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Who counts? Legitimate solutions in construction activities in preschool

Johan Boström[1] · Magnus Hultén[2] · Per Gyberg[3]

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Abstract

As has been pointed out in previous research, teacher-led learning plays an important role in developing preschool children's technological skills and technological self-esteem. What is missing in research are more detailed analysis of how the children's and teachers' actions and interactions shape the learning process. In order to study this within the field of construction, an action research project was conducted, where construction activities were developed, implemented and revised in an iterative procedure. Data from the second cycle were analyzed for this article using graphic transcriptions and multimodal analysis, with a focus on action, interaction and experience from a pragmatist perspective. Our findings show that children who quickly and decisively engage with the material, the teachers and their peers in suggesting which material to use and/or how the material can be used, end up in a central role in the design process. These children (or their actions) often get legitimized by the teachers. Thus, in order to give children access to equal opportunities in the construction activities, it is important for teachers to understand how the children's construction-focused actions become constitutive and what their role in that process is.

Keywords Preschool · Construction · Technology · Design process · Comics · Visual remake

✉ Johan Boström
johan.bostrom@lnu.se

Magnus Hultén
magnus.hulten@liu.se

Per Gyberg
per.gyberg@liu.se

1 Department of Physics and Electrical Engineering, Linnaeus University, 351 95 Växjö, Sweden

2 Department of Social and Welfare Studies, Linköping University, 601 74 Norrköping, Sweden

3 Department of Thematic Studies, Linköping University, 581 83 Linköping, Sweden

Introduction

The body of research concerning technology in preschool in general, and building, creating and constructing in particular, has slowly been increasing during the last 25 years (e.g., Boström et al., 2022; Campbell & Jobling, 2008; Elvstrand et al., 2018; Fleer, 2000; Kilbrink et al., 2014; Senesi, 1998; Siraj-Blatchford & Siraj-Blatchford, 1998; Sundqvist & Nilsson, 2018; Thorshag & Holmqvist, 2019; Walan, Flognman & Kilbrink, 2020). Previous research has pointed to teacher-led learning (e.g., the teacher being the guiding and supporting hand) as important for the development of children's construction skills, as well as their general understanding of technology (e.g., Boström et al., 2022; Fleer, 2000; Hallström et al., 2015). However, when Sundqvist and Nilsson (2018) examined preschool teachers' and child care attendees' view on technology education in preschool, they found that the respondents mainly saw their role in technology activities as being the provider of the material and the one who sets up a creative environment for the children. The respondents did not generally see themselves as having the role of the guiding and supporting hand in the children's technological learning.

But teacher-led learning is not a one-way activity, it always involves interaction with the child. In this regard, the teacher does not only interact with a thing, but with a person who has previous history and experience. Research has pointed to the importance of children´s earlier technological experiences and shown that children's experiences in and about technology may differ greatly, and can impact how they engage with technology in preschool, and thus also how they interact with the teacher (Plowman et al., 2010; Stables, 1997). Having easy access to, as well as user support regarding, different material and tools may enforce a child's technological self-confidence—both from a user perspective and a design perspective (Mawson, 2007; Stables, 1997; Sundqvist, 2020).

Even though earlier research has stressed that the active teacher is an important part of helping children enhance their technological know-how, not much of this research has defined what being an active teacher really entails, and how this can play out differently in relation to different children. In order to explore this, the research questions guiding this study has been formulated as:

- What kind of construction-focused actions are performed by the children in the teacher-led activity?
- Which of these construction-focused actions become constitutive for the design process?
- What kind of patterns can be identified behind the constitutive construction-focused actions?

Background

Action and interaction

This article takes its stance in John Dewey's view of action and interaction—or transaction, as he later used instead of interaction. Dewey (1859–1952) was an American philosopher that suggested that learning ought to be viewed through a pragmatist lens. Dewey's pragmatism can be seen as a philosophy that focus on learning and considers action as its base category—and it is therefore a relevant theory for educational researchers (Biesta & Burbules, 2003).

The basis for Dewey's view of learning was everyday life and the experiences this consist of (Elkjaer, 2000). Dewey meant that to completely understand an individual, one has to fully consider their ongoing interaction with their surroundings [environment] (Armitage, 2003). It is in the interactions (or transactions) between the individual and hirs surroundings that learning takes place. Learning can from this perspective be defined as predispositions to act in new situations or when facing problems (Biesta & Burbules, 2003; Hartman, Roth & Rönnström, 2003).

Experience is a central category in Deweys pragmatism—and in this article. According to Dewey, people's actions, as well as their motivations for learning, are affected by their prior experiences (Hartman et. al, 2003). Dewey describes experience as both a verb and a noun, i.e., something that one does actively, but also something that forms individual habits through our experiencing (Hartman et. al, 2003). Experience should thus be seen as both a product and a process. Our "surroundings are experiences, and experiences are achieved reflexively with the surroundings" (Elkjaer, 2000, p. 92). The individual habits are formed through human beings' continuous transactions with their environment. Different people's transaction with the same environment can therefore elicit different responses (Biesta & Burbules, 2003). Habits should, however, not be interpreted as akin to a routine, but a predisposition to act in new situations or when facing problems (Biesta & Burbules, 2003; Hartman et. al, 2003).

Elkjaer (2000) explains that experience involves the principle of continuity. This principle means that present experiences develops through past experiences, and in turn lead into future experiences. Or in other words "an experience takes up something from the preceding one and changes the quality of the subsequent one" (Na & Song, 2014, p. 1035). point out that the principle of continuity applies to "every case since every experience influences further experience" (Na & Song, 2013, p. 1035). Biesta and Burbles (2003) point to the fact that it is actions, carried out in a certain order, that result in certain outcomes, and that one therefore only can "identify the connection within the sequence and the contribution of each of the steps in achieving the end, once we know how the individual acts have contributed to achieving this end" (p. 34). This point to the importance of not focusing the analysis of educational practice on isolated acts, but to also consider the sequentially of acts and their outcomes, and different individuals' contributions in this.

Even though Dewey preferred the term transaction before interaction, because the latter implies that there exist a subject and an object (i.e., the interaction of separate entities) (Biesta & Burbules, 2003), we will in this article use interaction out of consistency (interaction is the term used in multimodal interaction analysis which informed our analysis of the data, see method section below).

The importance of children's past experience in learning technology

From the day they are born, children are exposed to; experience; and learn technology (e.g., skills and confidence in handling artifacts) through their daily activities (Campbell, 2010; Campbell & Jobling, 2008; Stables, 1997). Children learn through interactions with other people and the surrounding world. This learning builds upon the children's past experiences (i.e., the principle of continuity (Elkjaer, 2000)). The development of children's technological competences may however be limited due to factors such as social, cultural, economic and philosophical influence (Stables, 1997), as well as the fact that children's learning processes take place in a local contextualized practice and can therefore differ depending on which role a child has in said community (Lave & Wenger, 1991). Children engaging and experiencing technology at home may develop a wide array of technological skills (Mawson, 2007; Plowman et al., 2010). Reasons for this may have to do with family members feeling fewer inhibitions to being teacherly than preschool teachers generally do, and the participation being of a more authentic kind (Plowman et al., 2010). Research has shown that children's previous experiences may be informed by, and subsequently create, gender bias. Boys, in general, have a wider range of experiences regarding construction tools and materials, and it is more common for children to interact with a male relative than a female one when it comes to technology in regards to the trades (Mawson, 2007). There also seems to exist a preference for gendered vocational activities among children. This preference appears to be a result of positive gender reinforcement by the surrounding world (e.g., other children, parents, teachers), as well as of the individual child's own process of constructing hirself on the male–female spectra and putting this in relation to gender-appropriate activities (Turja et al., 2009). Through their actions, the teachers may influence the children in their understanding of appropriate gender behavior, and sometimes even consolidate gender differences (Hallström et. al, 2015). Research has shown that there exists a tendency among preschool teachers to think that they act more gender sensitive than they generally do (Boström, 2018; Eidevald, 2009; Turja et al., 2009).

Gender bias aside, preschool teachers play an important role in giving every child an opportunity to develop their technological skills and building positive attitudes towards technology (e.g., technological self-esteem)—"the more young children engage in technological activity, the more their confidence in their technological abilities may be established." (Stables, 1997, p. 51). Also, the more technological knowledge preschool children form regarding the whys and hows of a certain construction and the material with which to design it, the greater the motivation to take part in a construction activity (Thorshag, 2019). Regarding more specific strategies, Sundqvist (2019) suggests that one aspect of being an active teacher may revolve around helping the children discern differences in functionality, for example between tools (i.e., how the tools are differently suitable for the intended outcome of the activity). Further, Nilsson, Gustafsson and Sundqvist (2020) point out that rich technological learning can take place in preschool through the presence of a qualified preschool teacher who takes hir stand in the children's construction skills and creativity. Lastly, Boström et al. (2022) point to there being a toolbox of different technology didactic strategies—consisting of general didactic principles (i.e., to engage; to guide; to coordinate; to show) employed in technology specific areas (i.e., process; product; and concepts). But these strategies are only one aspect of the interaction taking place in a construction activity, the other aspects being the children's construction actions and how they shape the construction activities, and how the teachers position themselves in regard to these actions (e.g., how they prompt different construction ideas). A better understanding of these interactions can be a step in the direction of discerning how construction activities can be designed in order to give all children the chance to develop their technological knowledge and self-esteem.

Peer tutoring and collaborative learning also play an important part in developing children's technological knowledge and practice in the activities (Mawson, 2013). But, for children to be able to discern technical aspects (such as framed structures and strength), they must first have a certain level of confidence in handling hands-on material (Kilbrink et. al, 2014). Such hands-on material could be "saws, hammers, vice, screwdrivers, electric and hand drills, and a range of appropriately-sized timber, nails and screws. Hot glue guns, sewing equipment and a range of fabrics" as well as "a variety of kitchen equipment"

(Mawson, 2013, p. 449). However, the former, more "hard" side of technology may not be that common in Swedish preschools' daily activities (Boström, 2018).

Method

The material used in this article was collected as part of an action research project conducted during a period of 13 months at a preschool sector (consisting of two preschools) in a medium sized city in the south of Sweden. Action research is a method that enables the research field and the practice to meet on more equal terms. Ideally the practice identifies a problem within its own organization. An action (for example a lesson regarding a specific content matter) that the action research group (consisting of practioners and researchers) thinks can help shed light on the identified problem is planned and enacted in the daily operations. This action is observed through some kind of means (in our case, a video camera). The findings from this observation are then reflected on by the action research group in a collaborative setting, where the researcher/s may advance the understanding of the problem by putting forth literature and theories. The problem is then further examined through iterative cycles of plan-act-observe-reflect (Herr & Anderson, 2005; Rönnerman, 2010). The data used for this article comes from an action performed in the second cycle of the action research project.

