Article

Embodied Argumentation in Young Children in Kindergarten

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Abstract: In kindergarten, children are usually engaged with both verbal activities and non-verbal activities, often requiring the manipulation of physical objects. During technical tasks (e.g., problem solving), children can use argumentation as one of the languages of science that mediates how they interact with the surrounding world. In this paper, we focused on technical tasks in kindergarten in order to understand to what extent activities requiring the manipulation of physical objects also leave space for argumentation. The study involved 25 children engaged in three problem-solving activities requiring the manipulation of Lego® and some recycled materials. To analyze the non-verbal (embodied) side of the argumentative activities, we firstly identified the argumentative structure of each exchange involving the participants. Then, we focused on segments of "incomplete" argumentative dialogues (i.e., presenting only some elements typical of children's argumentation) by appealing to multimodal representations (speech, gestures, and physical objects). The findings of the study showed that even apparently incomplete exchanges can have an argumentative function generated by non-verbal elements of the interactions. Investigating the role of embodied argumentation during technical tasks in kindergarten can allow teachers to recognize and further develop children's argumentative resources.

Keywords: embodied argumentation; problem solving; kindergarten; reasoning; science education

1. Introduction

Argumentation is a pervasive activity for people throughout their everyday lives, for instance when interlocutors are arguing to make their intentions explicit, to repair a communicative breakdown, or to persuade someone to do something or to make some decisions. Argumentation also has an important role in various educational and professional contexts [1], since it allows people (including young children) to make explicit, during interactions, a reasoning for a specific choice or activity. However, limited attention has been reserved to the place of argumentation in embodied collaborative activities, i.e., tasks that involve the manipulation of physical objects in kindergarten. The latter constitutes the specific setting to which the present study was addressed.

Although there is not a single way to define argumentation, in the field of modern and contemporary argumentation theories it is described as a predominantly verbal activity [2,3]. The emphasis on the verbal components of argumentation is evident not only in terms of the definition of what argumentation is, but also in connection to the analytical tools and models that are applied to study argumentation in education.

In kindergarten, children are often involved in embodied activities requiring the manipulation of objects, such as building blocks or board games, more than producing verbal discourses. In these types of activities (for instance, in technical activities of problem solving), the solution lies in the way children coordinate bodily resources (such as manual gestures, gaze, and posture) and verbal behaviors in synchronized fashion over time. Although in "canonical" activities intended to promote reasoning at school the non-verbal components are

generally less embedded with the production of argumentation, in kindergarten the children's engagement in technical activities of problem-solving is strictly related to the type of activity itself. Technical tasks are situations of embodied activities requiring children to solve a problem mainly through non-verbal behaviors. Although it could be pertinent, especially in science education, to identify the children's engineering conducts in order to interpret their solution to a given problem [4], we intended to focus on the analysis of their reasoning process instead of looking at their performance's assessment (the capacity to solve a task in a correct way or not). Accordingly, we focused on argumentation produced during different technical tasks as an activity strongly dependent on its context of production.

Previous studies have recognized a link between scientific activities and causal arguments [5] or between the argumentative strategy of an alternative proposal and the free play with building blocks [6] involving young children. These elements highlight the relevance of investigating to what extent technical embodied activities also leave space for argumentation in kindergarten. Specific attention to non-verbal aspects would make possible for teachers to recognize the children's degree of participation and their contribution in argumentative activities requiring not only the discussion of a topic, but also the manipulation of objects in order to solve a technical task. For this reason, the present study intends to contribute to the field of argumentation in science by highlighting the role of non-verbal elements during embodied practices of young children.

The paper is organized as follows: after a presentation of the existing studies on preschool children's argumentative participation in kindergarten, we briefly rely on the main components of argumentation to introduce the possible reasons behind "incomplete", non-standard argumentations in young children. Then, the empirical study we conducted is introduced. The discussion of the main results of the investigation open a space for a general reflection about the challenges in studying children's argumentation within embodied technical activities.

2. Children's Argumentation in Kindergarten

Argumentation at school is widely encouraged by teachers and is exercised by children in oral communication from the preschool age. A main aspect explaining the actual or potential interest for looking at argumentation in education is the fact that argumentation is a form of critical thinking ad a way of reasoning about different phenomena [7]. In this vein, previous studies have shown how children are naturally inclined to advance hypotheses on the world (e.g. magnetism: [8]; sound: [9]; combustion: [10]).

Other studies have investigated preschool children's argumentation during spontaneous discussions with adults in kindergarten [11], within children's disputes at home [12–15], during different types of play (dramatic play, block play, and board games), and during problem solving with peers and adults in kindergarten [7]. All these studies show that as early as preschool age, children can take part in argumentative discussions with peers and adults. This confirms that children are familiar with various argumentative practices from a very young age [16–18] and are capable of arguing with different interlocutors. By the age of three, they can develop basic knowledge about the components of an argumentative discussion [19], they are highly effective in proposing arguments to persuade their parents during family interactions [20,21], and they can use a variety of argumentative strategies according to the type of play [6], as well as according to their interlocutors in peer-to-peer or peer-to-adult discussions [22].

