What is the task about? Exploring the issues discussed by preschool children in engineering activities at kindergarten

JOSEPHINE CONVERTINI

Department of Education and Learning
University of Applied Sciences
and Arts of Southern Switzerland
Switzerland
josephine.convertini@supsi.ch

Abstract

Problem solving tasks are one of the topics of investigation within the field of STEM and educational engineering involving children. However, young children have received less attention. Accordingly, this paper explores the issues discussed by preschool children during engineering activities. We focus on the issues participants discuss during three building problem solving proposed to preschool children at a kindergarten. The activities were audio-video recorded and the argumentative discussions were identified and transcribed. The argumentative analysis focused on different elements, such as the issues occurring in each argumentative episode, the standpoints, the arguments, and the argumentative structure. In particular, to explore the issues and their role in problem solving activities, three illustrative cases are presented. The findings show, from an argumentative perspective, a variety of issues explored by children in solving problems around building tasks. The task presented by the adult as a building activity represents something more for the participant children: for example, the children focus on the technical components to overcome possible obstacles, they refer to the collaboration with peers, to the possession of objects or to the meaning and utility of the working activities. As preschool children's engineering work appears as a complex activity, the present study highlights the value of analyzing the issues that are discussed by preschool children during building activities.

Keywords

Issue, problem solving, preschool children, argumentation, STEM, engineering

Résumé

Les tâches de résolution de problèmes sont l'un des sujets d'investigation dans le domaine STEM et de l'ingénierie pédagogique impliquant des enfants. Toutefois, les jeunes enfants ont reçu moins d'attention dans la littérature. Cet article explore les issues (un problème à discuter) traitées par les enfants d'âge préscolaire lors d'activités d'ingénierie. Nous étudions les issues discutées par les participants au cours de la résolution de trois problèmes de construction proposés aux enfants d'âge préscolaire dans une crèche. Les activités ont été vidéo-audio enregistrées et les discussions argumentatives ont été identifiées et transcrites. L'analyse argumentative s'est concentrée sur différents éléments, tels que les issues soulevées dans chaque épisode argumentatif, les points de vue, les arguments et la structure argumentative. En particulier, pour explorer les issues et leur rôle dans les activités de résolution de problèmes, trois cas illustratifs sont présentés. Les résultats montrent, selon un point de vue argumentatif, une variété d'issues explorées par les enfants dans la résolution de problèmes autour de tâches de construction. La tâche présentée par l'adulte comme une activité de construction représente quelque chose de plus pour les enfants : par exemple, les participants se concentrent sur les éléments techniques afin de surmonter des obstacles possibles, ils se réfèrent à la collaboration avec les pairs, à la possession d'objets ou le sens et l'utilité de l'activité de travail. Comme le travail d'ingénierie chez les enfants d'âge préscolaire apparait comme une activité complexe, la présente étude souligne l'intérêt de l'analyse des issues discutées par les enfants d'âge préscolaire lors d'activités de construction.

Mots-Clés

Problématique, résolution de problèmes, enfants en âge préscolaire, argumentation, STEM, ingénierie

Introduction

Many scholars in the field of education have devoted an increasing interest in defining, investigating and implementing science, technology, engineering and math (hereafter, STEM) at school. Many efforts have been directed towards the understanding of how to combine STEM disciplines in the curricula (Ravanis, 2017). In fact, while science and math are well investigated disciplines among students, technology has called the researchers' attention in recent years. Moreover, engineering is still an underexplored field in education and, for this reason, in the present paper we intend to explore engineering activities involving preschool children. Our main interest is to focus on

problem solving tasks and argumentative issues emerging in children's disputes during building activities.

In the first part of the paper, we will present the main issues related to STEM and engineering within education. This will allow to discuss which are the already explored aspects related to preschool children experiences in engineering activities. Afterwards, the conducted study will be presented to show how an argumentative analytical approach should account for a variety of children's issues in solving building problems at kindergarten. The results and a final discussion will complete the paper.

Theoretical framework

STEM, engineering and problem solving

Within STEM, engineering", is mainly intended as: 1) contents connected to the expertise in adopting technical terms, creating complex building structures or using objects in innovative ways; and 2) problem solving attitudes, described, for example, as the capacity to define a problem and to find and test one or more solutions. In the field of STEM, engineering emphasizes the role of problem solving and indicates "the process of identifying a problem, solution, innovation, prototype, evaluation, redesign - as a way to develop a practical understanding of the designed world" (Kennedy & Odell, 2014, p. 255).

