Dialogical argumentation in second- and third-grade science classrooms

Abstract

The current practice of teaching argumentation focuses on mastering the structure of argumentation schemes such as claim, evidence, warrant, and conclusion. However, this approach lacks the dynamics of epistemic criteria of children's reasoning and decision-making. The common approach also does not address practice of argumentation in the lower elementary grades (K–3), since these children do not master—similar to grammar—the structure of argumentation and, therefore, are considered not ready for processing argumentative discourse. Because of this reason, there is little research focusing on lower primary school students' argumentation in school science. This study, drawing on the social-psychological theory of the late L. S. Vygotsky (1989), was designed to investigate children's argumentation as social relations by investigating how second- and third-grade children develop the practice of evidence through social relations, especially burden of proof. The findings show (a) the capacity of connecting claim and evidence/responding to the burden of proof and critical move varies, (b) teachers played a significant role to emphasize the importance of evidence but experienced the difficulties of removing children's favored ideas during the turn taking of argumentative dialogue. The findings on the nature of dialogical reasoning and teacher's role provide further discussion on pedagogical approach to children's reasoning and decision-making.

Keywords

Argumentation, dialogical, evidence, burden of proof, lower elementary children

Argumentation has become an important avenue to teach the discursive practices of science (Osborne et al. 2004). There are indeed different approaches to teach science by means of argumentation; but many studies adapted Toulmin's Argumentation Patterns (TAP) for developing children's argumentation (e.g., Simon 2008). Implementing the approach, teachers ask children to make claims about the answers to given questions, provide evidence to back up their claims, and derive conclusions (Duschl and Osborne 2002). When researchers study what happens in such classrooms, they tend to emphasize the coherence between claims and evidence children provide. Whether children's argumentation is done in talking or writing, good reasoning and argumentation require children to use "evidence."

The TAP framework, even though there were some successes, recently has been subject to much criticism as being too linear, individual, and technical (Macagno and Konstantinidou 2013). Coding the elements of argumentation—e.g., claims, evidence, and warrants—in children's argumentative talk is often unclear; and it turned out to be challenging to determine the level of argumentation (Duschl 2007). Moreover, the framework does not sufficiently explain the dynamics of epistemic and social criteria of argumentation (Nussbaum 2011). TAP makes it a challenge to understand the criteria of claim acceptance or rejection, implicit premises and standpoints, and the dynamics of

social interactions and presumption that are often present in argumentative classroom discussions (Nielsen 2013). As a result, TAP schemes and analysis do not sufficiently explain how children learn to evaluate evidence, persuade and are convinced by others, and reach conclusions when their ideas are challenged by classroom interactions. Studies of argumentation tend to focus on students in the higher grades because children in lower grades (K–3) are thought to lack the mastery of writing required for producing argumentation structures. As a result, there is a paucity of studies focusing on early elementary school students' argumentation in school science.

This study was designed to investigate argumentation in early elementary school classrooms (Grades 2–3) in situations where the children encounter puzzling questions and problems. Of particular interest in this study is the practice whereby the burden of proof shifts among participants in collective argumentation. Aligning ourselves with other researchers of argumentation, we acknowledge the importance of coherence between claims and evidence. But we do not examine the numbers and levels of warrants and instead investigate how the coherence of claims and evidence emerges and develops dialogically. In so doing, we take a societal-historical approach to argumentation (Vygotskij 2005), where argumentation first exists *as* social relation, as a communicative exchange, before it becomes a higher psychological function of individual children.

Argumentation and social relations

Evidence and burden of proof in argumentation

A statement becomes a significant element in science classroom talk when it is part of an argument that requires dialogue for its resolution. Given that a word always is a reality for speaker and recipient in social dialogical contexts and changes in use (Vygotskij 1934), the emergence of argumentation always depends on how recipients respond to statements made. When the recipient challenges the speaker's statement with counter-statement or conflicting evidence, the course of argumentation takes place. Pragma-dialectical perspectives (van Eemeren and Houlosser 2002) and theories of presumptive argumentation propose the importance of social aspects of argumentation in collective activity (Walton 2008). These approaches look into dialectical nature of dialogue where community members interact with different and conflicting ideas and beliefs and still need to reach a conclusion (van Eemeren and Grootendorst 2004). Social interaction and critical evaluation of claims and evidence are crucial to collective argumentation.

The speaker has obligation to defend her statement by answering and providing better evidence. For example, if one states that caffeinated drinks help everyday performance, this could be taken as true or accepted until another person (a) responds that caffeinated drinks impact performance negatively or (b) asks for evidence to prove the benefits to everyday performance. In this case, the claimant has the responsibility to prove the truth of the claim, that is, she is charged with the *burden of proof* (Walton 1998). If she fails to prove the truth of her claim, then the opponent's claim is taken as true; and now the opponent holds the responsibility of providing and proving evidence for the opposite argument.