When an adult establishes sufficient conditions to set up a "thinking space" [23] in educational contexts, children can address new issues never discussed before, can negotiate the topic of discussion in a debate with the adult [24], and can also recur to coordinative, subordinate, and multiple argumentations [25]. Furthermore, preschool children are able to change their standpoints during a short dialog and to reason about the premises of their argumentation, their standpoints, and the actions of other speakers [7].

Despite children's participation in argumentation being broadly documented, it has also been shown that argumentation in young children is not always expected by the

adult, since it is not necessarily well structured in terms of argumentative components [26]. Some studies have investigated the possible reasons behind the children's apparently "incomplete" argumentation. An interesting aspect is that the explanations provided by different scholars are not always related to the child's age [27–29]. A focus on the issue of the presumed incomplete expression of argumentation that is often observed while studying discursive practices of young children is proposed in the next section.

3. Incomplete Argumentation in Young Children

Argumentation refers to a series of components of a discourse that contribute to defining an exchange as argumentative. As proposed by van Eemeren and Grootendorst [2], argumentation is composed of "a constellation of propositions justifying or refuting the proposition expressed in the standpoint" (p. 1). Accordingly, the two basic elements of argumentation are the standpoint and the argument(s). In fact, at the basis of an argumentation there should be a difference of opinion, that is, the existence of two conflicting standpoints (a "mixed" difference of opinion) or a single standpoint with respect to which a doubt is raised (a "non-mixed" difference of opinion). With respect to the standpoint, there are several possible arguments (a "set of propositions" in the definition of the above-mentioned authors) that can be generated, and therefore various possible ways to support a standpoint. A fragment of text cannot be considered *a priori* as an argument or a standpoint until we consider the function it is performing [30]. The role played by the argument is essential, because without at least one argument there is no argumentation. The function of the proposition that makes a fragment of text an argument is to support or refute the standpoint [31]. The argument can potentially be identified in the text thanks to the presence of some connectives, such as the adversative "but" [32].

Concerning the standpoint, it is positive when the protagonist expresses a favorable position with respect to a proposition, while it is negative when the protagonist expresses a position contrary to the proposition [2]. In the same way, a proposition can become a standpoint without initially being presented as such when the antagonist calls it into question [33]. The relationship between the standpoint and the argument can be more or less complex, depending on the number of arguments involved, but also on their relationship with the standpoint.

In presence of an argument, it is also possible to identify the issue, that is, an aspect that the participants recognize as problematic and with respect to which different standpoints and one or more arguments are configured [24,34]. The issue is always presented in the form of a question to which the different standpoints should respond; it is recognized as such only when the presence of an argumentation is envisaged. An example of a frequent issue in argumentative dialogues with young children concerns the possession of objects, such as questions like "whose is this object?" [35,36].

These elements are considered as the constituents of an argumentation. However, argumentation in young children is not always of the standard variety expected by adults. For example, young children's argumentation can occur in an embryonic form: proto-argumentations in adult-baby interactions are considered as precursors of subsequent well-developed linguistic forms of argumentation, as highlighted by De Vasconcelos and Leitão [37]: "proto indicates the precursor of child actions that tend to be interpreted by the adults as the assertion of a point of view (of desires, wishes, goals) and opposition (to desires, wishes, goals, commands on the other's part)". These conducts are shaped in very young children by prosodic elements, body movements, and crying, as well as vocalizations and constitute the central elements of argumentation. In these adult-child exchanges, the child can respond to conflicting sequences and start new ones [37]. Other scholars refer to proto-argumentations as early forms of oral argumentation often lacking some key features of a well-structured argumentation. These proto-argumentative forms may be detected as early as in children aged three and cannot include linguistic markers, an explicit concluding stage, and the reference to counterarguments [38]. Proto-arguments also are described as forms of weak arguments, as in the case of emotional arguments that

do not really respond to the main issue of discussion, as is common in family discourses with children [39]. These forms of proto-argumentation arise as the result of the children's age. They are described as precursors of a subsequent, more structured argumentation and outline how argumentation develops from a non-verbal form to a linguistic one. Studies on proto-argumentations support the hypothesis that even young children could participate in argumentative exchanges.

Other perspectives have been advanced to justify the incomplete and non-standard argumentation often employed by young children. The proposed reasons are related to how argumentation is shaped, if it emerges in the context of an oral communication rather than in written texts, and if it is elaborated in spontaneous conversations rather than in debates in which the participants are supposed to argue, and can pre-structure and reflect on before the argumentation to be developed. According to this view, a children's non-standard argumentation can be interpreted as a natural manifestation of oral conversation with children who do not plan their argumentative speech.

Oral argumentation is supposed to emerge in time as a highly situated activity co-constructed within the interaction [3]. In fact, argumentation can emerge as the result of multiple contributions, especially during conversations at school in which the standpoints are not the starting points of a child-adult debate, but are co-constructed step-by-step by the participants [40]. An argumentative contribution that may seem incomplete and non-standard can be completed by another participant at a later time [41], or an intervention at school could appear inconsistent because of the adult's method of defining the topic of discussion, or in managing the interaction. For example, an adults' repetition of the same question can lead the child to consequentially produce a different answer (e.g. [42–44]). While interacting the adults and with peers, children continuously face psychosocial obstacles that can interfere with their argumentative participation [29]. An apparent non-standard argumentation could be the effect of such conditions.