Problem solving has the potentiality to enhance STEM (Ejiwale, 2013) for different reasons: firstly, it suggests a systematic way to support students' exploration and learning; then, under certain conditions, it can provoke argumentative discussions. In fact, a constructive resolution of different argumentative exchanges can push the knowledge related to the scientific domain of the problem at stake (Fragkiadaki, 2020; Jiménez-Aleixandre & Erduran, 2007).

STEM is often considered as a meta-discipline that can stimulate students during scientific problem solving processes. For this reasons, school should educate students to solve different problems independently from a specific situation (Morrison, 2006), by presenting multiple strategies of resolutions (Priemer et al., 2020). For example, different studies within STEM emphasize the importance of a curriculum that can have positive effects on students' critical thinking, for instance based on inquiry activities, investigation of issues, sharing of questions and solving problems in real-world learning experiences (Adams et al., 2014).

Although STEM education is extensively investigated in elementary, middle or high school, many scholars claim for a further attention to support preschool children in approaching STEM disciplines (Brenneman, Lange, & Nayfeld, 2019). For this reason, a short overview on problem solving and engineering involving preschool children is presented in the next section of the paper.

Preschool children and engineering

To approach engineering and other STEM activities with preschool children, playful activities are considered as recommended situations (Cohen & Emmons, 2017; Dale Tunnicliffe & Gkouskou, 2019; Fleer, Fragkiadaki, & Rai, 2020; Gold, Elicker, & Beaulieu, 2020; Ramani et al., 2014). Preschool children are often observed during activities that include, most of the time, blocks and building materials. For example, Bagiati and Evangelou (2016) have examined preschool children's early engineering behavior through naturalistic observations during free play with blocks. This allows the researchers to elaborate a design process model, used as a map to identify the children's engineering conducts. This model includes various aspects, such as the identification of a goal, the construction, testing and improvement of solutions, the recalling of problems, design, actions and solutions already proposed, and the possibility to readapt a peer's construction. Studies like the above-mentioned one, showed that children playing with blocks during free activities are able to actively participate in solving problems, mainly through actions and non-verbal behaviors. Gold et al. (2020) also developed an engineering framework to assist teachers in recognizing and encouraging children's attempts when engaged in engineering design process. The authors elaborated a series of engineering play behaviors, such as: the communication of a goal; the building phase; the sharing of how things work; the resolution of problems; and the recalling of prior solutions, testing phase, proposition of innovative and new constructions, replication of prototypes of construction, and the use of technical vocabulary and expression of logic relations. During free play with blocks, children move throughout the different steps of the design process and reason about their different engineering behaviors. In another study, Dale Tunnicliffe and Gkouskou (2019) observed infants and toddlers during spontaneous play. They elaborated an educational tool to support teachers recognizing STEM during children's free-choice play activities. Their tool furnishes a checklist including a series of activities (e.g. building activities), basic science experiences that children can explore (e.g. stability), or designs and specific playing action connected to the activities (e.g. recognizing shapes and making specific constructions). As a result, the authors defined the free play activities as a fertile ground for children's engagement in scientific concepts and problem solving process.

Other scholars focused on preschool children's talk during engineering activities (Convertini, 2020; Migdalek, Rosemberg, & Santibáñez Yáñez, 2014; Ramani et al., 2014) and investigated argumentative strategies used by children during different free play activities (Migdalek et al., 2014) or during problem solving tasks (Convertini, 2020). Ramani et al. (2014) observed preschool children when solving a semi structured activity. Children were invited to build a house with blocks of big size and no additional indications were given about how to complete the activity. The researchers used a coding scheme to examine the preschool children's communication, their behavior and

the relation between the verbal structures and the coordinated actions with peers. It has been found that children discuss mostly about the symbolic representations and the design features of the object, namely the house (e.g. "This is a door" or "I'm going to put more blocks"), as well as math-related concepts (e.g. "There are two windows" or "Move this closer to here").

Another set of studies focused on the investigation of how children engage in engineering aiming to help teachers to train children in solving problems, and to guide their thinking in engineering activities. Lottero-Perdue et al., (2016) refer to it as engineering design process (EDP) for kindergarten that can be adapted according to specific aims and learning needs. A general structure of EDP includes the identification of a problem, the identification of different solutions, the choice of the best solution, the application and the improvement of it.