The problem identified by the action research group (see ethical considerations for more information about the group) revolved around children not getting the same opportunities to learn technology in preschool. The group wanted to see if it was possible to develop an activity that visualizes everyday technology for the children and at the same time heightens their interest in technology. The group's consensus was that construction could be an interesting area of technology to focus on.

The studied action

The action research group performed three cycles. The first cycle consisted of an open-ended task, to construct a model house out of cardboard (see Boström et al., 2022). The second cycle had a somewhat narrower focus, constructing a working door for a model house. The task of the third cycle revolved around constructing a working trunk lid for a model car. The data for this article comes from the second cycle.

The second cycle consisted of five implemented inhouse technology activities (one in each of the five preschool units that were a part of the study). Each activity included one or two preschool teacher/s and two or four children (see Table 1). The inhouse technology activities ranged from 45 to 80 min and were all video recorded. Out of this overall time

Table 1 Children and teachers in the five units

Unit	Children	Preschool teacher/s
Alpha	Ruth, Geoff, Sheila, Simon	Teacher A1, Teacher A2
Beta	Mary, Ian	Teacher B
Gamma	Steven, Susy	Teacher C
Delta	Joe, Viola, Kurt, Barbara	Teacher D1, Teacher D2
Epsilon	Amanda, Peter	Teacher E

frame, the planning phase of the activities took on average 8 min, and it is this part of the data that has been the focus of analysis in this article.

The activities, that were designed by the action research group, can be described as teacher-led construction tasks. These tasks revolved around constructing a working door (able to open and close) for an already existing model house (built out of cardboard by the action research group) using material such as screws, wingnuts, Masonite, corrugated plastic, cardboard, pipe cleaners, hinges, tape, hand operated drills, electric screwdrivers, hole punchers, clamps, etcetera. It was decided that the design process in the task should be done in a collaborative manner by the children and that they should construct two doors—each being designed using different materials—in order for them to practice their ability to compare different solutions. It was also decided that the teachers should start by explaining the problem for the children (i.e., that the house needed functioning doors) and show them the material and tools that were at hand for solving it.

Ethical considerations

Eight preschool teachers, from two different preschools and five different preschool units (three from one of the preschools and two from the other), ended up forming the action research group along with author 1. The eight preschool teachers had at least ten years' experience each. All of them identified as women and were somewhere between 35 and 55 years of age. During an initial meeting at one of the preschools, where all of the preschool teachers from both preschools were assembled, author 1 talked about the workings of an action research project. It was also stressed that attendance in the project was completely voluntary.

Research involving children always consist of substantial ethical issues. Children are considered to be in an extra vulnerable position, many of them may still be too young to be able to decide if they want to partake in the study or not. In our study, we started with obtaining consent from the children's legal guardians. This was done through an information letter, an information meeting and a consent form. The children who participated in the activities were selected by the preschool teachers taking part in the action research project. Only children whose guardians had signed the consent form participated in the videotaped activities.

However, obtaining consent from the legal guardians is only part of ensuring an ethical approach when dealing with children. In a study that involves children, it is important that the researcher constantly has the ethical aspects actualized. In order to ensure that the children agreed to their participation in the activities, author 1 tried to be as observant as possible during the introduction phase of each activity. If any of the children clearly expressed that they would rather do something else, said child had the opportunity to rejoin the regular group in the room next door.

The ethical problems with using still images from the video recordings were handled by altering the images:

- The still images selected from the data set were converted to grayscale.
- A filter was applied to the still images which made them take on the shape of drawn images.
- Words and pictures on the children's clothes were deleted.
- Finally, both the children's and preschool teachers' faces were erased and replaced with rudimentary hand-painted faces.

These steps should result in the possibility of identifying the individuals in the graphic transcription becoming next to non-existent. The process of editing the panels are however highly time consuming and we have therefore opted to focus this work on a few panels that exemplify our results.

Graphic transcriptions

In research in general, conventional text transcription has been the main method to convey video recorded data. However, when adapting data from one medium to another (e.g., film to text) some of the information may be lost. Either by the transcriber (i.e., what is included in the transcriptions) or by the readers interpretation—or both. Even if said transcriptions include narratives of other modes (e.g., gestures, gazes, object handling) than just the spoken word, those modes are not words. When being reformatted into words these non-verbal actions are interpreted multiple times, first by the transcriber and then by the reader. By changing them from visual form into words, the form of the content also changes (Grunditz, 2020).

Grunditz (2020) proposes that a way to analyze and present visual data is through a visual remake. This method is somewhat different than just analyzing and representing the data in a film according to standard transcription conventions or through a detailed narrative. The visual remake is a way to highlight and analyze such things as gaze and postures in the data. Grunditz (2020) suggests that the visual remake is a method that can conceptualize and make the analytical process of the researcher transparent. The visual remake is done by reframing original frames from the data, where important aspects regarding the research questions are highlighted (for example by zooming in on something of importance). This makes it possible to examine aspects that by just watching the film may otherwise be lost.

The unit of analysis in our study has been the different construction-focused actions performed by the participants. But not from a "vacuum"-perspective (i.e., that the action is seen as an isolated event). Our interest has been on how the actions build upon and inform each other, as explained in the theory section. We have therefore transcribed the material into a sequential form (e.g., Kuttner, Weaver-Hightower & Sousanis, 2020; Laurier, 2014). The use of these graphic transcriptions was chosen as a way to transcribe the data in order to convey the sequential interaction between individuals (and between the individual and their surroundings), and how the performance of one action may open doorways for the performance of another later down the line (e.g., ten seconds later or five minutes later). This is something that can be lost if just conforming to single stills from the data. According to Grunditz (2020), frames that are combined into comics sequences can, through panel layout and panel transitions, be a tool to "visualize the temporalities of actions in a film" (p. 9). Because reading comics involves simultaneously interpreting single panels and all of the content in the sequence, "this makes comics useful for visualizing the unfolding of an interactional event in a film" (p. 10).

However, in analyzing and presenting the data we have also taken inspiration from Norris' (2019) way of transcribing multimodal interaction and combined this with the visual remake. This 'amalgamethod' was used because if the data had only been transcribed into traditional comics (i.e., speech bubbles and captions), a risk existed that the mode of language would overshadow the other modes. Also, in conventional comics, the movement in and between panels is orchestrated through a script. This is not as easily done with stills from a video recording, they are what they are, so to speak. Using arrows and/or words to convey what is happening in the frames can therefore enhance both the analysis and the readers' understanding.

However, comics—just like a narrative text—is a different medium than film. So even when using graphic transcripts, some of the data may be lost. But since comics—just like film—is a visual medium, it can be used in order to retain some of the visual aspect of the data. Through the comics format, bodily actions and movements can be understood and analyzed through still images (Grunditz, 2020).

The comic sequences used in this article to analyze and visualize the data was mostly collected through a handheld camera, but also from a stationary web camera positioned in a corner of the room the activities were taking place in. Scenes/frames from the data were first turned into sequential comics (using Adobe Photoshop and Adobe InDesign) and then transcribed multimodally, one mode at a time (using Adobe InDesign). Of course, not every single action performed by the social actors has been transcribed, that would essentially take frame upon frame upon frame of the data. Instead, essential stills/frames for conveying actions important for the research questions were singled out and put together in sequential format.

The modes of gesture, gaze, head movements, facial expressions and proxemics were transcribed by using differently colored arrows and caption texts, and the mode of language was transcribed by using differently colored speech bubbles (see Table 2). Bold italics were used to show emphasis in language, a en-dash directly after a word was used to show interruption, a en-dash following a regular dash was used to describe an interjection or describe a sudden shift in thought, and three dots were used to describe a break in a utterance. The two different tables (i.e., the material tables and construction tables), could of course be considered a mode in themselves (that of layout), but since these stayed in a fixed position during the activities, we have chosen not to transcribe these as a mode (Fig.1).

Analysis

The analysis was done in four different steps: getting acquainted with the data; doing a graphic transcription; using the graphic transcripts to thematically categorize the construction-focused actions in the activities; identifying constitutive construction-focused actions and discerning patterns behind these.

The first step of the analysis concerned getting acquainted with the data. This process started with author 1 immersing himself in the video recordings from unit Alpha through Epsilon. Even though familiarization started during the video recordings of the activities (which were done by author 1), this step was mostly done through repeated viewings of the five different video recordings. During these viewings, author 1 wrote down

Table 2 The transcribed modes and how they were illustrated in the graphic transcripts

Mode	*Illustrated with*
Proxemics	
Gesture	
Gaze	
Head movement	
Object handling	
Facial expression	
Language	Speech bubbles

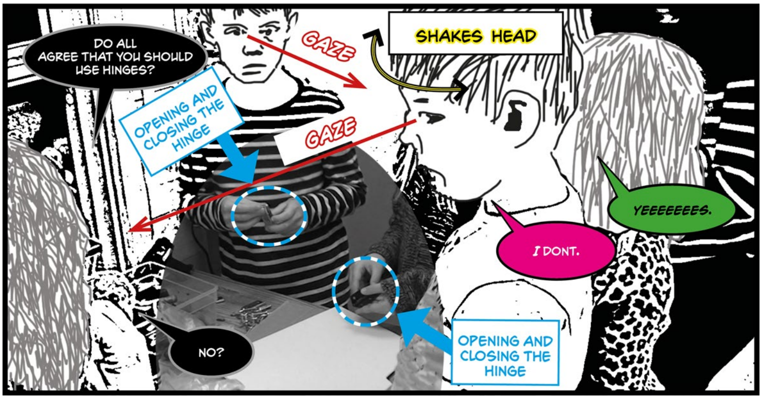

Fig. 1 An example of transcribed modes in a comics panel

(in summarizing terms) what was happening on screen (i.e., the interaction between the preschool teachers, the children and their surroundings). These summarizations were done from a multimodal perspective, where deeds had the same importance as words. In order to delineate the data and make it manageable for discussion with authors 2 and 3, video sequences from the five unit's planning phases were singled out. The three authors then watched the sequences together and did an initial joint mapping of what was happening in the planning phases of the activities.