The responsibility and role of proving evidence shifts among the arguers. The burden of proof is critical to understand the role of evidence in dialogical argumentation. Yet

there has not been much attention on young students' argumentation talk. This may be so because the term, burden of proof, normally is used in legal contexts where there exists the practice of deliberately shifting the responsibility of proving to the other party without suggesting any further evidence (Hahn and Oaksford 2007). In school argumentation studies, this term has been implemented as one of the critical components to move dialogues forward to strong relationship between claim and evidence.

Argumentation as dialogical genre

Dialogue inherently is argumentative (Bakhtin 1990). To teach argumentation skills in schools, teachers and researchers have introduced the TAP approach (e.g., writing a claim – evidence – counterclaim – conclusion). The learning of argumentation frequently is tied to writing or composing argumentation so that the teaching of argumentation tends to be delayed until students master writing at a certain level. Students are required to learn first how to structure argumentation. In other words, teachers teach the steps in argumentation first before children are asked to use argumentation. But this is like teaching grammar before someone has a language or is like learning the rules of a game prior to knowing the rudiments of the game (Wittgenstein 1953/1997). For this reason, many argumentation studies have evaluated argumentation elements and structures in children's talk and writing. There are few studies on young children's argumentation.

How might we think about the development of argumentation? Clearly, it is a higher psychological function. In regards to all higher psychological functions, societal-historical psychologists emphasize that these *are* societal relations before they are observed in the actions of individuals (Leont'ev 1959). To exemplify the emergence of higher function, consider the case of pointing. First, a child moves his hand arm or perhaps attempts to grasp and object; then the mother treats the movement as a gesture, taking the object in the extension of the arm and reaches it to the child; and finally the child begins to point (Vygotskij 2005). Here, the higher function—intentional pointing—was a mother–child relation first. Importantly, the higher function exists concretely and the child already is participating in it—rather than, as some scholars incorrectly assume, that the child has to construct it internally. There is nothing inside, so Vygotsky scholars point out, that is not already outside (e.g., Mikhailov 2001). This has the consequence that if science educators choose argumentative competency as a goal of their curricula, then children ought to participate *in* relations where argumentation takes place and where the *relation* itself *is* argumentation. In being produced, these societal relations transform and develop; and, together with the relations, those who participate transform and develop (given the relations are dialogical).

Classroom talk constitutes a junction of the individual psychological and societal dimensions of thinking and reasoning (Mercer 2008). The process of communicating can be understood as *interthinking* (Littleton and Mercer 2013) and this makes argumentation inherently and irreducibly a *collective* phenomenon (Mercer et al. 2004). The emergence and existence of argumentation is only possible in/through relations involving speaker and recipient. A child's claim becomes a claim only when it is stated and responded to by some recipient. Evidence becomes justifiable only when the persuasiveness of it is experienced and acknowledged by the generalized other. Thus, the role and effect of one's claims and evidence depend on others' responses—i.e., argumentation exists as

dialogical relation. In this non-linear process of argumentation, one cannot follow the structural order that they learned from writing the argumentation structure. This challenges the formal approaches to teaching argumentation structures which often fail in classroom conversation where children participate in collaborative tasks, the process of making and justifying claims is often messy and non-linear and does not follow a structural order.

Recent research in science education (Roth 2014) suggests that Vygotsky (e.g., Vygotskij 1934) and Bakhtin (e.g., 1990) agree that *all* knowing has a dialogical origin, that is, it exists as a soci(et)al relation first before it exists for the individual. Development occurs when a previous experience—e.g., participating in argumentative talk—reflexively becomes the object of current experience (Vygotskij 2005). When children participate in classroom talk, they may take different parts in what *collectively* already has argument structure (Kim and Roth 2014). Thus, A makes a claim, B provides supportive evidence, and C and D produce a conclusion. Each child is focusing on doing one thing, and this focus is reflected in consciousness. However, at some point, the same child might take on two steps of the argumentation. A does what she and B previously have done in sequence. This now is a different form of participation, which may arise when the children reflect on what they have done and as a consequence A does her and B's part. Thus, what *is* a social relation first, the production of the claim | evidence pair, now is accomplished in one contribution. That is, the soci(et)al relation is the condition for higher psychological functions. However, whereas all functions have been relations first, not all relations will show up as individual psychological functions. Thus, to learn scientific argumentation, children have to participate in relations that are of argumentative nature.

Research method

To investigate children's argumentation through social interactions, a descriptive case study is employed as a research method in this study. Case study is a way to show the context and interactions among participants in real life context (Baxter and Jack 2008). We describe and analyze class scenes of children's actions, discussions, and interactions with teacher and peers in order to understand how children's argumentative talk emerge and develop over time.

Research participants

This case study was conducted over the course of an entire school year in a multi-grade class including second- (n = 8) and third-grade students (n = 8) of an urban school in western Canada. The classroom teacher was dedicated and had considerable experience—more than five years teaching science at the elementary school level and several years of previous science teaching in informal settings. She was keen on developing children's thinking and problem solving skills in science. During her science lessons, she often strived to develop safe, creative, and conducive learning environment by encouraging children with statements like "let's be scientists," "scientists can be wrong too," or "I am not saying that's wrong. I am just saying you can think about other

answers." During the lessons, different teacher assistants—one at a time—were present. They generally did not have science backgrounds.