As highlighted in this section, different studies have been carried out to investigate how preschool children deal with engineering activities, but also to understand how to help teachers to recognize engineering behaviors and train children to solve problems. Although different models have revealed interesting aspects related to preschool children's engineering behaviors, these studies have mainly explored children's engineering behaviors during free play and through the application of pre-established models and sets of categories, independently from the context of observation.

Goal of the study and research questions

The main goal of this study is to analyze the issues as a central feature of problem solving tasks in which preschool children are engaged. The research questions are the following: which are the issues explored by children during engineering activities? Does the analysis of issues offer useful elements to better understand children's engagement in engineering problem solving tasks?

In order to answer these questions, we focus on the interactions among children and in particular on the issues emerging during argumentative discussions. The interest in focusing on issues is related to the fact that they refer to aspects that participants consider as problematic and decide to discuss. This means that the argumentation itself is a conflictual situation that requires reasoning to solve a certain problem. As argumentation is recognized as an important goal in STEM education, the focus on issues offers the possibility to analyze what children spontaneously discuss, instead of selecting pre-established categories of arguments.

Method

Participants and data collection

A group of 25 children (13 boys and 12 girls) aged 3 to 5 years (mean age=4: 8 years) participated in the study. The research was conducted in a kindergarten in Italy (from October to November 2016)[1] after having collected all the necessary permissions. Procedures to ensure anonymity and to guarantee an ethical use of the data were ensured throughout the research process. The data collection was preceded by a period of one week during which the researcher participated with the children and the teachers in the activities carried out within the kindergarten (e.g. welcoming of children in kindergarten, recreational or free play activities). This period allowed the researcher to become familiar with the children and their environment, and vice versa, to allow children to become familiar with the adult.

Data collection was carried out in the toy library of the kindergarten. The activities were audio and video recorded (an audio recorder was placed on the worktable of the toy library and a camera was placed in front of the worktable). Children were asked to engage in three activities connected to STEM, such as to jointly solve different engineering tasks by using tools such as Lego© and recycled materials. The following tasks were proposed: building a tunnel with Lego© in such a way that a car could pass through it; building a bridge with Lego© to connect two opposite points of a river; and building an hourglass with recycled materials. Children were divided in 7 triads and 2 couples. Each triad and each couple participated to the three activities. A total of 27 recordings, lasting about 16 hours, were collected.

Analytical approach

The software Transana Basic 3.10b was used to select the episodes of argumentative discussion[2] within the recorded data. These episodes (N=65) were transcribed by using a simplified version of the system elaborated by Jefferson (2004). The symbols of transcription are indicated in Appendix. Based on the transcripts, the following elements

1 The data have been collected by the author of the present article within a research project on children's implicit argumentation. The research has been funded by the Swiss National Science Foundation (grant n. 100019_156690) and carried out from 2015 to 2018 by the Institute of Psychology and Education (University of Neuchâtel) and the Institute of Argumentation, Linguistics and Semiotics (Università della Svizzera Italiana). Applicants: A.-N. Perret-Clermont, S. Greco, A. Iannaccone, A. Rocci. J. Convertini and R. Schär were PhD students within this project.

2 An argumentative discussion emerges when different participants' opinions (standpoints) concerning a problematic question (issue) are supported by advancing one or more reasons (arguments). For more details about the children's issues in different settings (cf. Bova & Arcidiacono, 2015, 2018; Greco Morasso, Miserez-Caperos, & Perret-Clermont, 2015; Greco, Mehmeti, & Perret-Clermont, 2017; Schär, 2018, in press; Schär & Greco, 2018).

were identified: the issues occurring in each argumentative episode; the standpoints and the arguments; and the argumentative structure (according to the pragma-dialectical approach, see Van Eemeren & Grootendorst, 1984, 2004). For the specific aim of this paper, we focused on the issues, expressed as questions. Accordingly, all the issues have been transformed into affirmative sentences and grouped into categories expressing their "topic of discussion" (as an etiquette assigned to each issue with respect to the subject of conversation). This step has been conducted by an inductive coding: firstly, two researchers performed this step independently; and then they worked together to finalize the list of topics of discussion[3]. Problematic cases during this process of categorization were discussed in detail, until reaching a consensus.

The final categorization of all issues according to their topic of discussion and the frequency within the corpus of data is presented in Table 1. An example for each category is provided to illustrate typical cases included in each topic of discussion.