The next step involved transcribing the video sequences. Author 1 excerpted stills from each activity and put them together into comic sequences that encapsulated the interaction in relation to the research questions. These sequences were then transformed into graphic transcripts and run by author 2 and 3 to see if the three authors' initial understanding of what was happening in the video sequences were still valid. The three authors found that the graphic transcripts helped in highlighting actions that had been overlooked during the initial mapping of events.

The third step of the analysis was to use the graphic transcripts to thematically categorize the interaction in the activities. Focus of this step of the thematic analysis was on construction-focused actions performed by the children—their engagement with each other; with the teachers; and with the material and tools. This part of the analysis helped us answering the first research question: What kind of construction-focused actions are performed by the children in the teacher-led activity? The coding process of thematic analysis has sometimes been criticized for being done a tad too arbitrarily (Boyatzis, 1998), but using a visual remake in conjunction with multimodal interaction analysis presented us with a way of methodically sifting through the data in search for codes and categories. When a tentative categorization had been developed and agreed upon by the three authors, the rest of the video recorded material was scrutinized by author 1 using said categorization. This process resulted in new categories emerging and some being combined. This was done until saturation was reached and no new categories of construction-focused actions could be found.

In the fourth step, all of the construction focused actions in the five units planning phases were scrutinized in relation to the outcome of said planning phase (i.e., which material and

Table 3 Construction-focused actions

Unit	Age	Child	Categories, sub-categories and number of times a construction-focused action was performed					
			Reciprocally engaging with a peer or a teacher		Engaging overtly with the material			
			Exchanging material	Exchanging ideas	Highlighting the functions of the artefact	Naming the artefact	Resource proclamation	Proximity seizing
A	5	Ruth	1	2	0	4	1	1
		Geoff	1	7	2	7	6	1
		Sheila	0	4	0	2	5	1
		Simon	2	15	4	5	6	2
B	3	Ian	1	4	0	0	4	1
		Mary	1	6	1	2	12	7
C	4	Suzy	0	3	3	2	7	4
		Steven	1	4	2	0	6	5
D	4 to 5	Joe	2	5	2	2	3	3
		Violet	0	1	0	0	1	1
		Kurt	5	10	4	1	8	8
		Barbara	1	3	1	3	6	4
E	3	Amanda	3	8	1	2	6	3
		Peter	4	4	0	5	17	4

solutions were chosen for the design process). Constitutive construction-focused actions (i.e., actions that shaped the design process and the outcome) were identified and analyzed from a perspective of what made them constitutive. This allowed an analysis not only of isolated acts, but to also consider the sequentially of acts and their outcomes, and different individuals' contributions in this, in line with Dewey's pragmatic perspective on learning described earlier. Through this step of the analysis we were able to answer our second and third research questions: Which construction-focused actions become constitutive for the design process? What kind of patterns can be identified behind the constitutive construction-focused actions?

Results

In Sect. 1 of the results, construction-focused actions, we will describe the different construction-focused actions that could be identified in the activities. But not all of the children's construction-focused actions became relevant for the outcome, only some of them. In Sect. 2, constitutive construction-focused actions and their legitimization by the teacher, we will describe which construction-focused actions became constitutive for the design process and the outcome of the planning phases. In Sect. 3, patterns behind constitutive construction-focused actions, we will take a closer look at factors that seemed important for these actions becoming constitutive.

Construction-focused actions

In the following section we present the results of the thematic analysis, in which we categorized all of the construction-focused actions performed by the children during the planning phases of the activities. In this section we will show what kind of construction-focused actions were performed by the children in the teacher-led activity. We use examples from the visual remake to exemplify the different types of actions found.

The thematic analysis (step three of the overall analysis) resulted in the following table (Table 3):

Two main categories emerged through the thematic analysis: *reciprocally engaging with a peer or a teacher* and *engaging overtly with the material.*

The category of *reciprocally engaging with a peer or a teacher* is divided into two sub-categories: *exchanging material* and *exchanging ideas*. The sub-category of *exchanging material* revolves around the children exchanging material in a reciprocal way with each other or with the preschool teachers. For example, when Simon is handing over screws and wing-nuts to Geoff, who is testing the Masonite door and the hinge against the door frame (unit Alpha, Panel A (see Fig. 2), or when Joe and Kurt exchange screws and wing-nuts with each other and with one of the teachers (unit Delta). This sub-category does not include a child grabbing a tool or a material from another child (or from a teacher), that kind of action is instead categorized under the sub-category of *resource proclamation* which is a part of the main category of *engaging overtly with the material (*which will be described in more detail a few paragraphs down).

The sub-category of *exchanging ideas* has to do with a child building on another child's (or a teacher's) problem-solving idea. This sometimes also involved the children engaging reciprocally in discourse around said idea. In the following panel we see Simon doing just that with one of the teachers (unit Alpha, panel B [see Fig. 3]).

Similar examples could be found between Joe and Kurt and the teachers in unit Delta, as well as Mary and the teacher in unit Beta.

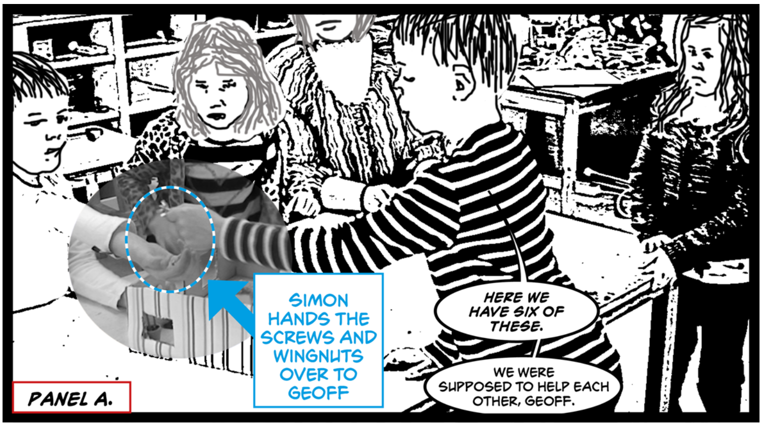

Fig. 2 Panel A—a panel from unit Alpha where Geoff and Simon are exchanging material

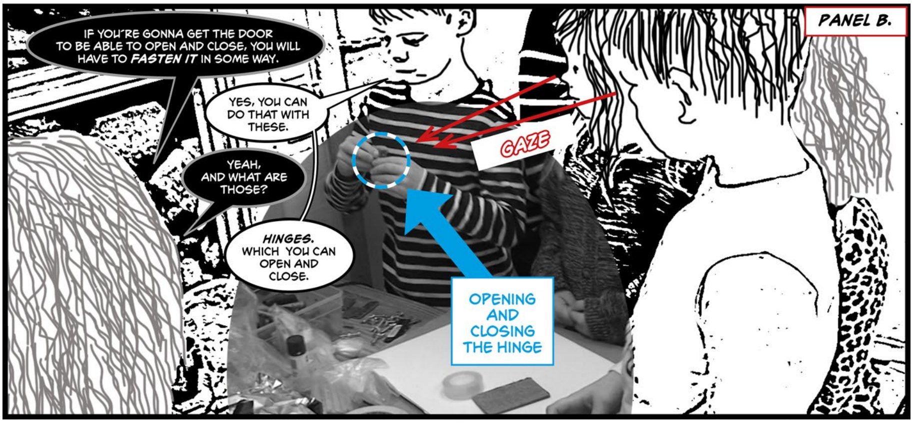

Fig. 3 Panel B—a panel from unit Alpha where Simon and one of the teachers are exchanging ideas. Simon is also naming the material

The category of *engaging overtly with the material* (the material for example being hinges, screws and wing-nuts) can be divided into four sub-categories: *highlighting the functions of the artefact; naming the artefact; resource proclamation;* and *proximity seizing*.

Panel B from unit Alpha above can also be used as an example for the sub-category of *naming the artefact.* This sub-category has to do with the children naming the tools and the material. When naming, for the most part, the children used the correct nomenclature. In panel B, (Fig. 3) we see Simon expressing the name of the artifact he is currently handling. Peter, in unit Epsilon, can be used as another similar example when he is saying "That is a hinge." (see Unit Epsilon in Appendix A).

The sub-category of *highlighting the functions of the artefact* has to do with the children suggesting how the artefacts can be used in the design process, alternatively showcasing how the artefacts are used in everyday life.

As can be seen in panel C above (Fig. 4), Simon (unit Alpha) is overtly showing the function of the artifact to the rest of the ensemble gathered around the table (the three other children and the two teachers). Another example of this can be found in unit Gamma.

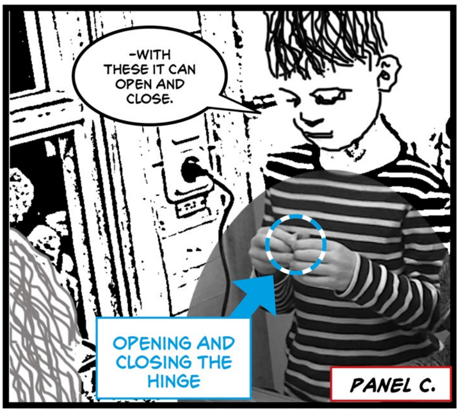

Fig. 4 Panel C—a panel from unit Alpha where Simon is showcasing the function of the hinge

When the teacher points at the hinge in Suzy's hands and asks if she knows what it can be used for, Suzy answers: "The doors—so that they can open and close…".

The sub-category of *resource proclamation* revolves around the children picking up the material and/or declaring what material to use in the design process. The picking up part includes both picking up the material from the table and grabbing the material directly from another child. In panel D (see Fig. 5), we can see Geoff from unit Alpha picking up the Masonite piece from the table, a piece which he held onto for the better part of the planning phase (as can be seen in panel A [see Fig. 2] which takes place at the end of said planning phase, he has brought it over to the model house from the material table in order to use it in the construction process of the door).

Another example of resource proclamation can be found in unit Beta, where Mary picks up one of the Masonite pieces and holds it up in the air for both Ian and the teacher to see. When the teacher tells the children that they shall start by completing one door, Mary quickly shouts "This one!" and raises the Masonite piece once more in the air (see sequence 3 [Fig. 8] later on).

The sub-category of *proximity seizing* has to do with the children positioning themselves in a physical and problem-solving central way in regards to the material, tools and/or the model house. For example, in panel A (Fig. 2) above, both Geoff and Sheila have stepped over to the model house, but it is Geoff who has taken a central position at the door frame of the model house and Sheila has more of a peripheral access. Similar situations could be identified in unit Delta as well, but to a significantly more extreme level. Here, both Joe and Kurt, quite literally, pushed themselves in front of the other children to get access to the material.