The science curriculum

Science class took place every twice a week for one hour each. The present data were collected while the children studied plants. The topics included the structure of plants, the functions of different parts of plants, light and photosynthesis, soil and water, seeds and roots, soil, and living things in soil. The children were engaged in various classroom tasks designed by the teacher to afford the learning of concepts and skills specified by the official curriculum.[1] In some lessons, the teacher spent most of class time explaining ideas and sharing stories around certain topics. Some lessons focused on children's writing, drawing, designing, and modeling phenomena following the teachers' instructions. In some classes, children watched videos related to the learning topics in class and shared their ideas. Whenever the teacher raised questions, there were multitudes of ideas and opinions leading to opportunities for studying argumentation. For the purpose of this study, we selected an exemplary where children encountered a mystery object. This task took two lessons for the children to reach a conclusion. We describe and analyze this case in depth to highlight the nature of classroom argumentation and children's learning.

Data collection and analysis

Two cameras were used to record children's classroom activities, one in front and the other in the back, for a total of 16 50–60-minute science lessons. All tapes were transcribed and available for analysis. The analysis of the data included both joint sessions following the precepts of *interaction analysis* (Jordan and Henderson 1995) and individual sessions. In the joint sessions, clips that turned out to be interesting (for specified or unspecified reasons) during a cursory viewing were played. Playing is stopped whenever a participant wants to comment, begin discussing some aspect, or initiate replaying a segment. Participants in a data session are not allowed to speculate but are held to provide evidence for any claim in the data. Play is continued when participants feel that everything pertinent to the segment has been said. All claims and hypotheses are noted for subsequent testing in the entire database during individual sessions.

In this study, we take a societal-historical approach, which holds that a word or statement never exists for one person but only exists for two or more (Vološinov 1930). Because of the societal-historical approach taken, the analyses focused on the elements of argumentation in *collective* talk. One recent study in science education suggests that researchers have to investigate how each turn at talk takes up, transforms, and builds on the preceding turn. A statement in the mouth of a speaker *simultaneously* is in the ear of the recipient: the statement belongs to both. To understand the dynamic of *collective* talk, therefore, pairs of turns need to be used as the basic unit of analysis. A statement is a question because there is a reply, and a statement is a reply because there is a question (Bakhtin1990). In our context, this means that every second member of a turn pair

[1] The curriculum may be obtained at https://www.bced.gov.bc.ca/irp/pdfs/sciences/2005scik7.pdf.

determines what the preceding turn has been. This is exemplified with a turn pair from our study:

1.13 Lee: [It looks like pumpkin.
1.14 Alex: [It looks like pumpkin.] How would it be a pumpkin?

In turn 1.14, "It looks like a pumpkin" is both heard and treated as a claim, for which the request for evidence is offered, "How would it be a pumpkin?" That is, our representation makes it clear how two elements of the argumentative pattern—i.e., claim and request for evidence—exist for one child constituting his part of a relation with another child. Whether the second statement is a request *in this conversation* depends on the next turn. It is not until we know the next turn (i.e., 1.15) that we may know how turn 1.14 has developed the conversation. This procedure is well known in conversation analysis, where the effect of a statement on others determines its function rather than the private intentions of the speaker (ten Have 1999).

The ethnographic background to the episode: the mystery object

The case analysis is based on the task that confronted the children with a mystery object: the root of plant. Prior to this task, lesson topics had included plant parts (seeds, cotyledon, stem, roots, leaves, fruits), functions of plant parts, seed germination, and the concept of photosynthesis. Over the course of two weeks, the class had grown beans in a jar that was transparent, which allowed them to observe the roots that were growing downward in the soil. Observations also included the changes of the cotyledon and leaves growing toward the sunlight. Then, one day, the teacher brought a Ping-Pong-sized mystery object for children to investigate. The task was for children to make claims about its nature and later they closely observe and dissected the object to find out what it was. Then the teacher explained how children could cut the object safely by using plastic knives. She explained: "you can take off this outside part and see what's on the inside, right, and then you might want to very carefully cut it open and see what's on the inside and see if you can figure out what's going on in there." Even before the objects and materials to dissect (plastic knives, magnifying glasses, piece of white paper as dissection plate) were distributed to each group, children already made claims: "it's onion!" or "I am pretty sure it is an onion." Teacher encouraged them to think about something else. As they investigated the object, children produced ideas about what it was, including cabbage, nut, dragon fruit, pumpkin, pineapple, and squash. Some ideas were supported or rejected with reasons and evidence and some ideas were not discussed any further after the spontaneous claim.