TABLE 1

Proportionality table representing the price to be paid according to the mass of apples

Topic of discussion	Frequency	Example
1. Adequacy of the material with respect to the aim of the task	5	Flavio, Giulio and Mattia are building a tunnel. Children try to push the car through the tunnel, but the tunnel is too tight. Mattia looks at the adult and asks her to search for another car "because the one provided by her is too big" Issue: Can the adult get another car?
2. Alternative ways to realize the work	12	Gianna and Damiano built a tunnel together. Gianna takes the car and tries to pass it through the tunnel, but the tunnel is too low. She says: "The tunnel must be higher because the car cant' pass through it" Issue: Do we have to build a different tunnel?
3. Adequacy of peer's action with respect to the aim of the task	6	Greta and Barbara are building a bridge. Barbara adds a piece of Lego that is out of the table. Barbara says: "Not in that way, because the bridge will fall" Issue: Should Barbara put the Lego out of the table?

3 For example, if there were two issues (Can Giacomo help Carlo? Can Jessica help Diego to carry out the activity?), they were grouped into the same topic of discussion coded as the "possibility to give/receive help".

TABLE 1

4. Adequacy of work done up to now	4	Carlo and Giacomo built a bridge, and Maria joined them. Maria says: "This is wrong because bridges are not made in this way. Bridges need stairs to get on it" Issue: Is the actual construction adequate?
5. Achievement of the goal	6	Fulvio, Mia and Giacomo are building a bridge. After about 30 minutes, Fulvio says: "We've done, we've done." Mia answers: "No, because we still have to add a small piece of lego." She adds a Lego and Fulvio starts to put away the bricks. Issue: Have they done the job?
6. Differences between peer's works	1	Three children are building two different bridges. The girl is using Lego of big size and the boys are using Lego of small size. The girl says: "My construction is higher than the other." The other children disagree: "Because you got up the construction from the ground" Issue: Which bridge is the highest?
7. Possibility to work together	4	The adult presents the task of building a tunnel and asks children to work together. Barbara answers that it is not possible, because Tom is not able to do it. Issue: Can children build the tunnel together?
8. Possibility to give/ receive help	6	Carlo, Giacomo and Maria are building a bridge together. Maria is looking the books in the toy library; the adult suggests to assist Carlo and Giacomo. Maria answers: "No, they should help me because I'm not yet able to help them" Issue: Could Maria help Carlo and Giacomo?
9. Possession of objects	4	Three children are building three different bridges. A child (Giulio) detaches a Lego from his construction. Another child (Flavio) picks it up. Giulio takes Flavio's hand and says: "You too, you have your own Lego" Issue: Can Flavio takes the Giulio's piece of Lego?
10. Differences between materials provided by the adult	1	Greta, Barbara and Tom are about to build the hourglass. Before starting the work, they explore the available materials. They are watching three spoons Barbara says: "This is the bigger one." Greta answers: "It is not the bigger one, because the ball ((the oval concave part of the spoon)) is bigger in the other one" Issue: Which spoon is the biggest?

11. Qualitative features of materials provided by the adult	5	Gianna and Damiano are about to build a tunnel. Before starting their work, they watch the pictures depicting four different kinds of tunnel. The adult says that there is nobody in one of the tunnel represented in the picture. Gianna answers: "There is a car because there is a light." Damiano says that there is a train and Gianna replies: "There is no a train, because the train should have the rail" Issue: Is there somebody or something in the picture?
12. Qualitative features of materials in the toy library	2	While Greta, Barbara and Tom are building a tunnel, they focus on a puzzle in the toy library. Greta says that the puzzle is missing a piece and they should find it. Barbara answers that this is not true, the piece is there but it is overturned; they only can see its white part. Greta answers that the puzzle is missing a piece because she touched the wall. Issue: Is the piece of puzzle in the wall?
13. Possibility to reach the goal	3	The adult is presenting the activity to Greta, Barbara and Tom. She asks children to build a tunnel for Sam firefighter's car. Tom answers: "But Sam firefighter's city does not have a tunnel." The adult replies that that is the reason why it is needed to build it. Issue: Should we build a tunnel for Sam firefighter's car?
14. Utility and futility of working	1	Giacomo and Carlo are building a tunnel. Giacomo starts a monologue about the activity and says that he is bored, but he wants to do the work as well. Issue: Does working make sense?
15. Possibility/impossibility to carry out own or other's project	1	Giacomo, Fulvio and Mia are about to building a bridge. Mia suggests to build a sidewalk and Giacomo answers that it is not possible because they have already do it once. Issue: Should children build the bridge as suggested by Mia?
16. Legitimacy of withdrawing from the activity	1	Two children are building a tunnel together. They are trying to maintain the work by their hands, but the structure is about to fall down. The girl gives a shot and the tunnel finally falls. She says that it's time to go to the teacher, but the other child disagrees: "The work it's not finished" Issue: Can we go back to the teacher?
17. Possibility/impossibility to carry out alternative activities	2	Three children are building an hourglass and two of them are spreading the sand on the table. Another child draws the attention of the researcher by pointing out that children are playing and the teacher would not approve it. A child of the triad replies: "But there are no more Lego" Issue: Can the children play?