According to another perspective, everyday conversation is governed by implicit (to different degrees) premises. While discussing with others, we all introduce new premises, avoid others, and reformulate pre-existing ones [45]. Even preschool children are capable of regulating the background's information to be shared with the interlocutors according to common-ground assumptions [46]. When children think that the (visual or verbal) information is shared with the interlocutors, they do not need to share it again in an explicit way, because it is obvious [26]. According to Perret-Clermont and colleagues [26], the fact that children present an argument that is partially implicit is not necessarily the result of an absence of linguistic abilities, but it may be the result of their compliance with the following cooperative principle: "Do not make your contribution more informative than is required" [47] (p. 45). For example, when preschool children are invited to explore mathematical concepts involving the manipulations of objects, their argumentation can be mediated by the use of gestures and other semiotic means [27]. In these cases, children's argumentation is not made completely explicit, because they can point to objects, nod their heads, lift objects from the table, and resort to deixis (e.g., "here") to advance their argumentation.

These elements should be considered as an integral part of the children's argumentative activities. Heller [48] showed how semiotic resources are made available for explaining mathematical terms. A child sharing an explanation with someone should adapt the use of semiotic resources to his/her actions. Frejd [28] explored how preschool children explain the reasons for animal diversity in group discussions, as well as the function of different materials (e.g., photographs, figurines, topographic world maps) in the meaning-making process. When children are faced with physical objects, these can be mobilized as tools to construct an argumentation. In another study, Tsamir, Tirosh, and Levenson [49] investigated the types of justifications given by children in kindergarten on numerical concepts and during geometry tasks with an adult. Children often accompany verbal justifications with an action in order to validate their ideas; in some cases, they also appeal to visual elements as a way to justify a statement (e.g., "because we see" (. . .) "with the eyes",

pp. 2601–2602). In this paper, we further explored this perspective by trying to identify the elements of embodied argumentation that appear during children's involvement in technical activities of problem-solving in kindergarten.

4. Goal of the Study

Assuming that children's argumentation is an important practice of interaction rooted in its context of production, we intended to identify to what extent technical activities in kindergarten (requiring the manipulation of physical objects) leave a space for argumentation. We adopted a dialogic perspective to observe how argumentation is embedded in the context of problem-solving activities involving small groups of children in kindergarten.

5. Method

5.1. Participants and Data Collection

The present study involved a group of 25 children (male = 13; female = 12) aged 3 to 5 years (mean age = 4 years 8 months) during autumn 2016. The data were collected by the first author in a kindergarten in Italy, within a project (see Funding section) devoted to analyze the children's implicit argumentation in educational settings. All the necessary permission consents and the procedures to ensure anonymity and to guarantee the ethic management of the data were established before the entire research process. Before the data collection, a researcher participated for a week in the usual daily activities of the selected kindergarten (e.g., activities with teachers, children, and sometimes with parents, such as welcoming to the kindergarten, free play time, and mealtime). This period allowed the researcher to become familiar with the children and the environment, and vice versa. The data collection was carried out in the toy library of the kindergarten, situated between the kindergarten's backyard and an indoor classroom.

Three activities requiring children to manipulate physical objects to solve a task were audio- and video-recorded. The first activity consisted of building a tunnel in such a way that a toy car could pass through (see Figure 1). To solve the task, children were invited to manipulate Lego® blocks and to use a small toy car to verify if it passes through the tunnel.
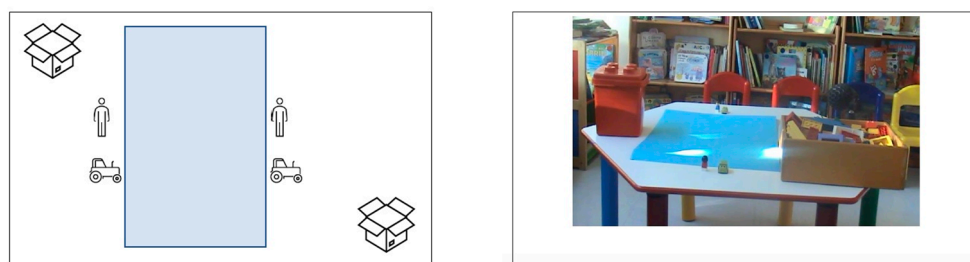

Figure 1. Task 1: Representation and material configuration of the setting [50].

The second activity was to build a bridge to connect two opposite points of a river and to allow two friends to meet by their toy cars (see Figure 2). For this task, children were requested to manipulate Lego® blocks to build the bridge and let the cars pass over.
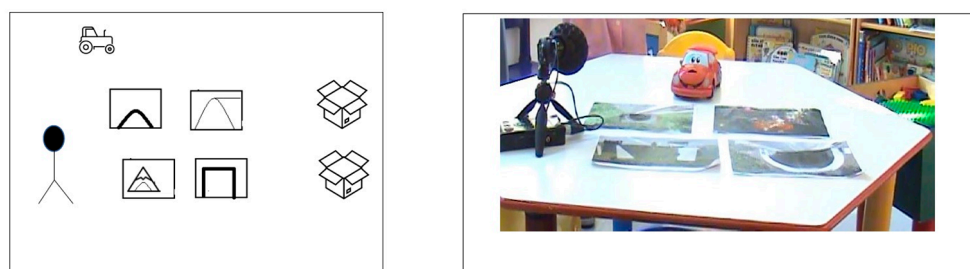

Figure 2. Task 2: Representation and material configuration of the setting [50].