Natural argumentative forms in early elementary science

The presence of warrants and justification with evidence has been one of desirable components of children's reasoning and argumentation in science classrooms. In interview settings, first graders (6–7 years) did present relational (cause–effect) reasoning in their individual writing or verbal responses (Metz 2011). However, it is not known how reasoning through evidence emerges and is developed in actual classroom situations.

This study was designed to specifically investigate the dynamics of burden of proof. In the following sections, we provide evidentiary support for two assertions (claims):

1. Even in the early, untutored elementary classroom, we observe natural forms of argumentation that constitute the preconditions for any scientific argumentation form. These forms include making claims with evidence and putting the burden of proof on others.
2. Teachers have a special role of supporting the emergence of particular discursive forms that are consistent with scientific argumentation and they as member of dialogical argumentation communities also experience the difficulties of persuading others (children) when evidence was missing.

Presence of argumentative forms in untutored classroom talk

Claims are commonly observable when children are engaged in problem-solving situations. Children state claims as a way of answering a question. In this section, we analyze the talk in two groups to exhibit how the connections between claim and evidence evaluation emerges. The following fragments took place when children started dissecting the object after the teacher asked children to think about other ideas rather than onion. In the fragment, we coded claims (C) and evidence (E) to show how claims and evidences appeared and interact throughout the dialogue. There are prediction-type claims (turn 1.7) or counter-claims (turn 1.5) and different sources of evidence such as evidence based on classroom observation (turn 1.1) or conceptual knowledge (turn 1.5), which we coded as claim or evidence to show claim-evidence interaction.

In one video, three children (Ireland, Alex, Lee) can be seen sitting together (Group A). They have received the object, they start observing, peeling, and cutting it and their conversation takes place.

Fragment 1: Group A

	1.1	Alex:	Look at the texture. I don't know what it could be.
C>	1.2	Lee:	It looks like baby dragon fruit. Yes, it does. Look with the loupe.
E>	1.3	Alex:	I have no anything but dragon fruit . . . but do, like, dragon fruits have stuff like this? ((*He is touching the top part*.))
C,E>	1.4	Ireland:	Maybe it is a pumpkin. Things like, Look!
C,E>	1.5	Alex:	It's not a pumpkin. Pumpkins, there would be nuts . . .
E>	1.6	Ireland:	It might be dried out somehow.
C>	1.7	Lee:	I think it's dragon fruit.
E>			When dragon fruit gets older, that has some ((*inaudible*)) . . . ((*He is touching the bottom of the object while explaining*))
C,E>			so this may be a baby one because it still has this. ((*Pause. Ireland is showing Alex the object that she was referring to earlier*.))
C,E>	1.8	Alex:	Dragon fruit, dragon fruit. I can see splits. ((*He gazes at it)*). Yea, dragon fruit. ((*He starts writing down the claim.*))

In this fragment, there are several pairs of claim-evidence evaluation; and burden of proof emerged around the ideas of dragon fruits and pumpkin. In the pair of turn 1.2|turn 1.3, a pair of a claim (dragon fruit) and observational evidence (the figure seen through the loupe) was suggested in turn 1.2. However, there is a claim | challenge pair, as the

second part asks about some stuff on the top (turn 1.3). The claim of dragon fruit called for further evidence to be accepted as a reasonable claim. This claim | call for further explanation is produced in the statement that the stuff would disappear when it gets older (turn 1.7). The turn pairs 1.2 **|** 1.3 **|** 1.7 reveal the presence of a claim | evidence | evaluation pattern and the practice of burden of proof.

In the course of the pattern described, a new claim | evidence pairs appear. In turn 1.4, a claim of pumpkin can be seen together with data. Ireland physically puts forward the mystery object and a magnifying glass ("loupe") so that Alex can take a look at and see the evidence. However, a claim | evidence pair ensues, "It's not a pumpkin [for] there would be nuts" (turn 1.5). The pairing of counterclaim | evidence shifts the responsibility for better evidence to another speaker. In this case, the counterclaim constitutes a critical movement in the unfolding claim | evidence | evaluation sequence.

In the turn pair 1.4 **|** 1.5, a conflict emerges between one claim | evidence pair and a counter claim | evidence pair. The counter-claim is reified as such by the statement that the pumpkin "It might be dried out somehow" (turn 1.6). The statement implicitly accepts the presence of nuts in pumpkins, but raises the possibility that these are missing for the reason specified. The burden of proof is decentered in the hypothesized reason for the missing evidence. Throughout the turn taking (turn taking of 1.2**|**1.3**|**1.7 and 1.4**|**1.5**|**1.6), the claim | evidence relationships are evident and the need to prove it was not a pumpkin emerged.

In turn 1.7, we claim | evidence pairs are offered, which are reified and accepted as such in turn 1.8. However, the dragon fruit related claim subsequently is challenged in a counter-claim involving a pumpkin (turn 1.13).