TABLE 1

18. Legitimacy of using specific materials to carry out the activity	1	Three children are building two different bridges. A girl is using Lego of big size and the other two children are using Lego of small size. The girl invites the dyad to watch her work. A child says that it is also possible to build a bridge with Lego of small size. The girl disagrees: "It takes too long." A boy says that it's not possible to use Lego of small size "because the teacher of the kindergarten doesn't allow children to use Lego of small size" Issue: Can we build the tunnel with Lego of small size?

RESULTS

Table 1 indicated that the total of 65 issues within the observed argumentative episodes were grouped into 18 different categories organized by topics of discussion. These topics show that the issues explored by children refer to their reasoning about the task, as well as their reflection on prior or other building, as it occurred in discussions about the possibility/impossibility to carry out own or other's project. The issues indicate that children test and monitor their solutions (cf. the adequacy of work done up to now), reason about alternative ways to realize the work and check if the goal has been achieved. Children also reflect on the possibility to reach a goal, on the nature of the material provided by the adult, its adequacy to reach the objective and the legitimacy to use it. Children discuss about the qualitative feature of the material at their disposal and about the surrounding environment. They also think about the utility and futility of working, by asking themselves whether they can engage in alternative activities from the one suggested by the adult. They also reflect about the possibility to leave the activity in order to reach the teacher. Along all the activities, children always are confronted with peers: they discuss about the possession of objects, they explore the possibility of working together and about the need to help other children. They also monitor the others' action and work. All together, these results show that preschool children engage themselves within a complex work during engineering tasks. In order to better highlight the role of the issue in identifying these findings, three illustrative cases are presented in the next section. These examples have been selected because they refer to the most frequent topic of discussion within the corpus of data, namely the alternative ways to realize the work. The rationale for focusing on three cases related to the same category is to understand whether children discussing about a topic show differences in the ways they afford a specific issue.

Illustrative cases

Case 1: A line of Lego

Three children (Aldo, Flora and Elena) are invited to work together to build a bridge with Lego[4]. The adult tells them that two friends are in their own cars, placed on opposite sides of a river. The two friends would like to spend time together and for this reason, they need a bridge to meet. The river is figured by a blue poster placed on the table. The two friends and the cars are represented by pieces of Lego. The adult invites children to build a bridge together with the bricks she provided to them. After presenting the activity, she sits in a corner of the room and tells the children to call her when they have finished or in case they need her help.

The children begin to build the bridge. Flora and Aldo are working together, while Elena works on the opposite side of the table. All the children decided to use Lego of big size. After a couple of minutes, they have almost reached the center of the poster by their construction, and the adult underlines that fact that the work is almost done.

EXCERPT 1

Participants: Aldo (5:2 years old), Elena (4:7 years old), Flora (5:2 years old), and the researcher (Adult)

Turn	Speaker	Original Italian transcription	English translation (verbatim)
(00:02:25)			
1	Adult	allora (.) manca poco dai (.) uniteli	so (.) it's almost done (.) join them ((the pieces of Lego))
2	Flora	No::: i Lego si devono mettere tutti in fila ((Elena ha accostato due pezzi di lego uno accanto all'altra e Flora li sposta allineandoli in fila uno dopo l'altro))	No::: Lego must all be placed in a line ((Elena has placed two pieces of Lego next to each other and Flora moves them one after the other))
3	Aldo	ha ragione Elena perché ci vuole un pochino di spazio ci vanno le macchine ((scorre il palmo della sua mano lungo il ponte))	Elena is right because we need some space for letting the car pass over it ((he runs the palm of his hand along the bridge))
4	Flora	si, lo so	yes, I know
(00:02:37)			

4 The case: "A line of Lego" has been analyzed, from a different perspective, in Convertini (2019).

When the adult realizes that the work is almost done, she highlights it and suggests the children to put together their constructions. In order to make the bridge, Elena places two pieces of Lego next to each other, while Flora puts the bricks one after another. When children reached the center of the paper, Flora moves Elena's bricks one after the other and says "No::: Lego must all be placed in a line" (Turn 2). Aldo says "Elena is right because we need some space for letting the car pass over it" (T. 3) and Flora answers "yes, I know" (T. 4).