For the third activity (see Figure 3), we invited children to build an hourglass with recycled materials (two plastic bottles, two hourglasses, a plastic container with sand, three spoons, a roll of tape, and three funnels of different size).
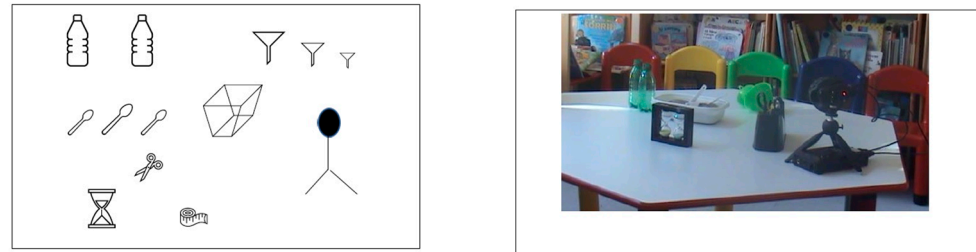

Figure 3. Task 3: Representation and material configuration of the setting [50].

Participating children were randomly divided into 2 dyads and 7 triads. Each group was requested to solve the three activities. A corpus of 27 recordings, lasting for a total of about 16 h, was collected and considered for the analysis.

5.2. Data Analysis

The episodes of argumentative discussion were selected within the recorded corpus of data by using the software Transana Basic 3.10b. A total of 65 episodes were then transcribed by using a simplified version (see Appendix A) of the system elaborated by Jefferson [51]. As this paper focused on "incomplete" argumentations, we also included in the transcription the non-verbal elements (such as the position of physical objects and the participants' gestures) that could play a role in the analysis of embodied argumentation.

Based on the transcripts, we firstly identified the argumentative structure of each argumentation within an episode. This step was conducted according to the principles of the pragma-dialectic model [2,31]. Afterwards, we selected the cases in which argumentation appeared as non-standard, i.e., segments of dialogue presenting only some elements of children's argumentation, but not others (e.g., explicit arguments). We analyzed these exchanges through the lenses of a discursive approach [52] combined with non-verbal elements (postures, gestures, and use of physical objects). This focus on other-than-verbal representations could contribute to display and make visible an argumentation [53] and "to support a more detailed analysis of oral argumentation in interaction" [38] (p. 476). Indeed, we reconstructed these exchanges according to the children's perspective by considering the interventions as embodied sequences and by emphasizing the interplay between the various resources mobilized by the participants for organizing their interactions [54].

Through this analytic procedure, we intended to rely on the critical issue of the roles (and responsibilities) of the analyst in explaining the child's answer. Accordingly, we appealed to a comprehensive approach, especially in those situations in which the child seemed to respond in an incomplete, non-standard way, or at least not in the way expected by the adult.

6. Results

In the corpus of data, we identified 89 argumentations (and 110 arguments) advanced by children during the tasks. These argumentations were classified in 6 cases of multiple argumentative structure, 12 cases of subordinate argumentative structure, 3 cases of coordinative argumentative structure, and 68 cases of simple argumentative structure.

By considering the main components of each argumentation (the standpoint, the argument, or both of them), we observed that the argumentation during technical activities was embodied in its context of production, so that the children's argumentative participation through verbal expressions may not be the most preferential channel. In this vein, even apparently incomplete argumentations can play an argumentative function. To account for such a result, we present three illustrative cases in which different components of argumentation were strictly embedded in their context of production. This highlights the

need for a comprehensive approach looking at the relevance of non-verbal elements during tasks that require the manipulation of physical objects.

6.1. Case 1: Embodied Standpoint

Case 1 presents an excerpt of interaction in which the standpoint of the argumentation advanced by a child is partially implicit. The situation involved three children (Barbara, 4 years 8 months; Tom, 5 years 3 months; and Greta, 4 years 9 months) engaged in the activity (inspired by Piaget, [55]) of building a bridge with Lego® blocks of small and large sizes. While presenting the task, the adult explained that two friends (two mannequins from the Lego® collection) are in their cars (two small toy cars), placed on the opposite sides of a river (a blue poster taped on the table). The friends would like to meet and spend time together. A bridge is needed. The adult invited the children to build such a bridge together, by using the available bricks of Lego®. After the introduction of the activity, the adult stayed in a corner of the toy library at the disposal of the children until they finished.

When the children began to build the bridge, Greta and Barbara collaborated, while Tom worked alone. After about 25 min, the two girls reached the opposite sites of the worktable and checked the length of the bridge. As it seemed long enough to connect the two sides of the river, the task should have been considered completed. However, Greta continued to add pieces of Lego® to the construction and the bridge reached the edge of the worktable. This produced a reaction in Barbara, because she presumed that the bridge could collapse.