Fragment 1 Cont'd

C,E>	1.12 Alex:	Yea. It must be a dragon fruit. Look.
C>	1.13 Lee:	It looks like a pumpkin.
	1.14 Alex:	How would it be a pumpkin?
E>	1.15 Lee:	I had a big pumpkin . . . like . . . ((*he starts looking through the magnifying glass*)).
E>	1.16 Alex	Pumpkins start off with something big . . . it's already stuff coming out.
C,E>		It's not a pumpkin. Look! Feel the texture.
E>	1.17 Lee:	I know. uh wait, wait ((*he is cutting*)) oh juicy inside! Look at that.
C>	1.18 Alex:	It must be dragon fruit.
E>	1.19 Lee:	If this is a dragon fruit, ((*inaudible*)) nice white and lots of seeds in it.
E>	1.20 Alex:	It's juicy

The conflict between the claim (dragon fruit) and counter claim (pumpkin) leads to a request for evidence (turn pair 1.14 | 1.15). The reply statement begins with reference to a personal experience with a big pumpkin, but remains incomplete as Lee turns to look at the object through the magnifying glass. This reply is paired with, and confronted by, an evidence | claim | evidence containing statement articulating (a) some missing part and (b) some part of the object (e.g., texture) (1.16). The supported claim offered is paired with an acceptance statement (turn 1.17). The burden of proof was emerging and evolving. Here, it externally moves back and forth between the two speakers, but it exists simultaneously for the respective recipient, who takes it up in the reply. In that evolution, the argument evolves with dragon fruit as the claim that obtains greater evidential support.

In the video, two distinctive claims can be seen to emerge. But each of these two claims excludes its counterpart. The necessity of choosing one answer put the children into an argumentative situation. Several pairs of claim-evidence evaluation and burden of proof emerge as the best claim needs to be chosen. The analyses provide evidence for the emergence of burden of proof and claim | evidence | evaluation sequence at the collective level and, in some instances, already occurring in individual statements.

Our second fragment shows children holding onto an idea even though the teacher previously has offered up ways of testing that would provide contradictory evidence. That is, the claim that the object is an onion continues to live even though the teacher previously has suggested testing whether the object smells like an onion and makes eyes water. In the episode, new claims include the object as a nut, cabbage, and pineapple, but these claims are not taken up further and therefore disappear from the talk without further claim | evidence |evaluation sequences.

The fragment begins with a pair that offers multiple claims, one of which is accepted (onion), the others constituting alternatives (nut, cabbage). Even though the cabbage claim is followed by a potential challenge (there is a rise in intonation, as associated with questions), the next two turns do not take up the challenge but offers a restatement of the onion alternative together with supportive evidence (turns 2.5, 2.6).

Fragment 2: Group B

C>	2.1	Ann:	supposedly onion, or some kind of nut.
C>	2.2	Cavin:	It's either an onion or cabbage.
	2.3	Sam:	Cabbage?
C,E>	2.4	Cavin:	Probably an onion because it made me cry, but
E>	2.5	Ann:	That made me cry and I'm wearing glasses . . . for some reason it doesn't affect some people
	2.6	Cavin:	I think it's like, well, I think it was making ((*inaudible*))
C>	2.7	Ann:	Maybe it's some type of nut, it could
C,E>	2.8	Cavin:	Eew, that looks like peeled old pineapple ((*he is showing the piece he just took out of the object*)).
C>	2.9	Ann:	No, I don't think it's a pineapple.
E,C>	2.10	Cavin:	Oh my god! It smells so bad! . . . It seems some kind of . . . and it gets into your eyes, and ((*he starts rubbing his eyes*)). . . . Definitely onion. These are onions or cabbage.
	2.11	John:	A cabbage? How?
E>	2.12	Cavin:	Look at this.
	2.13	John:	How do you feel?
E>	2.14	Cavin:	I think this onion feels nice.

In this fragment, four claims are made about the nature of the object (onion, nut, pineapple, and cabbage). But the evidence produced supports the onion, the claim that the teacher's dispreferred option. Twice the need for burden of proof emerges, but both times it is not developed with further evidence. We therefore observe that even though the teacher has made moves to turn the children away from the onion, the evidence produced in the course of this fragment leads back to it. That is, precisely because of the role of proof in the argumentative structure, the children pursued an avenue that moved them away from finding the actual nature of the object (a tulip bulb).

Both fragments therefore exhibit evidence for the existence of burden of proof and claim | evidence | evaluation sequences that exist *as* social relation, in the give and take of

the talk, where a relevant reply presupposes the existence for the respondent of the preceding turn, which is taken up and transformed in the first part of the response that stretches from the beginning of the reception to the end of the replique (Roth 2014).

