Negotiating Uncertainty to Develop a Joint Deepening Focus in Knowledge Building Discourse

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Abstract: In open-ended and creative knowledge building communities, students engage in socially shared reasoning and discursive interaction to develop deep understanding of authentic problems related to the real world. Regulating a shared deepening focus in sustained knowledge building involves negotiating uncertainty as a space for potential idea generation and improvement. The research explores socio-cognitive and discourse practices in a class of fourth-graders studying light, whereby a shared space of epistemic objects is shaped, challenged and adapted leading to deeper conceptual explanations of the optical phenomena. Qualitative analysis of talk-in-interaction, online students notes and teacher's journal showed patterns of cognitive embodiment and uncertainty-oriented discursive practices to explain shared regulation of progressive knowledge building.

Introduction

In knowledge building communities, members engage in sustained knowledge building discourse by which they constantly improve and advance shared understandings. Students are required to take individual as well as collective responsibility for continually advancing the community's knowledge while identifying deeper problems and challenges (Scardamalia & Bereiter, 2014; Chan & van Aalst, 2018). As a critical component, researchers need to better understand how students develop a joint deepening focus to sustain their knowledge building discourse over time (Tao, Zhang & Huang, 2015). Building on existing research on socially shared regulation (Järvelä & Hadwin, 2013) and collective structuration of collaborative knowledge building (Zhang et al., 2018), this study intends to make a deeper dive to produce a micro-analytic view of the socio-cognitive and discursive practices by which members generate ideas mediated by embodied artifacts and monitor knowledge uncertainty to deepen their understanding.

The regulation of collaborative knowledge building is socially distributed and embedded, as it involves the creation and adaptation of ideational artifacts (theories, hypotheses, proofs, etc.) in the contexts in which knowledge building actions and interactions unfold. Shared regulation of knowledge building connects with Winn's (2003) framework of embodiment, embeddedness and adaptation, which theorizes learning as a mutual interaction with the students' intelligible environment in which their ideas are embedded. Ideational artifacts embody perception-based representations of the idiosyncratic view students hold of the real world (e.g. analogies, physical perceptions, sensory imagery), of how students see and understand the investigated problem. As these artifacts get progressively scrutinized, negotiated and adapted, students' knowledge advances. Their regulatory function lies in their unbounded capacity to generate questions (Cetina, 2001), trigger puzzlement thus affording opportunities for clarifications and negotiation of understanding. Underpinning knowledge advancement is an intentional and imaginative quest for sources of uncertainty about existing ideas (Ford & Forman, 2015) in dialogue with other peers. We interpret uncertainty as a space for idea generation and improvement embedded in knowledge building discourse, and shared regulation involves the monitoring and adaptation of this space in which embodied knowledge is challenged for deeper understanding. By engaging in dialogic discourse students unveil, negotiate and resolve uncertainty as they seek increasingly sophisticated understandings. This study examines how uncertainty-oriented discourse around embodied knowledge can characterize student regulation of a shared problem space in a 4th grade science class adopting knowledge building principles.

Method

The study analyzes the inquiry work of a class of 22 Grade 4 students aged 9-to-10 years old at the Dr. Eric Jackman Institute of Child Study Laboratory School in Toronto. Students engaged in the exploration of optical phenomena during a three-month period based on a knowledge building approach. This included the use of Knowledge Forum (Scardamalia & Bereiter, 2014), an online tool for recording ideas, theories and other inquiry activity in problem-based views (i.e. workspaces). The teacher acted as facilitator and co-learner throughout the inquiry work. He supported collective regulation of knowledge building by scaffolding students' progressive discourse both during face-to-face meetings and online. He encouraged students to formulate initial questions, write notes and carry on research and experiments to refine their theories and deepen their understanding. Prior

to this inquiry students had already used Knowledge Forum in grade 1 when they studied how animals' fur reflects or absorbs light depending on its color. Reviewing their online notes written at that time marked the onset of the light inquiry during the first whole class talk (see also Zhang & Sun, 2011).