((Hour: Minute: Second): 0:25:26.5)

1.   Barbara: Greta no, no, no this way it falls

(Greta placed a piece of Lego® after another, but this protruded from the worktable)
2.   Greta: yes ((she pulled back the bridge and the piece of Lego® did not protrude anymore from the worktable)

((Hour: Minute: Second): 0:25:40.3)

When Barbara pointed out to Greta that "this way it (the bridge) falls" (see Figure 4), although her argumentation was partially implicit, it is possible to reconstruct Barbara's argumentative structure, as represented below.

Barbara
(Greta does not have to put the construction sticking out of the table)

↑

1.1   because otherwise it will fall (T.1)

Figure 4. Argumentative structure of Barbara's argumentation.

The standpoint of Barbara's argumentation was implicit. It was reconstructed through cultural background information and visual information obtained from the video-recording. Barbara, Tom, and Greta knew that they had to build a bridge to connect the opposite sides

of the river. Accordingly, the bridge needed to be long at least as the length of the blue poster representing the river. The bridge could be built longer than the poster. However, the bridge also needed to be shorter than the worktable. This constraint was not imposed by the adult's instructions, but was the result of the features of the material setting (the worktable). Greta seemed not to consider this constraint: while building the bridge, she added another piece of Lego® exceeding the length of the worktable. Barbara immediately noticed this action, and said to her: "Greta no, no, no this way it falls" (T.1). The information provided by Barbara ("this way") is partially implicit. The verbal information (the implicit standpoint) could have different meanings, but her argument helps to identify the exact meaning of the claim: there is something that is about to fall due to an actual state of affairs that should provoke a side effect to the achievement of a goal (for a reasoning about side effects of an action preventing the reaching of a goal, see [34,56]). To determine whether or not Greta's argumentation can be considered incomplete, we must look at her reaction to Barbara's claim. Greta's verbal participation was limited to the intervention "yes" (T.2). However, she also acted at the level of the material setting. In fact, she pulled back the bridge and the piece of Lego® did not protrude anymore from the worktable. Through her action, it is possible to reconstruct how she was interpreting Barbara's request. Greta was suggesting that "this way" referred to the part of bridge that was out of the table.

The excerpt indicates that Barbara's argumentation was not incomplete. Argumentation consists of a premise ("If . . . ") expressed through the argument and a conclusion ("Then . . . ") expressed through the standpoint. In this excerpt, the premise was explicit ("There is a bridge that could fall"), but the conclusion (what Greta should do in order to avoid this state of affairs) was reconstructed by looking at Greta's action. The exchange indicates that preschool children can reason with peers by adapting the amount of information to be shared with the interlocutor and according to the common ground assumptions already shared [46]. Children can leave an argument implicit, for example, because there is factual information that is visible to everyone [26]. In addition, children can leave partially implicit the consequences of a certain premise. If it is true that argumentation takes place along a process [57], then it is useful to consider how children's interventions are interconnected. In this sense, and according to the theoretical definition of argumentation provided by van Eemeren and Grootendorst [2], Barbara's intervention can be considered a case of argumentation. The standpoint advanced by the child was embodied in the activity she was performing with the other children.

6.2. Case 2: Embodied Argument

The case refers to the activity of building a tunnel (inspired by a task originally proposed by Piaget [58]) with Lego®. The researcher invited a dyad of children (Diego, 5 years 3 months, and Jessica, 5 years 1 month) to build a tunnel in such a way that a small toy car could pass through. The adult provided the following material: a small toy car already available at the kindergarten, a box containing bricks of different shapes and colors, and six images of different tunnels. To introduce the task, the adult first let the children to explore the materials on the table. She moved away and returned after a few minutes. Then, the adult presented the task and asked the children to build a tunnel in such a way that the car could pass through. Then, the researcher remained in a corner of the room waiting until the children finished.

When the children started to build the bridge, they chose to use the Lego® of larger size and to work alternately: first, Diego built a tunnel, but it was too narrow. Then, Jessica tried to build a new tunnel. While she was engaged in the activity, Diego said: "I say that it will not pass through it". In turn, Jessica answered "I say that it will pass through it". When Jessica completed the work, the children checked the result. The excerpt below concerns this moment of "testing phase".

((Hour: Minute: Second): 0:05:41.5)

1.   Diego: you see that it does not pass? I was right

(the toy car cannot pass through the tunnel built by Jessica. She pulled the two pillars of the tunnel, trying to move them away from each other, creating more space)

2.   (The two pillars were linked together by the roof formed by many pieces of Lego®. Jessica moved the pillars slightly away, but immediately after the structure re-established and re-adjusted to its original shape)

((Hour: Minute: Second): 0:06:47.0)

Diego and Jessica were trying to build a tunnel by working alternatively in order to reach a result big enough to allow the small toy car to pass through. The tunnel built by Jessica was sufficiently high, but too narrow. Before the moment of verifying if the size of the tunnel was adequate, Diego predicted that the car would not pass through the tunnel. When Jessica realized that the tunnel was indeed too narrow, Diego said: "you see that it does not pass? I was right" (T.1).