While Table 3 shows the number of times each construction-focused action was performed, and by whom, it does not show the importance of these actions in relation to the actual outcome of the planning phases (i.e., which ideas and materials were singled out for construction). All construction-focused actions are listed in Table 3, no matter their importance. If we use Peter in unit Epsilon as an example, he picked up a lot of the material on the table (or from the teacher, or from Mary) at one time or another (resource proclamation, $n = 17$), but this was often done in a somewhat arbitrary manner and many of these instances did not result in moving the design process forward. Thus, the next step of our analysis focused on discerning which of the construction-focused actions became constitutive for the design process.

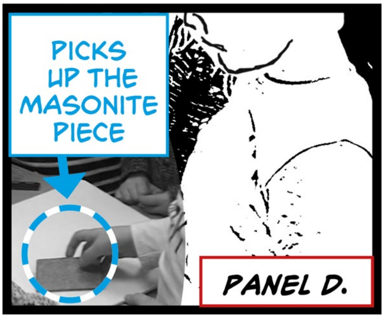

Fig. 5 Panel D—a panel from unit Alpha where Geoff picks up the Masonite piece

Constitutive construction-focused actions and their legitimization by the teacher

In the following section, we will describe the constitutive construction-focused actions. That is, the actions that drove the shaping of the design process and played an important role in the outcome of the planning phases of the five units (i.e., the answer to our second research question: Which construction-focused actions become constitutive for the design process?). The presentation is done from an outcome-perspective in which we have back-tracked which construction-focused actions (or events of construction-focused actions) that precipitated the choice of solutions. In some cases, the constitutive aspects of the actions where enhanced through the teachers' legitimizations. Constitutive actions are described with a C in brackets [C] and legitimizations are indicated with an L [L]. As the analysis and presentation of the constitutive actions are rather extensive, we will only present unit Alpha below. The other units can be found in appendix A.

Unit alpha

Teacher A1, Teacher A2, Ruth, Geoff, Sheila, Simon.

Outcome: Masonite door, hinge, screws and wing nuts.

Constitutive actions for the outcome of the ***Masonite door***.

UA 1Geoff picks up the Masonite piece and shows it to Teacher A1[1] and says that it can be used in conjunction with tape to [make a door that can] open and close[2].

1. *Resource proclamation of the Masonite door. [C]*
2. *Exchanging ideas with the teacher. [C]*

UA 2Simon points at the Masonite door in Geoff's hand and says that they can combine it with the hinge[1]…

1. *Exchanging ideas with a peer. [C]*

UA 3…and Geoff picks up a hinge and tests it with the Masonite door[1]. Teacher A1 suggest that they shall go over to the house with the Masonite door and the hinge[2].

1. *Highlighting the function of the hinge. [C]*
2. *Legitimization of an idea and a material by teacher A1. [L]*

UA 4 Simon tells Geoff to go over to the model house with the hinge and Masonite door[1].

1. *Exchanging ideas with a peer. [C]*

UA 5Geoff walks over to the model house and the door frame[1] and tests the Masonite door and hinge against the door frame and shouts "It fits!"[2].

1. *Proximity seizing of the door frame. [C]*
2. *Resource proclamation of the door. [C]*

Constitutive actions for the outcome of the ***hinge***.

UA 6Simon picks up a hinge[1], uses its correct name[2], answers Teacher A1 what its function is[3], and suggests that they can use it for the construction of the door[4].

1. *Resource proclamation of the hinge. [C]*
2. *Naming the hinge. [C]*
3. *Highlighting the function of the hinge. [C]*
4. *Exchanging ideas with the teacher. [C]*

UA 7Simon holds up a hinge in the air (in front of the teachers and the other children)[1] and answers Teacher A1 that it can be used for opening and closing stuff[2,3].

1. *Resource proclamation of the hinge. [C]*
2. *Highlighting the function of the hinge. [C]*
3. *Exchanging ideas with the teacher. [C]*

UA 8Teacher A1 asks the children about how to solve that they have two different ideas on how to construct the first door (Geoff—tape, the others—hinge). Sheila suggests that they use one method for each door frame[1] (the model house has two empty door frames). Simon uses the hinge in his hand and points at the Masonite piece in Geoff's hand and says that they should use hinges for that one[2,3&4]. The teachers agree with Simon[5].

1. *Exchanging ideas with the teacher.* [C]
2. *Resource proclamation of the hinge.* [C]
3. *Naming the hinge.* [C]
4. *Exchanging ideas with the teacher.* [C]
5. *Legitimization of an idea and a material by the teachers.* [L]

UA 9Geoff picks up a hinge and tests it with the Masonite door[1&2]. Teacher A1 suggests that they go over to the model house with the Masonite door and the hinge[3].

1. *Resource proclamation of the hinge.* [C]
2. *Highlighting the function of the hinge.* [C]
3. *Legitimization of an idea and a material by teacher A1.* [L]

Constitutive actions for the outcome of *the screws and wing nuts.*

UA 10Simon uses the correct name for the screws[1] and answers Teacher A1 that they can be used for fastening the hinges[2&3]. The teacher agrees[4].

1. *Naming the screws.* [C]
2. *Highlighting the function of the screws.* [C]
3. *Exchanging ideas with Teacher A1.* [C]
4. *Legitimization of an idea and a material by the teachers.* [L]

UA 11Teacher A1 asks how they are going to fasten the hinges, Simon picks up some screws and wing-nuts and says that they will use those[1&2].

1. *Exchanging ideas with Teacher A1.* [C]

2. *Resource proclamation of the screws and wing-nuts.* [C]

UA 12 Simon informs Geoff that they need screws for the Masonite door and the hinge[1&2].

1. *Exchanging ideas with a peer.* [C]
2. *Naming the screws.* [C]

UA 13Simon and Ruth pick up screws and wing-nuts[1]. Simon says that they need them for fastening the door[2].

1. *Resource proclamation of the screws.* [C]
2. *Highlighting the function of the screws.* [C]

UA 14 Simon picks up/are handed some of Ruth's screws and wing nuts[1&2]….

1. *Resource proclamation of the screws.* [C]
2. *Exchanging material with a peer* [C]

UA 15 …and walks over to the model house and hands them to Geoff[1].

1. *Exchanging material with a peer.* [C]

The results from the analysis are summarized in Table 4. The constitutive construction-focused actions are listed in two columns, using the two main categories from Table 3. In the column called *reciprocally engaging with a peer or a teacher* we have put the number

Table 4 Number of constitutive construction-focused actions and legitimizations in units Alpha through Epsilon

Unit	Child	Reciprocally engaging with a peer or a teacher	Engaging overtly with the material	Legitimized by the teacher
A	Ruth	1	1	0
A	Geoff	2	6	2
A	Sheila	1	0	0
A	Simon	9	13	2
B	Ian	5	3	1
B	Mary	4	21	3
C	Suzy	2	12	4
C	Steven	5	11	3
D	Joe	2	7	1
D	Violet	0	2	0
D	Kurt	3	13	3
D	Barbara	1	2	1
E	Amanda	9	11	3
E	Peter	5	8	5

of times each child took part in a reciprocal engagement that shaped the outcome of the planning phase. In the column called *engaging overtly with the material* we have put the number of times each child positioned hirself in a way that shaped the outcome of the planning phase. Thus, the two columns together show the number of construction-focused actions that became constitutive. In the column called *legitimized by the teacher,* we have put the number of times each child's constitutive construction focused-actions got acknowledged by the teacher/s.

Patterns behind constitutive construction-focused actions

In order to better understand how the constitutive construction-focused actions became constitutive, an in-depth analysis was made of these sequences in the visual remake. This analysis helped us answering our last research question: What kind of patterns can be identified behind the constitutive construction-focused actions?

Two patterns emerged from the analysis. The first being the children's ability to—in a quick and decisive manner—take possession of the material (e.g., quickly picking up and showcasing the function of a hinge) and through these actions get the opportunity for further actions regarding putting forward ideas in the design process. Children who quickly—and in a verbal way—present a feasible solution, often get reaffirmed by the teachers in the form of reassuring gazes, nods, smiles, gestures and verbal interaction. Regarding the verbal interaction, the prompting seems to be enhanced if the children also know the correct nomenclature for the material and its conventional use (i.e., the function). This would suggest that children with prior experience and familiarity with the material and tools may easier get their voices heard in this kind of construction activity. The data shows that the teachers focus a lot on Simon in unit Alpha, and Kurt and Joe in unit Delta. These children seem to have a prior understanding of the hinges and screws. For example, as can be seen in sequence 1 (see Fig. 6), Simon is very quick in naming the material and expressing ideas on how to use it to solve the problem. His ideas pique both the other children's and teachers' interest—and his ideas are quickly reaffirmed by the latter.

The second pattern being the children's ability to position themselves in regards to the material and the other children and teachers. Children who had a lot of say in the design process were exchanging ideas and material with the teachers (in all units) and/or with one of their peers (in unit Alpha and Delta), as well as physically positioning themselves in a

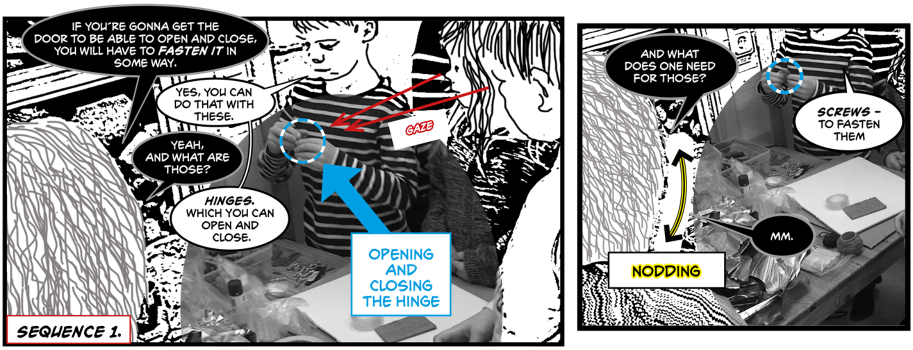

Fig. 6 Sequence 1—a sequence of events from unit Alpha

central role. Overall, the teachers seem more prone to focus on the quick and decisive children—and through actions and deeds legitimize those children's ideas.

