytales included in the study did not influence the kind of perspective-taking linking that emerged. The different linking of perspectives and choices were merely related to the children's interests, particularly addressing values related to aesthetics or functionality. All groups applied elaboration linking discussions where most of them were of an examplifying or specifying character rather than being persuasive. However, in one of the groups the elaboration linking was more of a correcting and explanatory character. Here, two of the group members wanted to keep up with a certain perspective and were thus arguing to persuade the other two group members to consider this perspective as the most relevant. In the following subsections, we present the outcomes of our analysis.

5.1 Perspective-Taking Through Elaboration Spatial Extensions

Perspective-taking through the linking-types of elaboration and spatial extension refers to how the children by linking all the perspectives (fairytale content, creative material and Ozobot robots) argued for a co-presence of the whole rather than focusing on parts of the different tools. The elaboration that was taking place within the group was discussive and argumentative in an agreeing manner. The different tools were put together in a cohesive manner, where the perspectives of each of them contributed to representing the core aspects of the fairytales that the group members jointly were agreeing upon. The argumentations were of a specifying or explanatory kind, where one group member specified, for example, what he or she meant by adding a prop to represent the fairytale or how Ozobot's character was in line with the content of the fairytale. In this way, the perspectives of the individuals' were listened to and accepted.

In this theme, the participants primarily applied spatial extension linking. The group who worked with the Crying wolf fairytale can exemplify this. This group's main focus was on how different props could be related to each other, for example the foam clay meadow and the Ozobot robot, or alternatively how Ozobot robots wayfinding could be connected to the props so that the co-presence of these aspects fitted into the core of the part of the fairytale they had chosen as key. The group divided tasks in pairs, where a girl and a boy worked with the creative material and another girl and boy focused on the pathway of the Ozobot robot. During all of the four phases, the group members were aligned with their individual understanding of the task as a whole and of the parts that together should form their cohesive design that communicated the perspectives that they through the different tools created. They agreed upon the moral of the story in such a way that it made sense "to speak the truth so that people in the long run would believe what you say".

The challenge the group dealt with was how this moral could be conveyed in a meaningful way. While they all discussed this, they focused on spatial dimensions. For example, they all found it crucial that the fairytale environment which they created with foam clay and the pathway that the Ozobot should 'walk through' were aligned. They discussed and described to each other how they thought that the Ozobot and the green grass where the shepherd and the lambs were located could demonstrate the "lazy shepherd who just wanted to lay in the grass and not take his task seriously". Jointly they concluded that Ozobot "needs to move slowly alongside the green grass" (representing the meadow where the lambs grazed grass) and stop in front of the huge grass plot. In other words, the ways the foam clay environment and the Ozobot alongside the pathway it was moving along should make connections and, thereby, when supporting each other extend the meaning of the moral perspective that they wanted to convey (Fig. 3).

Fig. 3. Children discussing how they can convey the message of a shepherd that did not take his work seriously (spatial extension linking).

With this background, perspective-taking was present in two ways. First, it communicated the children's shared point of view of the moral of the fairytale. Second, the groups' final representation of the fairytale showed how the different tools through their proximity appeared to signify a shepherd who by being lazy was not taking his job seriously.

5.2 Perspective-Taking Through Elaboration, Temporal and Addition Extensions

Perspective-taking through the linking-types of elaboration, addition and temporal extensions includes how the children by applying temporal linking put efforts into connecting the creative tools (foam clay and LEGO) with the pathway of the Ozobots to convey the context of the fairytale. As in the previous theme (Sect. 5.1), the elaboration type of linking within this theme were discussive and argumentative in an agreeing manner. The difference though was that within this theme the storyline was in focus in terms of how the different events of the narrative cohesively could be communicated. Another type of linking that was used within this theme was the addition extension. This was particularly shown when children added a perspective to an item, which will be exemplified in the below text.

This theme can be illustrated by examples from the groups working with the fairytales of The little red riding hood and What the old man does is always right. While the underlying moral message from The little red riding hood was clear for the children, it was less clear regarding What the old man does is always right. When the children elaborated on the latter, they specified details from the storyline regarding how the farmer's (the old man) every exchange of goods resulted in less money. From this, the children summarised the moral message by not understanding how the farmer's wife could hug and kiss her husband when he arrived home with a bag of rotten apples, after all he left the home with a horse. This resulted in an engaged moral discussion, where the children's perspectives were aligned, but not fully in agreement with the underlying perspective of the fairytale.

When the groups applied the temporal extension linking, they simply followed the storylines of the two fairytales. They started from the beginning, which was followed by what came 'after' that. These 'after' relations, i.e. what will follow next, were understood from the fairytale context. For example, when the children discussed a certain episode of the fairytale, they used words like 'next', 'after, or 'then'. When they arrived at the end of the storyline, they became procedural in their discussions by addressing the question of how to represent the end to adequately represent their perspective (i.e. how they considered the moral of the fairytale) (Fig. 4).

The children's application of the addition extension link can be exemplified by how they introduced new material in the form of foam clay to add to Ozobot. In doing so, they simply added, for example, a red hat to the little red riding hood to make it clear that Ozobot represented this character. While doing so, the child who added the material described for the other children in the group how this addition could make the Ozobot character more trustworthy.