The children's interactions had some elements that can be considered argumentative. (see Figure 5). In fact, in the observed situation, two opposite points of view were presented. There are those of Jessica who thought that the car would pass through the tunnel ("I say that it will pass through it"). She built a tunnel and, even when Diego pointed out that the car would not pass through, she remained on her position. From the perspective of Diego, he thought that the car would not pass through the tunnel. What is missing in case 2 is the presentation of explicit arguments supporting the children's standpoints. For example, Diego should have indicated "because the tunnel is too narrow". In absence of such a verbal indication, some visual elements should be invoked to understand that Diego and Jessica were sharing this piece of information: in particular, Jessica tried to pull the two pillars of the tunnel in order to move them away and to create a larger space. The structure, which was a single piece comprising many pieces of Lego®, was somehow modified by Jessica's attempt, but she immediately readjusted it to the original shape. Jessica's action seems to suggest that she noticed that the obstacle to the passage of the car was the width of the tunnel. Although the argument was not made explicit, the structure of the children's argumentation could be presented as follows.

1.   The car does not pass through the tunnel (T.1)

↑

1.1   (because the tunnel is too narrow)

Figure 5. Argumentative structure of the children's argumentation part 1.

As already suggested by Perret-Clermont et al. [26], children do not make explicit something that is obvious, so the available visual information is not always verbally made explicit by the children. Diego's intervention "you see" (T.1) is an invitation to focus on the visual setting. In other episodes observed in the same corpus of data, children made explicit the arguments in cases in which they were not supposed to be shared with the interlocutors. For example, Convertini [50] presented some illustrative cases in which the

children make explicit the reasons justifying why a construction needs to be built differently. Examples of interventions are "because a bed in the tunnel is missing and people need to rest" or reasons connected to the fact that a bridge needs to be built up to the sky, or that a bridge is not adequate because the stairs or the railing are missing. In these cases, children suggested making a different construction not because the actual one does not comply with the instruction of the task (shared by the interlocutors), but because it does not comply with the children's ideas of what a tunnel or a bridge are, according to their representations of the world [50]. In this excerpt, the constraint about how to build the tunnel was established by the adult. By presenting this case, we do not just want to show that children omit some information and that this process is legitimate, but rather we intend to highlight that an interaction can have an argumentative function (in children's perspective), even when the argument is completely implicit.

As is not possible to have an argumentation without an argument [2], it could become difficult, in the present case 2, to detect the argumentation by looking exclusively at the verbal information. Both Diego and Jessica made explicit their opposite points of view, but they did not advance arguments. However, their reasoning activities cannot be exclusively limited to their verbal participation: the children advanced opposite points of view, relied their reasoning on other points of view, shared an (implicit) cultural background, and tried to solve the (argumentative) impasse through a multimodal discourse [59].

6.3. Case 3: Embodied Argumentation

The activity proposed in the present case concerns the building of an hourglass and was inspired by a task presented by the Foundation "La main à la pâte" (http:// www.fondation-lamap.org/en/international (accessed on 2 July 2021)). The adult invited Barbara (4 years 8 months), Greta (4 years 9 months), and Tom (5 years 3 months) to build an hourglass with the following recycled materials: two plastic bottles, two hourglasses, a plastic container with sand, three spoons, a roll of tape, and three funnels of different size.

The activity was introduced to the children through several stages. First, the adult gave the children the time to explore the material on the table and moved away; then, she returned to the worktable and explored the material with the children, especially the two hourglasses. Then, she proposed that the children build an hourglass all together and asked the children to call her once the activity was completed before leaving the worktable.

The excerpt concerns the moment in which the researcher already presented the instructions. The children were trying to build the hourglass and, in particular, they were filling the plastic cups with sand. Barbara was putting the sand into the plastic cup that Tom was holding and which was placed on the table. Tom lifted the plastic cup up off the table and the sand began to fall through the hole at the bottom of the container.

((Hour: Minute: Second): 0:07:41.5)

1. Barbara: Tom (he had a spoon in one hand and the plastic cup in the other. The plastic cup had a hole at the bottom. The plastic cup was placed on the table and Barbara was putting the sand in it. Tom lifted the plastic cup up off the table and the sand began to fall out of the hole) no, Tom

(The sand fell on the table. Tom put the spoon he held in the other hand under the hole and the sand fell into the spoon)

((Hour: Minute: Second): 0:07:45.3)

In case 3, Barbara and Tom were trying to fix all the material together to make the requested final product (the hourglass). Greta was distracted by the books in the toy library and she had her back to the table. Tom and Barbara were working together. By watching at the two models of hourglasses, Barbara and Tom knew that two plastic cups must be filled in with sand. The plastic cup was placed on the table and Barbara was putting the sand in. At some point, Tom lifted the plastic cup up off the table and the sand began to fall down. Barbara claimed: "Tom, no, Tom" (T.1). The boy put the spoon he held in the hand under the hole and the sand fell into the spoon.

In this exchange, Barbara reacted to Tom's action. As in case 1, Barbara's claim was an answer to an action that can provoke side effects to the achievement of a goal [34,56]. Tom's action of lifting the plastic cap provoked the fall of the sand onto the table. As the plastic cap must contain the sand to achieve the goal, Barbara's action went in the direction of the final goal, while Tom's action neutralized the benefits of Barbara's work. An argumentative confrontation can arise from one or more propositions that underline a difference of opinions [2]. However, actions also can be an important element in giving rise to a difference of opinions during the confrontation stage. It emerges that an action can be an important element in the development of argumentative confrontations because, on the basis of the action, a person can attribute opinions to the other and can conclude that there is a difference that is worth resolving.