Based on the verbal exchange, the issue and the argumentative structure are the following:

ISSUE: How do children should place the Lego?

Elena	Flora	Aldo
STANDPOINT: (Lego must be placed one after the other)	STANDPOINT: Lego must all be placed in a line	STANDPOINT 1: (Lego must be placed one after the other)
		ARGUMENT 1.1: because we need some space for letting the car pass over it

In excerpt 1, it is Flora who opens an argumentative discussion: she raises doubts about the way Elena placed the Lego and she proposes an alternative standpoint. The standpoint of Elena is implicit and represented by her action of placing the Lego one after the other. Aldo's standpoint supports Elena's one, by proposing the following argument: "because we need some space for letting the car pass over it". Accordingly, the issue of this argumentative discussion is the following: How do children should place Lego?, and it refers to the category "Alternative ways to realize the work" because children are discussing about possible alternative ways of placing the Lego. Flora is suggesting that the bridge should be done differently, specifying that this means to put the Lego in a different way. Aldo adds that this is important in order to reach the goal (letting the car pass over the bridge). The children are then reasoning and discussing about different ways of building the bridge.

Case 2: A bed in the tunnel

Two girls (Elsa and Silvia) are invited to build a tunnel with Lego[5]. They have at their

5 The case: "A bed in the tunnel" has been analyzed, from a different perspective, in Convertini (2018).

disposal a toy car, a set of building blocks of different shapes and sizes and some images of four tunnels of different shapes (showing various vehicles passing through it). The adult asks the children to build a tunnel with Lego in such a way that the available car can pass through it.

The two girls begin to build the tunnel and start to discuss about how to shape it. At some point, Silvia finds a piece of Lego representing a bed and decides to use it for the tunnel they are building.

EXCERPT 2

Participants: Elsa (4:4 years old), Silvia (5:3 years old) and the researcher (Adult)

Turn	Speaker	Original Italian transcription	English translation (verbatim)
(31:43.1)			
1	Silvia	ci vuole il letto::	we need the bed::
2	Adult	il letto nel tunnel? ((Silvia annuisce)) ma in strada non c'è un letto	the bed in the tunnel? ((Silvia nods)) but there is no bed in the street
3	Elsa	in strada non c'è un letto	there is no bed in the street
4	Silvia	ma va be' (.) almeno così la gente si riposa	but okay (.) at least people can rest
5	Elsa	e ci dorme	and sleep
6	Adult	mentre guida?	while driving?
7	Silvia	no (.) quando è stanco di guidare	no (.) when they are tired of driving
8	Adult	uhm (.) può essere un'idea	uhm (.) maybe this is an idea
9	Silvia	così scende e così si riposa un pochino	so they leave ((the car)) and rest a little bit
10	Adult	certo nel tunnel (.) potete metterci quello che pensate sia più carino	sure in the tunnel (.) you can put what you think is the nicest
(32:45.4)			

When Silvia finds a piece representing a bed in the Lego box, she says "we need the bed" (T. 1). Then, the adult tries to trigger a discussion on the appropriateness of the piece representing the bed while building a tunnel, by saying "there is no bed in the street" (T. 2). Elsa repeats what the adult just said, but Silvia remains of her position: "at least people can rest" (T. 3). Elsa seems now to support Silvia's standpoint, by adding "and sleep" (T. 5). The adult tries to sustain the argumentative discussion when she asks "while driving" (T. 6). Silvia says "no (.) when they are tired of driving" (T. 7). Finally, the

adult seems convinced by this possibility and accepts Silvia's standpoint: "in the tunnel you can put what you think is the nicest" (T. 10).

The issue and the argumentative structure are the following:

ISSUE: Do we need a bed in the tunnel?

Silvia	Adult
STANDPOINT 1: we need the bed (T.1)	STANDPOINT 1: (we don't need the bed)
ARGUMENT 1.1: at least people can rest (Elsa: "and sleep") (T.4-5)	ARGUMENT 1.1 there is no bed in the street (T.2)

In excerpt 2, it is the adult that opens the argumentative discussion. She raises doubts about Silvia's standpoint and presents her own argument: "there is no bed in the street". Silvia presents an argument to support her standpoint and suggests that "at least people can rest" (T. 4). Elsa co-participates in the construction of the argumentative discussion at stake. In turn 3, she strengthens the adult's standpoint, although in the turn 5 she reinforces Silvia's arguments. The issue of the argumentative discussion is the following: Do we need a bed in the tunnel?