Below we will use excerpts from our visual remake (in the form of comic sequences) and descriptions from the five units to exemplify our results, by using both similar and contrasting examples.

In unit Alpha, Simon quickly picks up a hinge (*resource proclamation*) when the material is introduced to the children and engages in discourse (*reciprocally engaging with a teacher*) with a teacher about the function (*highlighting the function of the artefact*) and definition of the hinge (*naming the artefact*). In sequence 1 below (see Fig. 6), we see how Simon is both using the correct name of the hinge and is also highlighting its function. This happened fairly early in the planning phase, and all eyes (both children's and teacher's) were fixated on Simon (these constitutive actions can be found in description UA6 and UA10 in the outcome description of unit Alpha above).

Simon was very quick in both picking up the hinge and showing the ensemble around the table its function, he was also the one taking the initiative in answering the teacher's question. This resulted in a reciprocal engagement from the teacher about what he would need to fasten the hinge. Simon's initiative in quickly handling the material and engaging in discourse with the teacher put him in a position where he later on could suggest a path forward regarding the design process, which was then further legitimized by the teachers. The children and the teachers reached the decision that one solution should consist of a Masonite door with a hinge, and the other of a Masonite door with tape for hinges. However, as seen in sequence 2 (see Fig. 7), Simon quickly points out which method they should use for the first door (the Masonite door in Geoff´s hand combined with the hinge he himself was holding).

Simon's suggestion is then legitimized through the teachers' actions when they tell him that they think his idea is the right way forward. Notably the teachers legitimize his suggestion without him having an explanation on why this should be the way forward. Instead they ask him how to fasten the hinge. He quickly picks up a screw and wing-nut (*resource proclamation*), explains what it is *(naming the artefact)*, and what it can be used for (*highlighting the function of the artefact*) (these constitutive actions can be found in description UA11 and UA12 in the outcome description of unit Alpha above). It should be noted that Ruth is also picking up a screw and wing-nut (*resource proclamation*), but this is not acknowledged by the teachers. Important aspects for a child ending up in a central role in the design process thus seems to include: being quick in picking up the material, laying out a strategy forward (in a decisive way) and having knowledge about the artefacts.

A similar example of being quick and decisive in one's interaction with the material and the teacher can be found in unit Beta (sequence 3 in Fig. 8), where Mary picks up the door-shaped Masonite piece and repeatedly points out to the teacher that that is the one they will use as the door (*resource proclamation*). The teacher interacts with Mary and prompts her to test it against the door frame of the model house (*reciprocally engaging with a teacher*). Just like Simon (in unit Alpha), Mary is quick in handling the construction material overtly and verbally expressing an idea on how to proceed with the design process—actions that gets legitimized by the teacher. A difference between the two cases is that Mary does not bring up the aspect of function. An explanation for this could be the age difference, the children in unit Alpha being 5 years old compared to 3 years of age in unit Beta.

When the teacher suggests that Mary tests the Masonite piece against the door frame, she decisively steps over to the model house and does exactly this (*proximity seizing*)—and quickly shows that it fits. The teacher immediately responds by saying since that is the case, Ian will have to put his smaller piece back on the material table (i.e., the Masonite

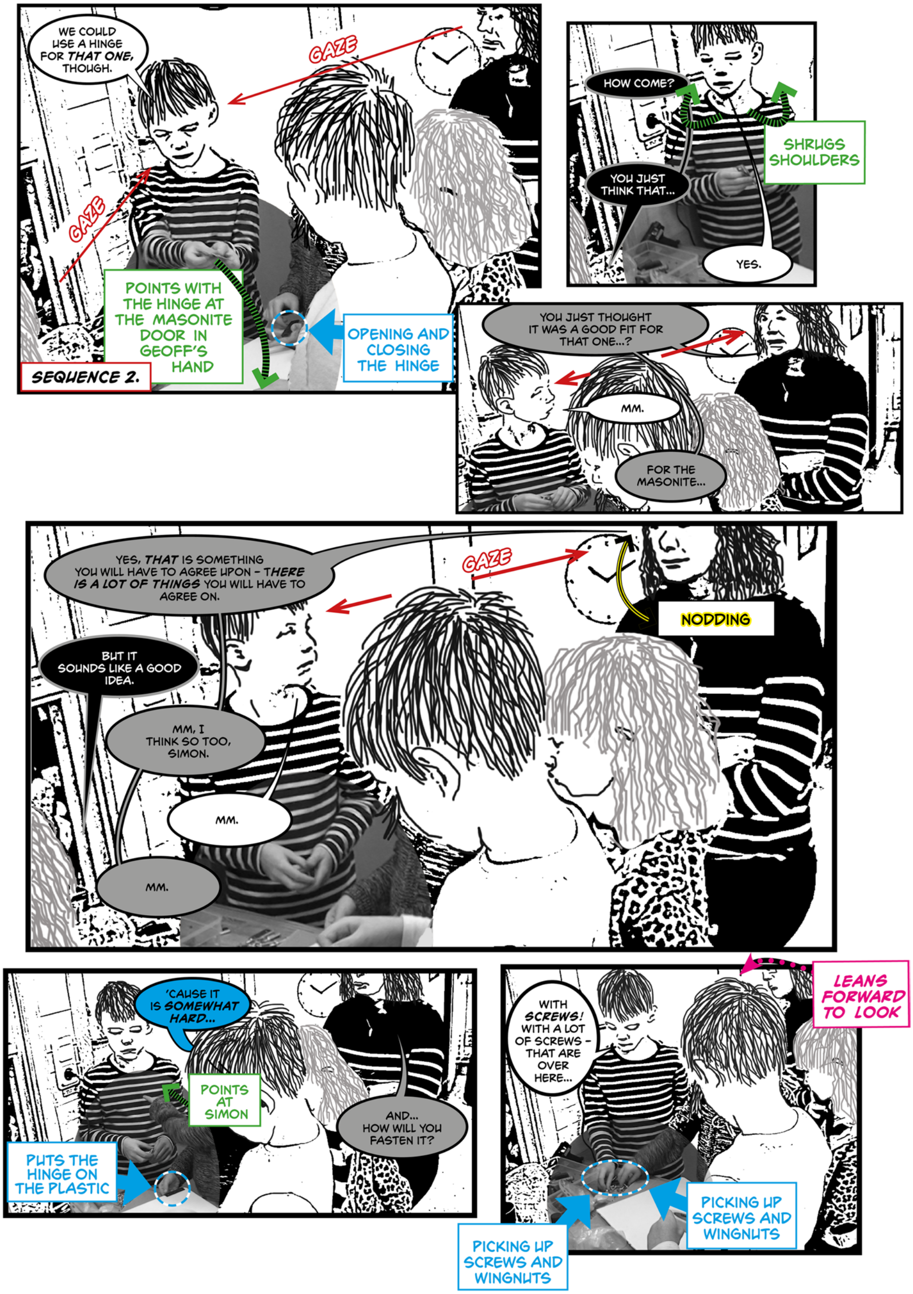

Fig. 7 Sequence 2—a sequence of events from unit Alpha

piece in Mary´s hand is the way to move forward). Similar to the events in unit Alpha, the teacher does not ask Mary why she wants to use "her" Masonite piece or if other options exist.

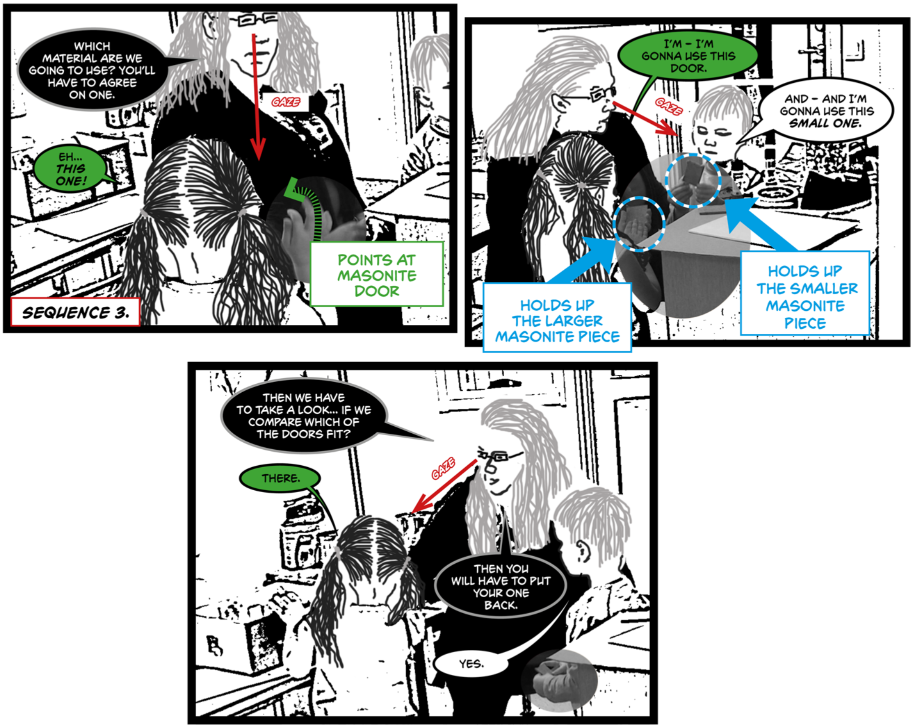

Fig. 8 Sequence 3—a sequence of events from unit Beta

Except for being quick in getting a hold of the material and putting it forward to the teacher in an overt way, the data also shows Mary forcefully positioning herself in a central way, both in the interaction with the teacher and in regards to the design process (she quickly takes place front and center by the model house while Ian is looking on from behind).

Another example of this kind of proximity seizing playing an important role for the children ending up in a central role for the design process can be found in unit Alpha. In panel A (Fig. 2) we can see how Geoff has moved over to the model house to try out the Masonite piece and hinge against the door frame (*proximity seizing*) (these constitutive actions can be found in description UA5 in the outcome description of unit Alpha above). A similar example from unit Delta is when Kurt on several occasions squeezes himself between the other children, so that he ends up right in front of the material (*proximity seizing*). He also pushes himself in front of the teachers (*proximity seizing*) in order to discuss his idea on how to move on with the design process (*exchanging ideas*). This was also done, but to a lesser extent, by Joe. The two teachers in unit Delta did not show any signs of noticing that this was happening. Instead they engaged in discussion with Joe and Kurt about the material and the two children's ideas on how to proceed with the design process (*exchanging ideas*), thus legitimizing the two children's actions and ideas.