The role of the teacher in the emergence of argumentation

Teachers as participant in classroom dialogues have a special role of supporting the emergence of particular discursive forms that are consistent with scientific argumentation. Given that the curriculum is an irreducibly collective event—sometimes referred to as "enacted curriculum"—no teacher is in absolute control over what is said and done. This is especially the case when curricular directives ask for greater student-centered lessons. However, there is a role for the teachers in classroom talk, as through their contributions, even without the traditional teacher-student-teacher turn-taking routines, the classroom talk may focus on those issues that more likely lead to the topics of interest from a scientific perspective (as stated in the mandated curriculum). As studies in early mathematics classrooms show, however, even though teachers might insist—by repeatedly stating the rules governing the type of evidence that is legitimate—scientifically inappropriate evidence may continue be mobilized for a considerable amount of time (Roth and Thom 2009). This is so because the teacher's new form of talk about evidence is confronted with those very natural forms of argumentation described in the preceding section. In this section, we focus on articulating the role of the teacher turns in the emergence of argumentation at the collective level.

In the early part of the task, the queries concerning the nature of the mystery object resulted in "onion" as the response. That claim persisted throughout the task (e.g., Fragment 2). But there were also turn sequences that could be glossed as "attempts to dispel the 'onion' option," which manifested themselves in equally persistent query | reply sequences concerning particular attributes of onions that could not be perceived in the mystery object at hand. Thus, query | reply sequences focused on smell (turn 3.1), its tear-producing property (turn 3.5, 3.9, 3.11, 3.12), texture (turn 3.8), and smell (turn 3.12, 3.14). Fragment 3 ends with a summarizing and evaluative turn that none of the evidence provided immediately before supported the claim that the object was an onion.

Fragment 3

	3.1	Teacher:	Does this smell like an onion?
E>	3.2	Cavin:	Yeah!
E>	3.3	Children:	N-o-hhh!
	3.4	Teacher:	What happens when you cut open an onion?
E>	3.5	John:	You cry!
	3.6	Teacher:	We need to be scientists, right? Does the evidence say it's an onion?
E>	3.7	Alex:	Ummmm, they don't come usually and like they don't have this kind of . . . this kind of texture.
	3.8	Teacher:	Ok, so the texture's different than an onion. Right? You know, maybe some of you guys haven't cut open an onion before, but those of you who have, or have helped your mom or dad cook in the kitchen, how did it smell when you cut open an onion?
E>	3.9	John:	Crying.
	3.10	Teacher:	It's very strong smell, what happens to your eyes?
E>	3.11	Alex:	They start watering!

E>	3.12	Teacher:	They start watering . . . right? So, Let's focus on what actually happens. We wanna be scientists and we wanna use real evidence right? So real evidence is it makes your eyes cry. It has a strong smell.
C>	3.13	Cavin:	I think it's cabbage.
	3.14	Teacher:	so, what does this smell like? Does it smell like an onion?
E>	3.15	Children:	No. no.
E>	3.16	Teacher:	Okay, so . . . I don't have the evidence supports that it's an onion. So what else could it be? We need to be a good scientist, right?

In the course of the fragment, the same type of turn pair appeared repeatedly: invitation to provide evidence | provision of evidence. In the turn pairs 3.6 | 3.7, 3.8 | 3.9, and 3.10 | 3.11 we observe at work sequences of claim | evidence | evaluation; that joint work of teacher and student produced a burden of proof procedure as to the nature of the mystery object. In the course of the procedure, the amount of evidence against the onion-nature increased, thereby undermining the claim. It is therefore not surprising that one of the turns (turn 3.13) already offered up "cabbage" as an alternative to the onion; by the end of the fragment, however, no evidence was yet produced to support that new claim. The fragment is a good example of how the burden of proof typical of science lives in the social relation. In all cases, the articulation of the querying halves of the turn pairs falls to the teacher, whereas the articulation of the reply turns stating the lack of evidence falls to students. That is, our phenomenon exhibits the asymmetry between participants, as they come to be associated with different parts in turn-taking pairs and sequences. However, as shown in the description of the analysis above, if the query turn were not also a reality for students, no classroom talk would unfold; and if the reply turn were not also a reality for the teacher, no classroom talk unfold. Thus, claim |evidence | evaluation and burden of proof are social facts jointly produced by, and being reality for, teacher and students.

Our next fragment exhibits the difficulties to refute a claim when the evidence apparently supports it and, therefore, as the evidence is complexly intertwined with uncertainty. In Fragment 4, the burden of proof procedure is applied to the "cabbage" claim; the invitation to provide evidence | provision of evidence pattern is as it was before. Up until turn 4.12, all evidence and agreement turns are in support of the cabbage-related claim, when a query is offered up that questions the expertise of the respondents: "Have you ever opened up a cabbage and cut it?" (turn 4.12). Although the affirmative next turn articulates the similarity of the smells (turn 4.13), the next turn does not take it up but names all preceding reply turns to have been "guesses" (turn 4.14). That is, this turn constitutes an evaluation turn pair undermining the validity of all forms of evidence provided so far. Again, perhaps unsurprisingly, the original onion claim is offered as an alternative—even though it seemingly had been discarded. But that reappearance may not surprise, as studies have shown that even though certain forms of evidence are explicitly marked as illicit by a teacher turn, they may still be produced in the course of classroom talk (e.g., Roth and Thom 2009).