In the exchange, as in the first case (A line of Lego), children are discussing about possible alternative ways of building the tunnel. The children and the adult are advancing arguments about the possibility to introduce (or not) a bed as additional (and appropriate) element while building a tunnel. Differently from the first excerpt, the participants' reasoning is not subordinate to the aim of the activity (we need to build, differently, otherwise we cannot solve the task), because in this excerpt it is possible to build a tunnel even without adding the bed (that should be considered, by contrast, as an element that prevent children to reach the goal of the activity). In this case, to propose an alternative element of construction means to make the product nicer ("the nicest") by using the available materials.

Case 3: The sky is infinite

Three children (Mia, Fulvio and Giacomo) are invited to build a tunnel (as for the case 2)[6]. When the children start to build the tunnel, Mia is on one side of the table and uses Lego of big size, while Giacomo and Fulvio use Lego of small size. After approximately twenty minutes, Mia raises her works, then she turns to the researcher and asks her to look at it.

6 The case: "The sky is infinitive" has been analyzed, from a different perspective, in Convertini (2019).

EXCERPT 3

Participants: Fulvio (4:4 years old), Mia (4:7 years old), Giacomo (5:2 years old) and the researcher (Adult)

Turn	Speaker	Original Italian transcription	English translation (verbatim)
(0:12:19.0)			
1	Mia	io lo faccio alto fino a qui, così ((solleva la costruzione costruita da lei ne tocca con un dito il punto più alto)) a::nzi (h) fino a qui ((indica un punto più alto rispetto alla sua costruzione))	I do it up to here, so ((she raises the construction she made and touches the highest point with a finger)) a::ctually (h) up to here ((she indicates a higher point compared to the construction))
2	Fulvio	no, fino in cielo ((alza il braccio))	no, up to sky ((he raises the arm))
3	Mia	Non ci arrivo neanche (.) poi il cielo è infinito, non c'è neanche il cielo, sembra che c'è, ma non c'è ((Fulvio e Mia guardano fuori dalla finestra))	I can't even reach (.) then the sky is infinite, the sky isn't even there, it seems that it is, but it's not there ((Fulvio and Mia look out the window))
4	Fulvio	poi (.) poi il cielo xxx	then (.) then the sky xxx
(0:12:39.3)			

Mia raises her works and wants to show it to the researcher. She is indicating the height that her construction could reach. She says, "I do it up to here, so actually up to here" (T. 1). Fulvio looks at her construction and says "No, up to sky" (T. 2). He raises his arm. Mia disagrees with Fulvio and presents her arguments: "I can't even reach (.) Then the sky is infinite." She looks out the window and points out the sky. At that point, Fulvio also turns towards the window and Mia adds another argument: "the sky isn't even there, it seems that it is, but it's not there" (T. 3).

The issue and the argumentative structure are the following:

ISSUE: Can Mia's construction be made up to sky?

Fulvio	Mia
STANDPOINT 1: Mia can make her construction up to the sky	STANDPOINT 2: I can make the construction up to here (T.1) ((and not up to the sky)) ARGUMENT 2.1: I can't even reach it ARGUMENT 2.2: the sky is infinitive /the sky isn't even there

Fulvio opens the argumentative discussion related to excerpt 3. In fact, while Mia proposes to build the bridge up to a specific point, Fulvio advances a different standpoint. He suggests to build the construction up to the sky. Then, Mia advances arguments against Fulvio's standpoint.

The issue of this argumentative discussion is the following: Can Mia's construction be built up to the sky? As in the previous cases, this issue is categorized as an alternative way to realize the work because the children are discussing about alternative heights that Mia's construction could reach. But, differently from the other two cases, here the child is not arguing about the possibility to build the bridge in another manner. She is arguing about the impossibility to do it. In this excerpt, the possibility of proposing an alternative element of construction means to make the product higher. Moreover, the reasoning about alternative ways of building the tunnel focuses on the reasons about what children are expecting from the peers' work.

Discussion and conclusion

The literature on STEM describes that young children are daily and spontaneously playing with blocks, trying to solve problems related to building activities. At the same time, less is known about engineering tasks involving preschoolers. Another point is that existing mainstream approaches often are based on models and indicators elaborated before the real observation of children experiencing engineering tasks (Van Meeteren, 2018).