Another example of this more physical way of positioning oneself (in this case through both *proximity seizing* and *resource proclamation*) can be found in unit Gamma. If one just looks at Table 4, it seems that Suzy and Steven were on a somewhat equal footing when it

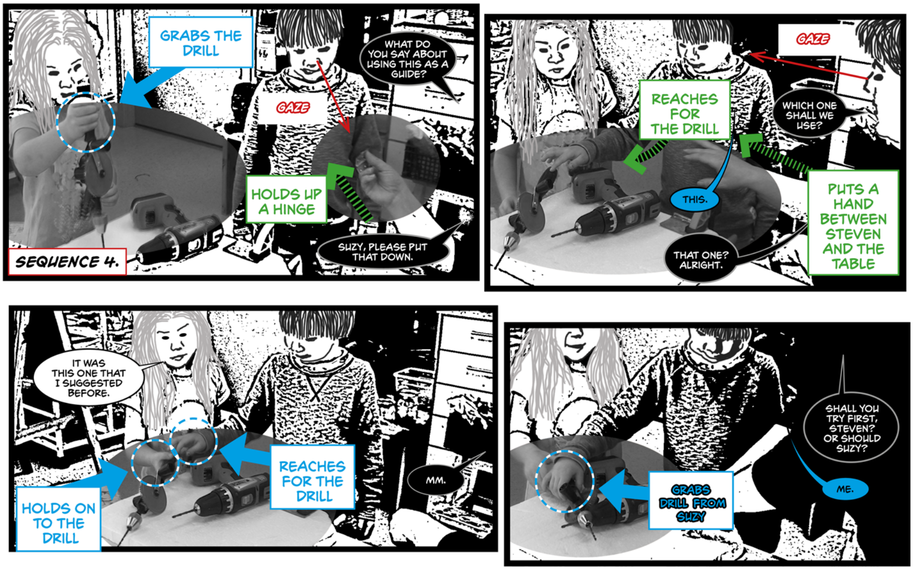

Fig. 9 Sequence 4—a sequence of events from unit Epsilon

came to constitutive construction-focused actions. However, the interaction between the teacher and Suzy and the teacher and Steven were at times quite different, especially when the trio moved over to the drill and clamp. The teacher sometimes blocked (both literally and figuratively) Suzy's opportunities to resource proclamation and proximity seizing and instead facilitated Steven's. Thus, legitimizing his ideas (see sequence 4 in Fig. 9). This legitimization was done through a combination of different modes, such as gazes, gestures and words.

But it was not only through the physical positioning that some of the children ended up in a central role. This was also done through some of the children exchanging both ideas and material with a peer. This could only be identified in the two units involving four children, though.

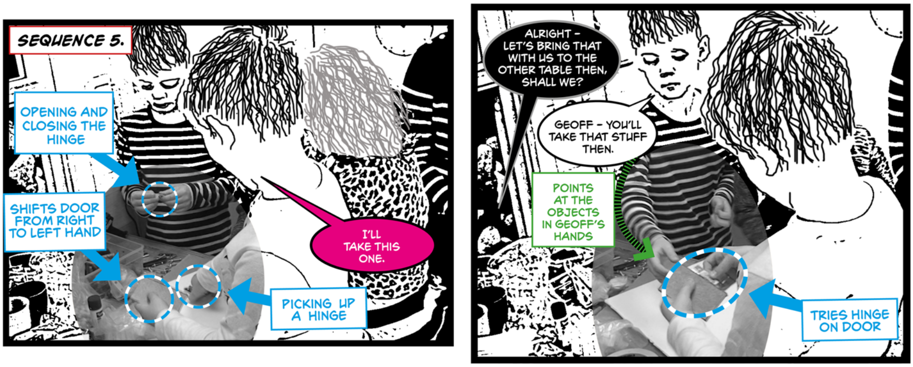

Fig. 10 Sequence 5—a sequence of events from unit Alpha

Geoff's (unit Alpha) initial idea for the door (i.e., using tape as a hinge) was "relegated" to being the solution for the second door. Instead Simon put forward the idea that the first solution should be designed with a hinge. Geoff quickly conformed to this idea and entered into a reciprocal interaction with Simon.

Looking at sequence 5 (Fig. 10) above, we see how Geoff, after his original idea has been put on hold, quickly picks up a hinge (*resource proclamation*), and then engages in discourse with Simon on what material to use in the coming construction process (*exchanging ideas*) (these constitutive actions can be found in description UA8 and UA9 in the outcome description of unit Alpha above). The fruits of their interaction are legitimized by one of the teachers. This interaction opens up for further construction-focused actions in the coming design process. For example, a while later Geoff walks over to the other table, hinge and door in hand, and positions himself next to the model house's door frame (*proximity seizing*). Shortly thereafter, Simon hands him screws and wing-nuts (*exchanging material*) (see panel A, Fig. 2).

As a contrast, the interaction between Ruth and Simon takes on another shape, one not so reciprocal in nature. Ruth and Simon both engage with the material and are picking up screws and wing-nuts (*resource proclamation*). However, Ruth's role in this can be seen from more of a helping-hand perspective in that Simon exclaims what they are going to do. He ultimately picks the screws and wing-nuts that he needs directly from Ruth (*resource proclamation*) (see sequence 6, Fig. 11) (these constitutive actions can be found in description UA13 and UA14 in the outcome description of unit Alpha above), and walks over to Geoff at the table with the model house and hands them over to him (*exchanging material*)—while Ruth looks on from a distance (see panel A, Fig. 2).

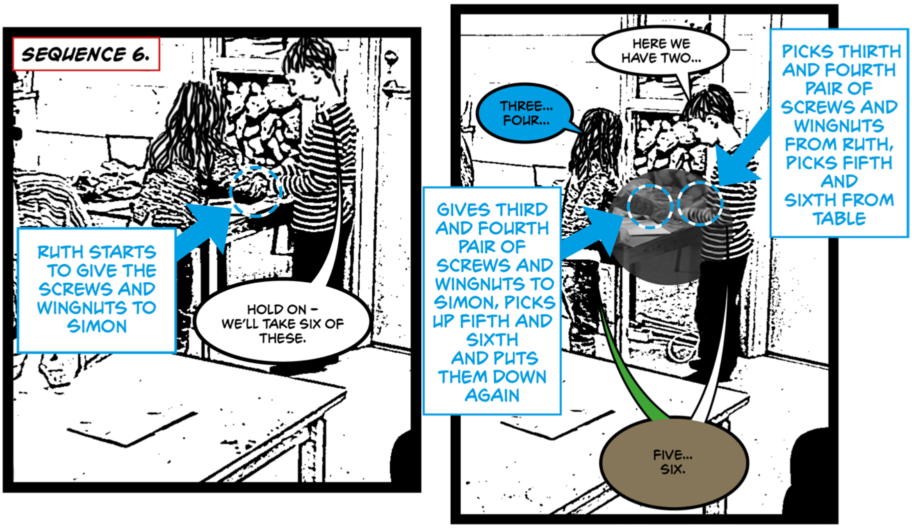

Fig. 11 Sequence 6—a sequence of events from unit Alpha

Discussion

Our first question of inquiry had to do with trying to discern what kind of construction-focused actions children performed in a construction activity in preschool. Our analysis of the design process of the planning phase shows that the children engaged in the process through six different categories of actions. The children were *naming* the material (i.e., they were using the correct names for the tools and the material); they were *highlighting the functions of the artefacts* (e.g., the hinge); they were *seizing the proximity* to the material and tools; and they were *proclaiming the material* (i.e., the tools and the material). These four actions can be described as the children *engaging overtly with the material.* The remaining two actions the children used for taking part in the problem-solving process were *exchanging material* and *exchanging ideas* in a *reciprocal way with a peer or the teacher.* All in all, the study showed that the developed activities gave the children rich opportunities to create technologically relevant experiences (cf. Hallström et al., 2015).

However, not all of these experiences became central to the outcome of the construction activity. Our next two questions of inquiry therefore revolved around which of these actions became constitutive for the design process—how the children's construction-focused actions during the planning phase became constitutive for the design process and what the teacher's role in this was. Our results showed that some of the children had a central role in the outcome of the planning phase (e.g., Kurt in unit Delta); other children had a somewhat lesser role (e.g., Barbara in unit Delta); and some of them had very little input in the outcome (e.g., Violet in unit Delta).

As has been previously pointed out, teacher-led learning (e.g., Boström et al., 2022; Hallström et. al, 2015; Fleer, 2000); the possibility to engage in the design process (Nilsson et al., 2020; Sundqvist, 2019); and small groups (Hallström et al., 2015; Sylva, et al., 2007) are important aspects when arranging construction activities in preschool in order to help children develop technological skills. However, the teachers in our study did all this—they took on the role of the guiding adult, engaged the children in the design activity, and only had a small group of children. Despite of this, only some of the children ended up in a central position in the design process. Thus, our data show that the above factors are only parts of the solution if one wants to give all children opportunities to develop their technological skills and confidence. Another important factor to take into consideration is how the children's prior experience of construction activities affect their interactions and experiences in the one being undertaken. Thusly, it is important that the teachers reflect on whose design ideas are legitimized as the way forward and why—and why others aren't; to reflect on what kind of material is prompted and why.

Our findings show that children who quickly and decisively engage with the material (artefacts and tools), the teachers and their peers in suggesting which material to use and/or how the material can be used to solve the problem at hand, end up in a central role for the design process. Understanding how the material works and how it is conventionally used in everyday life seems to be important for getting one's voice heard. Seen from the theoretical perspective of Dewey, and the continuity of experience, we may argue that certain habits, formed through previous experiences, are favored over others. These experiences then lead to the possibility of future experiences, i.e., ending up in a central role for the outcome of the construction activity.

Gender has not been the main focus of this study, but our results indicate that gendered experiences may have a role in what happens in the activities. Actually, it seems the teachers through their actions to a high degree came to reinforce gendered technology experiences, rather than to challenge them (cf. Hallström et al., 2015). If Mawson (2007) is correct about boys having a wider range of experiences regarding construction tools and materials, this kind of construction activity could, if not handled properly, create a gender problem. The activity reported on in this article could of course be problematized from the perspective that it is built on the traditionally "hard" side of technology (e.g., hinges and wing-nuts) and therefore is easier accessed by those children having taken part in similar activities at home, which often is those who identify themselves as boys (Mawson, 2007). However, it is always important to remember that this doesn't mean that all boys have taken part in such activities, or that none of the girls have. Also, it is not only prior experiences that influence children's actions. Gendered expectations from the surrounding world (e.g., parents, teachers, other children) also limit their way of being (Hundeide & Järvå, 2006; Kimmel, 2000).