Fragment 4

	4.1	Teacher:	Why does it look like a cabbage?
E>	4.2	Cavin:	It does.
E>	4.3	John:	the seed.
	4.4	Teacher:	what part of it reminds you of a cabbage, do you wanna come show us?
E>	4.5	Cavin:	the outside part.
	4.6	Teacher:	the, the parts that peeled away, the leaves?

E>	4.7	Cavin:	yeah.
	4.8	Teacher:	okay. Yup?
C>	4.9	Sam:	I said it's like a cabbage.
	4.10	Teacher:	Does it smell like a cabbage?
E>	4.11	Sam:	yes, it does.
	4.12	Teacher:	does it? okay. Have you ever opened up a cabbage and cut it?
E>	4.13	Lee:	yeah it does smell like a cabbage.
	4.14	Teacher:	so . . . what are some ways we could test our guesses? What do you think?
C>	4.15	John:	hm, it's probably an onion because cabbages don't have ((*inaudible*)).

Turn 4.14 might have been an opportunity to move the dialogue toward the next step of argumentation, i.e., testing their claims. However, this turn was paired with reappearance of onion. The classroom talk appears to be back to square one. Following turn 4.15, we again observe claim | evidence | evaluation sequences as those described above, requesting and providing evidence concerning the claim that the mystery object is an onion. Some of the evidence is the same, others are new, such as there being a purple part that is a common attribute to onions and the mystery object. We can even observe a shifting of the responsibility of proof to the teacher. Thus, turn 4.25 questions and evaluates simultaneously the veracity of the affirmative "kind of" that asserted two attributes of the mystery object: smelling like an onion and making eyes water (turn 4.23). But the affirmative that follows (turn 4.26) now shifts the burden of proof to the previous speaker, who, as the transcription shows, comments on the relationship between evidence and claim (turn 4.27).

Fragment 4 Cont'd.

	4.23	Teacher:	Okay, but does it smell like an onion? ((*4 second pause. Cavin smelled the object but no answer*)) Does it make your eyes water like an onion?
E>	4.24	Cavin:	Kind of.
	4.25	Teacher:	Really?
E>	4.26	Cavin:	Yes!
E>	4.27	Teacher:	I'm not convinced. To me, it, if the evidence isn't showing me, isn't saying onion because it's not like any . . . unless it's a new kind of onion I've never seen. How could we test it?

Fragment 4 shows that even if the teacher had intended to undermine the claim that the mystery object was an onion, the very procedure employed in the requesting evidence | providing evidence may keep that claim alive. Because the science teacher is only part of the collective involved in the production of classroom talk, s/he does not have control over its trajectory. Thus, even if the teacher was convinced that the mystery object does not smell like an onion (turn 3.1) or cabbage (turn 4.10), an affirmative next turn produces a reality that the talk now has to deal with. The fragment also shows that there is a particular division of labor in the production of classroom talk, where the querying parts of turn sequences fall to or are taken up by the teacher, whereas the reply turns fall to the students. In fact, in situations where the nature of the speaker in a transcription is unknown, this pattern leads to the identification of the speaker taking the querying parts as someone in a teaching role—e.g., teacher in formal science settings or a guide in an informal science setting (Roth 2015).

The important dimension of the teacher participation lies in the fact that claim | evidence | evaluation sequences are jointly produced. The children participate in this production. In participating, they produce the entire form of argument because a response is diastatic, spreading across active receiving | replying: thinking begins by actively attending to what the speaker says and continuous during the production of the reply. That the response contains the argumentative form is seen in an expanded version of turn 4.24:

	4.23 Teacher:	[does it make your eyes water like an onion?
E>	4.24 Cavin:	does it make your eyes water like an onion?] Kind of.

In that turn 4.24, which features an entire response (Vološinov 1930) we already observe an argumentative pattern, which, here, *is* a relation between teacher and student. When what here constitutes the entire response is produced in the replay part, then it can and tends to be attributed to the speaker. In any case, as Vygotsky (1989) points out, what is attributed to the individual—i.e., the higher psychological function—has its genetic origin in and more importantly *as* a social relation. The present study shows the joint work that makes argumentation forms exist as relations. Our work leaves open the question how much of such classroom talk it takes before observing the argumentation forms in the *reply* part of responses. Indeed, some of the turns already include claim | evidence pairs (e.g., turn 2.10). Evidence provided in other studies (e.g., Roth and Thom 2009) suggests that after a few lessons, claim | evidence pairs may be produced by students in second grade even when the teacher is not present in an exchange.