The presence of an action presupposes intentions, and the intentions presuppose beliefs on the side of the person who intervenes. For this reason, it is possible for a hypothetical interlocutor to attribute an opinion to the actions of the other and then, possibly, to hypothesize a difference of opinions based on the actions themselves. The present situation could be related to the connection between the theory of mind and the children's perception of the world through the eyes of another child. In fact, it may be possible to explain Barbara's behavior towards Greta, who seemed to perceive a playful motive in her behavior. Another possible view is to refer to the children's theories of understanding of physical phenomena, for instance, to consider that children can construct intuitive understandings of the physical world based on their everyday experiences organized as framework theory [60] and coherent knowledge approach [61]. In our case, it is interesting to consider Barbara's and Greta's understanding of the phenomenon of an impending building catastrophe and their ability to assess the situation regarding the loss of equilibrium in the structure they are building.

In our case, therefore, Tom's action could potentially give rise to difference of opinions (see Figure 6). Indeed, when Barbara claimed "Tom, no, Tom" (T.1) she made explicit her opposition concerning the partner's perspective. As in case 1, Barbara's standpoint was implicit and referred to Tom, without adding any other information. As in case 2, the Tom's reaction allowed us to reconstruct Barbara's argument according to Tom's perspective. After Barbara's claim, Tom put the spoon he held in his hand under the hole and the sand fell into the spoon. According to him, the problem was that the sand was falling. The argument never made explicit by the children could be reconstructed as follows: "otherwise the sand falls". The possible argumentative structure is presented below.

1.　(Tom must put the spoon under the hole)

↑

1.1　(otherwise the sand falls)

Figure 6. Argumentative structure of the children's argumentation part 2.

The children's argumentative elements are highly implicit. However, some minutes before the situation presented in the excerpt, Greta, Barbara, and Tom were already building the hourglass. Greta and Barbara were filling the plastic cap with sand, then Tom moved the plastic cap away from the container. The cups had a hole at the bottom, which were

not noticed by the children during the exploration phase. The sand started to fall on the table. Barbara said "Tom, put here the sand (she indicated the container), otherwise you throw all the sand". After Barbara's intervention, Tom moved the cap back to the ground of the container and the sand stopped falling. This indicates that the children were already engaged in a similar situation before the moment presented in case 3. In the previous situation, Barbara made explicit both the standpoint and the argument in response to Tom's the action. Therefore, the children already knew the consequences of moving the plastic cup. In case 3, they would not need to again share this information, as it was already discovered a few minutes before. This is why, also in case 3, the children did not show an argumentation, as it was expected by the adult: their argumentative participation was coherent with the already-shared experience. As in the two previous cases, the children's exchange had an argumentative function through multimodal representations.

7. Discussion and Conclusions

Argumentation in educational contexts is widely encouraged by teachers and it is experienced by children in oral communication from the preschool age. However, the adults interacting with children do not always report well-structured examples of children's argumentation, especially when they interact with young children that argue in an incomplete, non-standard way, different from the one expected by the adult. The present study suggested that, among the reasons behind this event, the fact that argumentation can be expressed through semiotic means, different from verbal forms, is a valuable way to enlarge the consideration of argumentative participation of young children, especially during embodied activities requiring the coordination of verbal and non-verbal actions. Assuming that "the fact that children do not exhibit elaborate argumentative abilities in factual disputes should not lead to the conclusion that they do not have them at their command" [62] (p. 53), we identified elements of embodied argumentation that appeared during the children's involvement in technical activities of problem-solving in kindergarten.

The findings showed that children's argumentation during embodied activities is a complex process. As we advanced the hypothesis that children's argumentation is much more than what is made explicit through verbal means, we observed in our corpus that even apparently incomplete argumentations could have a function in solving technical tasks. Despite the children's argumentative participation, we also observed that these activities did not always leave enough space for (verbal) argumentation. In fact, the adult's expectations about the children's argumentation can sometimes be disrupted by the type of task. In this sense, it is extremely important to consider the child's answer with respect to the activity he/she is performing, especially in those situations in which the standard way (expected by the adult) is not present.

In technical activities of problem-solving, children use different resources to elaborate their arguments and justifications, including actions and non-verbal conducts that play a relevant role in accomplishing the task. Through signals, namely actions by which a person signifies something to another, people deliberately create signs within interactions [63]. As indicated by Arcidiacono and Neuenschwander [64], "an element is only a sign if it is addressed to someone, thereby creating the conditions for an interpretation of the sign (for example, words, gestures, noises)". Furthermore, signs are part of a relationship between an object and an interpretation by the reference to icons, indexes, and symbols that are, on the one hand, in dynamic and spatial connection to the object and, on the other hand, connected to memories, general knowledge of the world, and the meaning of the person who is interpreting the signs [65].

In case 1, the verbal reference to the indexical "this" (see: [66]) accompanied by the action of placing a piece of Lego® was the way used by the child to designate the object in question, through a composite signal: indicating was the method used by Barbara to create indices for the object she wanted to refer to. According to Clark [63], this index is a sign that is "physically connected" (p. 165) to the thing speakers want to refer to and must satisfy the requirements being in the participants' joint focus of attention, locating the

object in space and time by means of a physical connection with the object, and having the object specified under a particular description. In such a case, the speaker presupposes that the addressee can work out these steps based on their current common ground. This latter point was evident in Greta's reaction who, after having said "yes", pulled back the bridge: this locative action is relevant to reach a joint solution of the task and should be considered as a form of stylization [63], namely, a manifestation of an action making use of movements that distinguish the manifested action from the same action not being manifested.