In our study we could not identify the boys in general being more interested in the construction material than the girls, but looking at the two units involving four children (units Alpha and Delta), we can see how some of the children interact through a form of collaborative team-up. Simon and Geoff in unit Alpha, and Joe and Kurt in unit Delta. One explanation for their tight collaboration could be that these children have a prior experience of the material. Table 3 lends some credibility to this in that both Geoff and Simon are naming and highlighting the functions of the material, while Ruth and Sheila do this to a lesser degree. However, looking at the data from unit Delta, Joe and Barbara seem to be on equal footing regarding this aspect. But still it is Kurt who Joe collaborates with. Ruth in unit Alpha also seems to have prior knowledge about the names of some the material, but in the end, she acts more as a helping hand to Simon than a collaborative partner. Both Ruth and Barbara show a will to engage reciprocally with Simon and Geoff and Kurt and Joe respectively, but in the end, they are not fully let into the core of the collaboration. While we do not know for sure why that is, an explanation could be the historicity of the material. Hard construction material has a long history of being connected to what has been described as the male sphere of technology (Berner, 1999; Faulkner, 2003; Mellström, 1999; Oldenziel, 1999). For example, Mawson (2007) describes that it is more common for children to interact with a male relative around technology related to the trades. It could therefore be that Simon and Geoff, and Joe and Kurt, see each other as the significant other when it comes to this kind of activity. According to Emilson and Johansson (2013) children both position themselves, and are positioned by the surrounding world due to the dominant gender discourse. If the discourse revolves around a normative bipolar model of gender, boys may end up in a position of power while girls' role become more of an adopting one. Of course, gender is only one possible explanation for this. Other factors that may play a part could for example be age, competence and social order. According to Westlund (2011), gender may be a structural obstacle for preschool children in exercising influence, but more often they are affected by their own volition—their initiative—to exercise influence. However, the trouble is knowing if children aren't interested in exercising their influence or if they simply don't feel secure enough to express their opinion—and as has been shown before, children engaging with technology at home may have more experience and a greater technological self-esteem than children who don't (Mawson, 2007; Plowman et al., 2010). An understanding of how children's prior experiences form their experiences in, and the outcome of, a construction activity in preschool (i.e., the principle of continuity) thus become important for preschool teachers to consider.

In this study we broke down and analyzed a planning phase of a construction activity in preschool by combining a multimodal analysis with graphic transcriptions. Through this extensive process we were able to pinpoint not only which construction-focused actions took place, but also which of these actions (or sequences of actions) were constitutive for the outcome of the design process. We suggest that this process let us disseminate the interactions between children and teachers in a construction activity in preschool to a degree which hasn't been done that often.

Implications for practice and further studies

Preschool teachers always have a power position—and should therefore, always, ponder how—not if—they shape the outcome of an activity (Westlund, 2011). When arranging a construction activity in preschool with the intention of creating equal opportunities that foster technological self-esteem for *every* child, teachers need to contemplate and examine which construction-focused actions they legitimize; which they do not; and why. Thus, teachers also need to have insight into what kind of construction-focused actions children perform, and an understanding of their legitimization and non-legitimization of different solutions.

Preschool teachers should also be aware of the possibility of lost opportunities. If they put focus on comparisons about different solutions and material during an activity's planning phase, there is a chance of every child's voice being heard. This may also enhance the children's understanding of functionality.

For future research it would be interesting to study other types of construction activities, to verify or challenge the results from this study. Also, we suggest having a gendered perspective in those analyses, as that category seem important, given the results of this study. To enhance the understanding of how previous experiences might interact with the outcome and interactions in construction activities, complementing observational data with interviews with children about their previous technological experiences should be considered.

Appendix A

Unit beta

Teacher B, Ian, Mary.

Outcome: Masonite door, tape.

Constitutive actions for the outcome of the ***Masonite door.***

Mary picks up the two Masonite pieces shaped like doors and compares them[1].

1. Resource proclamation of the Masonite door. [C]

When the teacher asks which material to use for the door, Mary points at the Masonite piece in her hand and loudly exclaims that they will use that one[1].

1. Resource proclamation of the Masonite door. [C]

Mary reiterates that it is the Masonite piece that she is holding that shall be used as a door[1].

1. Resource proclamation of the Masonite door. [C]

The teacher asks the children if they agree on Masonite as the material. Both says"yes."[1].

1. Legitimization of an idea (Mary's). [L]

The teacher asks the children to compare the Masonite pieces they are holding [Mary is holding a door shaped piece and Ian is holding a more squarish piece] with the door frame of the model house. Mary steps over to the door frame[1], tests her piece, and declares that it is the one[2&3]. The teacher agrees[4] and asks Ian to put his piece away.

1. *Proximity seizing of the door frame.* [C]
2. *Resource proclamation of the Masonite door.* [C]
3. *Exchanging ideas with the teacher.* [C]
4. *Legitimization of a material.* [L]

Mary shows were the Masonite door can be fastened on the model house[1&2].

1. *Resource proclamation of the Masonite door.* [C]
2. *Proximity seizing of the door frame.* [C]

Mary once again shows were the Masonite door can be fastened on the model house[1&2].

1. *Resource proclamation of the Masonite door.* [C]
2. *Proximity seizing of the door frame.* [C]

The teacher asks Ian what he thinks about the Masonite door that Mary is holding, he says that he thinks it is too small, Mary says that it isn't[1]—while at the same time holding the Masonite door against the door frame[2&3].

1. *Exchanging ideas with the teacher.* [C]
2. *Resource proclamation of the Masonite door.* [C]
3. *Proximity seizing of the door frame.* [C]

Constitutive actions for the outcome of the ***tape.***

The teacher asks Mary how they shall fasten the door on the door frame. Mary answers that they can use tape[1&2], walks over to the material table and picks up a roll of tape[3], and returns to her position at the door frame[4].

1. *Naming the tape.* [C]
2. *Exchanging ideas with the teacher.* [C]
3. *Resource proclamation of the tape.* [C]
4. *Proximity seizing of the door frame.* [C]

The teacher asks Ian if he also thinks tape is a good idea, he says "yes" [1], and the teacher decides that tape it is[2].

1. *Exchanging ideas with the teacher.* [C]
2. *Legitimization of an idea (Mary's).* [L]

Mary starts trying to tear of a piece of tape.[1] 1. *Resource proclamation of the tape.* [C]

The teacher gives a pair of scissors to Ian[1], who then helps Mary to cut off a piece of tape[2].

1. *Exchanging material with the teacher.* [C]
2. *Resource proclamation of the tape.* [C]

The piece of tape is caught on the blade of the scissors, Ian tries to pull it off, but Mary intervenes[1] and does it instead…

1. *Resource proclamation of the tape.* [C]

…Mary tests the piece of tape with the Masonite door and door frame[1&2]…

1. *Resource proclamation of the tape.* [C]
2. *Proximity seizing of the doorframe.* [C]

…but it is too small to fasten the door with. The teacher asks the children what to do about it. Ian says that they should use the other tape instead[1], the teacher agrees[2], Ian walks over to the material table and brings it back to the model house[3]. Ian tells Mary that it is better, she agrees[4].

1. *Exchanging ideas with the teacher.* [C]
2. *Legitimization of an idea by the teacher.* [L]
3. *Resource proclamation of the tape.* [C]
4. *Exchanging ideas with a peer.* [C]

Mary pulls a piece of tape from the tape roll that Ian brought with him[1].

1. *Resource proclamation of the tape.* [C]

Ian uses the scissors to cut the tape.

1. *Resource proclamation of the tape.* [C]

Mary tests the piece of tape with the Masonite door and door frame[1&2].

1. *Resource proclamation of the tape.* [C]
2. *Proximity seizing of the doorframe.* [C]

Unit gamma

Teacher C, Steven, Suzy.

Outcome: Masonite door, hinge, screws and wing nuts.

Constitutive actions for the outcome of the ***Masonite door.***

Suzy picks up the Masonite piece shaped like a door[1] and says that it is a door[2], the teacher reiterates that idea[3].

1. *Resource proclamation of the door. [C]*
2. *Naming the door. [C]*
3. *Legitimization of an idea and a material. [L]*

Suzy walks over to the model house and tests the door against the frame and declares that it fits[1&2], the teacher agrees[3]. She then returns to the material table.

1. *Resource proclamation of the door. [C]*
2. *Proximity seizing of the door frame. [C]*
3. *Legitimization of the material. [L]*

Steven picks up screws (with wing nuts), a hinge and another Masonite piece shaped like a door[1], and walks over to the door frame of the house[2]…

1. *Resource proclamation of the door. [C]*
2. *Proximity seizing of the door frame. [C]*

…and Suzy does the same.

1. *Resource proclamation of the door. [C]*
2. *Proximity seizing of the door frame. [C]*

Constitutive actions for the outcome of the ***hinge***.

Suzy and Steven pick up a hinge each[1].

1. *Resource proclamation of the hinge. [C]*

The teacher asks Suzy if she knows what it is used for, she answers that it can be used for opening and closing doors[1]—while opening and closing the hinge.

1. *Exchanging ideas with the teacher. [C]*
2. *Highlighting the function of the hinge. [C]*

Steven opens the hinge in his hand and suggests that it can be clamped around stuff[1]. The teacher suggests that they'll take a look at the hinges on the door to the room they are presently in[2].

1. *Highlighting the function of the hinge. [C]*
2. *Exchanging ideas with the teacher. [C]*

The teacher asks the children if they know where on the door the hinges can be found, Steven points at the edge of the door frame that connects the frame with the door[1&2], while the teacher opens the door and shows the hinges[3].

1. *Exchanging ideas with the teacher. [C]*
2. *Proximity seizing of the real-life door frame and hinges. [C]*
3. *Legitimization of the material. [L]*

The teacher asks where the door is fastened. Steven points at the hinges and the door frame[1].

1. *Exchanging ideas with the teacher. [C]*

Steven picks up screws (with wing nuts), a hinge and another Masonite piece shaped like a door[1], and walks over to the door frame of the house[2]…

1. *Resource proclamation of the hinge. [C]*
2. *Proximity seizing of the door frame. [C] (already coded in Driving actions for the outcome of the Masonite door)*

…and Suzy does the exact same.