In order to propose another approach, this paper investigated which are the issues that young children explore during engineering activities of building problem solving. The argumentative analysis of the issues has been a helpful tool to reconstruct children's argumentation during problem solving activities. The findings reveal that even preschool children, in accordance with previous studies (e.g. Dale Tunnicliffe & Gkouskou, 2019; Gold et al., 2020; Ramani et al., 2014), face multiple aspects that are recognized as central in problem solving processes. For example, children discuss about the task and reflect on prior or other's work, they test and monitor the solutions, reason about alternative ways to realize the work and check whether the goal has been achieved or not. In addition, they also discuss about issues that are not taken into account by the existing literature about children's engineering or seem not to be recognized as central topics within problem solving processes. For instance, children discuss about the possibility to carry out the activities suggested by the adult, even before starting to build what is required, as well as they also afford this issue at a later stage. This means that children can question the adult's proposal and are able to discuss the meaningfulness of a task (Greco et al., 2018). They also discuss about the working activity, especially when they reflect about its meaning and its utility. For example, for

the observed group of children, the act of working excludes the possibility of playing and singing: for them, working also excludes the possibility to reach the teacher before the activity is finished. Children also reflect on the conditions that can determine whether a work could be considered as completed or not. They also question the materials provided by the adult, its adequacy with respect to the aim of the task and its efficacy in reaching the goal of the activity. This occurs especially when children check if the goal of the task has been achieved. The materials provided by adult or available through the surrounding environment also become the object of discussion when the children argue about their ownership, their qualitative features or differences. Another interesting element to be considered is the fact that, along the activity, participants are always confronted with peers. In fact, they monitor others' action and work and they continuously question the adult's request of working together and helping each other.

Moreover, children can explore the same issue in different ways. For example, when they discuss about alternative ways to realize the work, from one side they reason about the meaning of alternative as additional possibility to reach the goal, and, from the other side, they refer to alternatives as ways to make the product nicer by using the available materials or different, according to the peers' expectations. While discussing about alternative ways to realize the work, children also refer to the possibility/impossibility of making it differently.

Apart from acknowledging all the different issues involved in children's discussions, the results also offer useful elements to better understand which issues are considered more valuable for completing the task or more valuable for the educator to encourage children's expression of ideas or utilize for teaching. The analysis allowed not only to investigate the main aspects that participants consider as problematic while solving a problem, but also to rethink/redefine the engineering problem itself. In fact, the task presented by the adult as a building activity represents something more for the participant children. For example, they focus on technical components to overcoming obstacles, they refer to the task in order to collaborate with peers, discuss about the possession of the objects or the meaning and utility of the working activity. Thus, by avoiding the application of predefined models of considering engineering activities and looking at how children discuss, reason and behave in context (Weil-Barais, 1996), we can promptly observe that preschool children's engineering work is a complex activity. This means that children do not imitate or direct appropriate the adult world, but they creatively produce their own peer culture, according to Corsaro (1985). Within the peer group, children propose a huge set of innovative knowledge, practices and routines and simultaneously contributes to actively maintain over time adult culture (Corsaro, 2003; Corsaro & Eder, 1990). In other words and following these perspectives, children do not simply emulate real engineers, but they creatively contribute to re-define and expand engineers' culture.

Although it has been possible to describe the children's work as a complex activity, we recognize the limitation of our investigation, especially because it has been focused exclusively on verbal aspects and through the observation of a small sample of participants. However, accordingly to previous works (Convertini, 2020), the approach assumed in the present study also suggests that it is possible to refer to young children's engineering activities as complex networks of elements. In fact, the study of the issues reveals the different children's topics of discussion, their actions, the use of materials, their understanding of the goals, and the various forms of reasoning that they mobilize during a building task. All those elements strictly depend on the adult's request and on the environmental conditions in which the activities are framed. Further studies and more in-depth analyses should favor a better understanding of the interplays of these aspects, especially in terms of connection between verbal and non-verbal features of peers' interactions. In this sense, visual and multimodal approaches could be useful tools for studying how the elements verbally discussed by children are interrelated with gestures, sounds, and proxemics aspects (Colletta & Guidetti, 2012; Mondada, 2016; Rocci & Pollaroli, 2018) during a complex task. Taking into account the benefits of combining these approaches is a promising avenue that will contribute to better understand how children (and teachers) act in situations in which STEM activities involve preschool participants.

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Appendix

Transcription symbols adopted in the excerpts

(( ))	nonverbal information
(h)	laugh
:	extension of sound

?	rising intonation
(.)	short pause
xxx	non understandable utterance