Argumentation *as* social relation

This study was designed to investigate the emergence of argumentation patterns and burden of proof procedures through the dialogical lens of societal-historical approaches. We use as our empirical case materials from classroom sessions where second- and third-grade children are engaged in finding out the nature of a mystery object. The classroom talk produces claim | evidence and claim | evidence | evaluation sequence that most often are spread across multiple speakers but at time already are found in the statements individuals make. We observe the refutation of claims by means of evidence that did not match the claims. The evaluation of claim | evidence was evident throughout the turn-taking sequences. The burden of proof also appeared in the classroom talk. Instead of suggesting new evidence to refute a claim, a statement—articulated by some and heard by others—raised doubt and asked if dragon fruits had the parts that he was unsure about. Others come to be invited, by a shift in the burden of proof, to support the counter-claim with better evidence. This type of shifting the responsibilities of proving one's claim was shown when children found mismatching evidence or were the strength and validity of claim | evidence pairs are questioned. The teacher, given her experience, is particularly well placed to voice challenges inviting the production of more convincing evidence. Teacher-produced statements did not refute children-produced claims but instead, tended to raise doubt requiring and requested further evidence.

The patterns we describe constitute the production of a *social* phenomenon. It is observable as such. As pointed out, if experienced analysts are confronted with transcriptions that do not reveal the nature of the participants, the regularities in the turn

sequences allow attributing teacher and student roles to the different speakers (Roth 2015). Thus, the phenomenon we describe is independent of the particulars of these participants and their school; these participants, in a strong sense, *staff* the social phenomenon that is (a) observed and (b) produced to be observed by other participants.

The examples provided here exhibit the existence of argumentative patterns—claim | evidence and claim | evidence | evaluation sequences—*as* social relations. Because of the division of labor concerning the different parts of this sequence, they can be produced even in the absence of explicit teaching of TAP patterns observed in related research (e.g., Erduran et al. 2004). That is, just as children first speak and then learn grammar, our participants participate in argumentation before any teaching of argumentation pattern occurs. In fact, knowing argumentative patterns requires knowing to argument, because otherwise the teaching of the pattern could not be related to anything the children know.

Importantly, the patterns did not exist somehow mysteriously *in* social relations from where they had to be transferred into the mind of the child—a misinterpretation wrongfully attributed to Vygotsky, who actually writes that "any higher psychological function . . . was the social relation between two people" (Vygotskij 2005, p. 1021). The children in this study did not have formal instruction in argumentation in the way that those usually older ones in existing research. Instead, the assumption underlying the teaching was that argumentation first would exist as social relation. During their engagement with the task of identifying the nature of a mystery object, claims, counter-claims (thus disagreement), and evidence emerged. For one speaker to respond to another, the sound-words articulated by the first speaker also have to exist (in the ears) of the respondent. As a result, a response in which the replique provides evidence in support of a claim implies that the claim also exists for the respondent, and, therefore, that the claim | evidence sequence exists as a unit for the child. No mysterious transfer needs to occur from an inter-psychological to an intra-psychological plane; the intra-psychological plane already contains the more complex pattern as shown in our expanded transcriptions of the complete response, which includes what is actively received as well as the actual articulated reply. That is, children participate in argumentation before actually having learned argumentative patterns. The form of their relation *is* the higher psychological function of argumentation. In this study, we only observe the beginning of the emergence, as some statements already offer claim | evidence pairs simultaneously. One may anticipate, however, the emergence of more complex patterns once children are more familiar with engaging in the processing of evidence from their investigations until conclusions are reached collectively. "Everything" that might be considered internal and attributed to the individual "was necessarily once external" (Vygotskij 2005, p. 1021), that is, existed as an objective social fact.

The teacher told us about her intention to develop children's understanding of the importance of evidence in science. Thus, in Fragment 4 her turns include comments and raise questions concerning the role of evidence and how important it is for making scientific claims and doing science. The emphasis of evidence was deliberate and explicit throughout the study. In her science classes, she often talked to children about how "scientists look for evidence [because it] needs evidence." In this way, evidence-based argumentation comes to be embedded and exhibited in classroom talk. Yet, teaching and developing children's reasoning and argumentation skills through practicing

argumentation, the teacher also experienced the challenges of achieving the intended goals of content knowledge. Following the lessons, she talked about being frustrated that children did not give up the idea of onion even though she attempted several times. It was hoped that children would mention some kind of root as possible answer so that they could move onto the next unit of root and soil but the argumentation activity was not moving toward the intended curriculum. But the same scientific procedure that was to be taught also mitigated against a unilaterally determined path of the classroom talk.

The episode exhibits how complex it is to teach a new idea when the idea is not aligned with existing ideas. Teachers can directly explain children the knowledge in intended curriculum, however, to be truly taught and learned, it needs to be understood and accepted by children. Children did not accept the teacher's suggestion on the mystery object because it did not match with evidence. Until they evaluated and cleared confusion and conflicts among different pieces of evidence, any formal knowledge of missing evidence was not accepted and thus ignored. In typical classroom scenes, teachers explain the content knowledge and expect it "understood" by children. Yet, the episode of this study challenged the notion of learning and understanding in a deeper level. What if the teacher had given up the argumentation process and told them what it was not an onion but tulip bulb and moved on to the next curriculum goals? It is unknown what would be the learning outcomes from that course of action but we may assume that children were not completely understood why this onion looking object is not an onion. Yet, the teacher in this study continuously invited children in the production of argumentation, which they did accept.

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