Within this theme, perspective-taking was present primarily through the children's perspectives related to the narrative, which facilitated an elaborative discussion on perspectives related to how the group members looked at something, for example, the moral message of the What the old man does is always right.

Fig. 4. Children adding prop details following the narrative of The little red riding hood (addition extension linking).

5.3 Perspective-Taking Through Elaboration and Logical Extensions

Perspective-taking through the linking-types of elaboration and logical extensions refers to instances where the children did not agree on how the fairytale should be conveyed, in particular regarding in what order the different tools should be used; should they start with Ozobot and its wayfinding or start with establishing the fairytale context by means of the creative material. This can be exemplified by the group working with The little match girl. Here, the moral message was not in focus at all but rather which material, creative material or Ozobot robots, that should form the context of the fairytale. Throughout the second and third phases of the task, three members of the group applied the elaboration linking style by constantly arguing for the case of coding Ozobot's wayfinding as the most important feature to tell the story. The props that the other two children were making were considered as secondary. Through this arguing, the three group members tried hard to persuade the other two group members to agree with them.

This group applied a logical extension linking type when they were trying to convince each other about perspectives to take. This was applied in the forms of comparisons of the two conditions; to start with Ozobot or to start creating the fairytale environment. For example, the three group members who favoured Ozobots as the main components of the story expressed this by saying, "If we place this christmas tree here, the robot cannot pass by. It has to wait and be placed when we have finished the way Ozobot should move". Also, causal links were made such as 'because' or 'for that reason'. The comparative links most often indexed contrasts that should persuade the ones who had another perspective or, alternatively, make an argument by comparing aspects of the different perspectives that were discussed (Fig. 5).

This logical extension linking resulted in that the children created two parallel perspectives, which from both sides were considered as the most important. The two members who created props with LEGO and foam clay repeatedly tried to put these into the other three members' coding map. In doing so, they applied a positive condition subtype, such as "if doing this way…". However the three group members were not agreeing and constantly applied a negative condition subtype by saying, for example, "no, this would not work".

Fig. 5. Children representing the fairytale by logical extension linking type by designing Ozobot's wayfinding separated from the overall fairytale composition.

Within this theme, perspective-taking was present primarily through logical extension linking types, primarily based on contrasting and negative subtypes. Positive subtypes were included from one part of the group, but did not work to persuade the other part.

6 Conclusive Discussion

In this paper we set out to explore how a designerly approach can foster children's perspective-taking while creatively programming robots. Our findings have shown that by using a designerly approach with robotics in programming activities, conditions were created for children to engage in interactions and reasoning with each other, where the robots reinforced children's abilities of perspective-taking. In contrast to previous research, which mainly has studied perspective-taking from a cognitive or technical perspective, our study has shown that a designerly perspective offered opportunities for school children (9–10 years of age) to practise different strategies of perspective-taking. Thus, we argue that robots in education play a distinctive role by providing children extended learning opportunities. In this regard it was not important whether the robot gave adequate feedback or not. Instead, challenges in the child-robot interaction opened for children's reasoning about, for example, moral questioning. Additionally, child-robot interaction can also facilitate and/or challenge children's perspective-taking.

This implies that perspective-taking also pedagogically can be applied in relation to not only domain-specific skills but also transversal skills. Based on this, we emphasise that designerly framed child-robot interaction situations can create meaningful learning processes. This should be harnessed from yearly years where children are capable of displaying creative ideas and perspectives via designelrly experiences.

To answer our research question, we have explored how designerly processes, i.e. using a combination of creative material and robotics, can support primary school children's perspective-taking. Our results showed that perspective-taking was present in two ways. First, it communicated the children's shared point of view of the moral of the fairytale. Second, the groups' final representation of the fairytale showed how the different tools through their proximity appeared to signify a shepherd who by being lazy was not taking his job seriously. Furthermore, perspective-taking was present primarily through the children's perspectives related to the narrative, which facilitated an elaborative discussion on perspectives related to how the group members looked at something, for example, the moral message of the What the old man does is always right. Finally, perspective-taking was present primarily through logical extension linking types, primarily based on contrasting and negative subtypes. Positive subtypes were included from one part of the group, but did not work to persuade the other part. Just like bricoleurs, the children approached perspective-taking by arranging, rearranging, presenting, representing and by reasoning with bits of materials and technologies.

To conclude, perspective-taking is an important transversal as well as subject-specific skill. A designerly approach to perspective-taking, i.e. to combine different materials/modalities, can facilitate children to practise perspective-taking. Through such activities, the children could create complex perspective-taking reasoning with their peers that involved interaction between their own understandings of classical fairytales, their creative constructions and robot characters. The findings clearly showed how this invited the children to reason about consequences and implications of their arguments. However, this needs to be facilitated and verbalised by the teachers to make children aware of such matters. Our study suggests that children's engagement in perspective-taking activities in school settings augment their social, cultural and creative knowledge creation. With such an approach, this study can contribute to the field by improving robotic tasks, such as programming, by means of designerly processes in primary school teaching and learning, but also contribute to the area of technology design targeting this age group of children. In addition, another contribution is to have a design-oriented approach when implementing technology in teaching, i.e. robotics, as it helps to create situations where a teacher need to reason about and understand the technology in its context.

This study has presented results that augment previous research on children's perspective-taking. More studies will be useful to further investigate complexities and other framings of child-robot interaction in education that can support designerly ways of learning based on children's initiatives.

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