1. *Resource proclamation of the hinge. [C]*
2. *Proximity seizing of the door frame. [C] (already coded in Driving actions for the outcome of the Masonite door)*

Constitutive actions for the outcome of the ***screws with wing nuts***.

Suzy picks up a screw and wing nut, holds them in the air and asks the teacher how many they will need[1]. The teacher asks what her thoughts are and Suzy answers that they will probably need two[2]. The teacher says that two it is[3].

1. *Resource proclamation of the screws and wing nuts. [C]*
2. *Exchanging ideas with the teacher. [C]*
3. *Legitimization of the material. [L]*

Steven picks up screws (with wing nuts), a hinge and another Masonite piece shaped like a door[1], and walks over to the door frame of the house[2]…

1. *Resource proclamation of the screws and wing nuts. [C]*
2. *Proximity seizing of the door frame. [C] (already coded in Driving actions for the outcome of the Masonite door)*

…and Suzy does the exact same.

1. *Resource proclamation of the screws and wing nuts. [C]*
2. *Proximity seizing of the door frame. [C] (already coded in Driving actions for the outcome of the Masonite door)*

The teacher suggests that they need holes in the Masonite piece to be able to fasten it with the screws[1], and points to the end of the table where some tools are positioned. Suzy and Steven walk over to the tools[2].

1. *Legitimization of the material and the idea (Suzy's). [L]*
2. *Proximity seizing of the hole making tools. [C]*

The teacher shows the children a clamp, and Steven reaches for it, is handed it[1]—and at the same time pushing himself in front of Suzy…

1. *Exchanging material with the teacher. [C]*
2. *Proximity seizing of the hole-making tools. [C]*

…The teacher asks Steven to test the clamp[1].

1. *Legitimization of an idea. [L]*

The teacher asks which tool to use for the hole-making, Steven points at the hand drill[1]. The teacher asks who wants to start drilling, Steven picks up the hand drill—simultaneously as Suzy also tries to grab it—and answers that he will start[2]. The teacher agrees[3].

1. *Exchanging ideas with the teacher. [C]*
2. *Resource proclamation of the hole-making tools. [C]*
3. *Legitimization of the material. [L]*

Unit delta

Teacher D1, Teacher D2, Violet, Kurt, Joe, Barbara.

Outcome: Masonite door, hinge, screws and wing nuts.

Constitutive actions for the outcome of the ***Masonite door.***

Barbara picks up a Masonite piece from the material table and suggests that they shall use it as a door[1]. Teacher D1 suggests that she tries it with the door frame in the model house. Barbara walks over to the model house and does just that[2&3]. Teacher D2 says that she thinks it looks good[4].

1. *Resource proclamation of the door. [C]*
2. *Exchanging ideas with the teacher. [C]*
3. *Proximity seizing of the door frame. [C]*
4. *Legitimization of an idea and the material. [L]*

Kurt picks up the other Masonite piece shaped like a door and walks over to the model house and tries it out with the door frame[1&2]…

1. *Resource proclamation of the door. [C]*
2. *Proximity seizing of the door frame. [C]*

…Violet looks on while Kurt does this, and when he puts down the Masonite piece, she picks it up and tries it out with the door frame[1&2].

1. *Resource proclamation of the door. [C]*
2. *Proximity seizing of the door frame. [C]*

Kurt picks up the Masonite door[1] (which Violet put down on the table after she had tried it) clamps a hinge around it, holds it against the door frame[2] and declares that they can drill holes and then use the screws to fasten it.

1. *Resource proclamation of the door. [C]*
2. *Proximity seizing of the door frame. [C]*

Constitutive actions for the outcome of the ***hinge.***

Teacher D1 asks the children how they shall construct the door. Joe picks up a hinge[1] and shows that it can be used for opening and closing.[2&3]1. *Resource proclamation of the hinge. [C]*
2. *Highlighting the function of the hinge. [C]*
3. *Exchanging ideas with the teacher. [C]*

Kurt steps in between Joe and Violet[1], picks up a hinge[2], faces Joe (Violet behind him), and starts opening and closing it synchronously with Joe[3&4].

1. *Proximity seizing of the hinge. [C]*
2. *Resource proclamation of the hinge. [C]*
3. *Highlighting the function of the hinge. [C]*
4. *Exchanging ideas with a peer. [C]*

Teacher D1 asks Joe if he remembers the name of the artefact in his hands (the hinge), he says that it is a hinge.

1. *Naming the hinge. [C]*

Teacher D2 notes that Joe and Kurt have found a hinge, Joe points out that they have two hinges. [1&2] Teacher D1 reiterates the statement[3].

1. *Resource proclamation of the hinge. [C]*
2. *Naming the hinge. [C]*
3. *Legitimization of the material. [L]*

Kurt walks over to the model house and tries his hinge against the frame[1], Teacher D1 asks him what they shall use to construct the door, Kurt suggests the hinge[2&3].

1. *Proximity seizing of the door frame. [C]*
2. *Resource proclamation of the hinge. [C]*
3. *Exchanging ideas with the teacher. [C]*

Kurt holds up the hinge in front of Teacher D2 and points out that the Masonite piece (door) can be fastened in it[1&2]. Both teachers exclaims “that’s correct!”[3].

1. *Resource proclamation of the hinge. [C]*
2. *Highlighting the function of the hinge. [C]*
3. *Legitimization of an idea and the material. [L]*

The teachers ask Kurt if he can explain the idea he had one more time[1]. He picks up the hinge[2], opens and closes it[3], and says that they can fasten the Masonite piece (door) in it.

1. *Legitimization of an idea and the material. [L]*
2. *Resource proclamation of the hinge. [C]*
3. *Highlighting the function of the hinge. [C]*

Constitutive actions for the outcome of the ***screws and wing nuts.***

Joe picks up a screw and wing nut and walks over with it to the table with the model house[1].

1. *Resource proclamation of the screws and wing nuts. [C]*

Kurt picks up the other Masonite door (which Violet put down on the table after she had tried it) clamps a hinge around it, holds it against the door frame and declares that they can drill holes and then use the screws to fasten it[1]. Teacher D2 exclaims “exactly!”[2].

1. *Highlighting the function of the screws. [C]*
2. *Legitimization of an idea. [L]*

Unit epsilon

Teacher E, Peter, Amanda.

Outcome: Plastic door, tape.

Constitutive actions for the outcome of the ***plastic door***.

The teacher asks the children what material they want to use for the door. Peter answers plastic[1], Amanda answers cardboard[1]. The teacher holds up the plastic and cardboard sheets and asks the children to reach a consensus. Peter reaches for the plastic and grabs it[2].

1. *Naming the material of the door. [C]*
2. *Resource proclamation of the plastic. [C]*

The children want to use different materials, the teacher suggests that they make two doors—the first one in cardboard, the second in plastic—but Peter disagrees and says that they will start with the plastic.[1] The teacher turns to Amanda and asks if that is alright with her, she nods[2].

1. *Resource proclamation of the plastic. [C]*
2. *Legitimization of the material by the teacher. [L]*

Peter picks up the Masonite piece shaped like a door[1], fits it against the plastic sheet[2] and then against the door frame[3]. The teacher asks if it fits, Peter says it does[4].

1. *Resource proclamation of the matrix for the plastic door (the Masonite piece). [D]*
2. *Resource proclamation of the plastic. [C]*
3. *Proximity seizing of the door frame. [C]*
4. *Exchanging ideas with the teacher. [C]*

Amanda picks up the Masonite piece, tests it against the doorframe[1&2] and says that it does not fit perfectly. The teacher takes the piece and holds it against the door frame and says that it actually does fit[3].

1. *Resource proclamation of the matrix for the plastic door (the Masonite piece). [C]*
2. *Proximity seizing of the door frame. [C]*
3. *Legitimization of an idea (Peter's). [L]*

The teacher shows the children that they can use a pair of scissors to cut the plastic sheet[1].

1. *Legitimization of the material.*

Amanda picks up the scissors[1], but Peter says that he wants them[1], the teacher reiterates this[2] and Amanda gives him the scissors[3].

1. *Resource proclamation of the tool to shape the door (the scissors). [C]*
2. *Legitimization of an idea (Peter's). [L]*
3. *Exchanging material with a peer. [C]*

The teacher suggests that the children help each other in shaping the plastic into a door[1]—she suggests that Amanda use the scissors and that Peter holds the plastic sheet. Peter gives the scissors to Amanda[2].

1. *Legitimization of an idea (Peter's). [L]*
2. *Exchanging material (the scissors) with a peer. [C]*

The teacher takes the scissors and helps the children, she asks Amanda on where to cut the plastic. Amanda shows her.[1]1. *Exchanging ideas with the teacher. [C]*

The teacher suggests that they use the Masonite piece to compare if the newly cut plastic has the right shape. Amanda picks up the plastic piece[1] and Peter the Masonite piece[2]—and then they compare them together[3&4].

1. *Resource proclamation of the plastic door. [C]*
2. *Resource proclamation of the matrix for the plastic door (the Masonite piece). [C]*
3. *Exchanging ideas with the teacher. [C]*
4. *Exchanging ideas with a peer. [C]*

Amanda tells the teacher that the plastic piece is still too big and the teacher cuts away some more of the plastic[1&2].

1. *Exchanging ideas with the teacher. [C]*
2. *Legitimization of an idea. [L]*

Amanda picks up the newly cut plastic piece (door)[1] and tries it against the door frame[2].

1. *Resource proclamation of the plastic door. [C]*
2. *Proximity seizing of the door frame. [C]*

Constitutive actions for the outcome of the ***tape***.

The teacher informs the children that using glue (the children´s first idea) can be problematic in that the door will be hard to open when glued to the door frame. Amanda picks up the role of tape and shows it for the teacher[1&2].

1. *Resource proclamation of the tape. [C]*
2. *Exchanging ideas with the teacher. [C]*

The teacher asks the children about how they shall solve the problem. Amanda points at the tape and says that they will use it[1&2]. The teacher agrees[3].

1. *Naming the tape. [C]*
2. *Exchanging ideas with the teacher. [C]*
3. *Legitimization of an idea (Amanda's). [L]*

The teacher gives Peter the scissors and Amanda the tape[1], and asks them to help each other cut of pieces of tape that can be used to fasten the door[2].

1. *Exchanging material (tape and scissors) with the teacher. [C]*
2. *Legitimization of an idea (Amanda's). [L]*

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