In case 2, we observed the use of an iconic explanation ("you see") to synchronize the action and the speech as a demonstration. While Diego was saying "I was right", Jessica was pulling the two pillars of the tunnel and, immediately after, re-adjusting its shape. In doing this, she was performing a demonstration composed of an incidental aspect to the objective of the demonstrator, by encompassing an act of depiction, namely, "the deliberate marking of marks on surfaces or other modification of objects such that an image or pattern results which is recognizable as an image of something" [67] (p. 125). The child's demonstration was also a selective depiction because it was intended to support the performance of the depictive aspects of the referent. In other words, the participants were interacting by referring to verbal content and to iconic gestures having the goal of explaining how things work and depicting what was being talked about [68,69]. These gestures were facilitative and, at the same time, informative and communicative.

In case 3, we observed a situation in which the Barbara's intervention ("Tom, no, Tom") was a directing-to action signal [70] in order to create a shared focus of visual attention and a grounded mutual knowledge about the next phase of the task [71,72]. In fact, the boy was producing a gestural reaction and performed the expected action: after lifting the plastic cup up off the table, he was handling a spoon to collect the sand and to prevent it from falling down. In this way, the non-verbal behavior performed during the interaction was a sign to which the participants could attribute a signification, as a result of the representative characteristics of the task. Therefore, it was a sign which referred to the objects and a way to ensure the collaborative embodied work requested by the assigned activity.

The three selected cases indicated the accomplishment of different signaling processes performed by the participants during the tasks. In the first case, the children created signs as the representation of spatial surroundings, having the location of entities as the basic process. In fact, children coordinate their actions of locating entities in their immediate surroundings. The second case was referring to the creation of icons as signs having the goal of imagining appearances, calling the participants to an effort of memory for appearances. The children were working together to coordinate themselves in order to imagining the way things appear. In the third case, the symbolic sign created by the child saying "no" in order to qualify the work of the other child was producing an activation of rules mediated by the gestural reaction of the partner: the children were creating a mental representation of the appearance and working to adjust the situation and to prevent possible negative consequences. The three cases indicate that both speakers and addressees were able to coordinate their actions by activating different cognitive resources, such as referring to conventional rules, representing the surrounding space, and appealing to their knowledge of perceptual appearances.

As we observed in our corpus of data concerning interactions in kindergarten around a technical task, we can highlight that the verbal channel is not always the privileged one. In other words, technical activities requiring the manipulation of physical objects can be even an obstacle to the children's verbal participation in "standard" (expected) argumentative practices. In the development of communication between the participants, gestures contribute to creating and maintaining an image in space and time [73], allowing a direct relationship between the action (as a signaling act) and the object itself [64].

In light of the results of our study, the role played by acts in the reflection of the child through the tasks are multiple. Firstly, the signaling acts could enable the emergence of argumentation in the child. Teachers and educators should consider the effects that these acts (of different forms) could produce in specific interactions requiring the manipulation of different

objects for technical tasks in kindergarten. Accordingly, technical and scientific activities can be turned into constructive experiences by designing the tasks through a careful consideration of the children's verbal and other-than-verbal communicative means [74,75]. We would like to highlight the responsibility of the adult/researcher in designing the proper conditions for promoting children's explorative experiences and in analyzing its effects. This element was already highlighted in a previous work [29] in which the focus was on the psychosocial aspects that could be observed as obstacles during problem-solving situations. The present paper offered an extension of those results by considering non-standard argumentative sequences as a characteristic of the embodied nature of the task. In addition, with respect to the study conducted by Perret-Clermont, Schär, Greco, Convertini, Iannaccone, and Rocci [26], in which it was found that the children's standpoint could be implicit when it is an available visual information, the present study contributed to indicating that also the argument (and the entire argumentative process) could be not verbally made explicit. Our present contribution refers to the exploration of argumentative functions in children's discussion, especially when the verbal argumentation is left implicit. Their multimodal representation is a strength, rather than a limit, in their participation in problem solving activities.

Finally, we intend to highlight that the exploratory nature of the study did not allow us to analyze the temporal distribution of verbal and non-verbal interventions in relation to their interactive functions throughout the embodied tasks, for example, to identify whether these can be more frequent at the beginning of a task when participants had to figure out the functions of the building objects and tools that they had available. Further studies could develop these lines of investigation by looking at a larger sample of interactions. Future research will contribute to making predictions about what types of embodied activities may lead to an increase in the quality of argumentative interactions across tasks. In fact, the present study suggests the opportunity of encouraging the adoption of an integrate approach to plan technical embodied activities aiming at promoting children's argumentation in kindergarten.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the University of Neuchâtel.

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Appendix A. Transcription Symbols

Sign	Description
(( ))	non-verbal information
=	latching
[	overlapping
::	extensions of sound
(.)	short pause
↑↓	increasing or decreasing intonation
xxx	non-understandable utterance

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