To characterize the regulation of uncertainty in knowledge building discourse, we carried on a qualitative analysis of a set of data including audio recording of whole classroom discussions, small group dialogues and experiments. The analysis was extended to online artifacts in Knowledge Forum and records in the teacher's reflection journal. We applied a whole-to-part inductive approach (Derry et al., 2010) to first develop a macro representation of the whole inquiry and then zoom on some of the most meaningful excerpts of conversational episodes to unpack the conversational flow and analyze discursive features. At this lower grain of analysis, we progressively identified patterns associated with the concepts of embodied, embedded knowledge, and dialogic discourse practices of seeking and resolving uncertainty.

Findings

Students investigated the topic of light and its interaction with objects through various activities such as participating in small group and whole class discussions, searching for authoritative sources and carrying on self-designed experiments. Their inquiry work evolved throughout the three months leading to the creation of seven views in Knowledge Forum, each containing notes focused on newly identified or deeper problems of understanding related to optics. Three salient patterns were identified from the data analysis showing how the community developed and deepened its joint focus to sustain knowledge building over time.

Initiating a shared area of inquiry with embodied experiences and artifacts

During the whole class kick-off meeting, the teacher showed a view in an old database of Knowledge Forum created by the students in 1st grade. The view titled "Adaptive Weirdos" collected notes about how animals adapt to light. One note in particular containing a theory about grey fur reflecting light generated an interesting discussion around light and color reflection during which students contributed explanations using examples from their direct experience with the real world. The teacher reported, for example, that a student "made a connection to the black streaks worn by football players." The fact that it was snowing outside during the discussion occasioned a new emerging interest about the connection between snow and white in relation to light. As reported in the teacher's journal, "We asked the question if there was a reason why snow was white". The online notes were collected in a new view that the teacher created and called "Grey Fur and White Snow" in symbolic reference to the former theme in grade 1 and the emergent topic of color reflection. Bringing to the students' attention the existence of several notes in Knowledge Forum about "how black and white interact with heat", the teacher proposed this sub-topic as a new problem of understanding. Students started offering theories on whether black attracts heat or light bringing in examples of various objects.

The initial stage of problem inquiry was characterized by the development of ideas and explanations embodied in figures of speech and analogies (Table 1). By defining physical properties or explaining abstract concepts, these figurative arguments were used as a means to enter the problem space and get hold of an idea as "to solve a problem quickly" (Dunbar, 2000, p. 54).

Table 1: Examples of building knowledge using embodied experiences

Students discourse moves	Description of embodied knowledge
"Light is cold like the light reflected from the moon"	A figure of speech based on the student's direct perception of the moon light
"Black is like magnet, it absorbs heat"	An analogy explaining absorption as an attraction force
"What does black does with the light - absorbs like a sponge?"	Another figure of speech suggesting the idea of black as a porous material
"The moon is greyish white and we said that snow reflects light because it is white"	An implicit analogy suggesting that the moon reflects light like snow because of its greyish white color
"Cold in the night because the moon is sort of like mirror since heat travels from sun to moon and then to earth – a lot of heat is lost in travel"	A simile – the moon being like a mirror – followed by a visual imagery conveying the idea that heat is a physical entity losing intensity across space

Another example of embodied reasoning was the use of visual imagery in the form of perception-based and "intuitive functional explanations" (Hakkarainen, 2003):

Student	I can see ... the moon is kinda colder than the sun, it would get colder... if you went on to the moon with a space suit you wouldn't die, but if you went onto the sun with a space suit you would die.

The production of embodied ideational artifacts and the use of objects to think with provided an initial and yet incomplete or, at times, misconceived view of the phenomena in the real world. However, it appeared to have an important function in maintaining a shared focus by triggering curiosity and promoting further questioning. Underpinning subsequent steps of progressive inquiry was an intentional and purposeful search for uncertainty as a space within which these objects of knowledge could be refined and sharpened.

Seeking and negotiating uncertainty as a space for deepening understanding

After framing the initial questions and developing early explanations, students pursued their inquiry to find evidence, refine their ideas, and overcome misconceptions. Although their goal was to improve their theories, their emerging and transitional focus was on seeking uncertainty (gaps and problems) in those initial explanations, spotting something that could not be accounted for by their current theory, or introducing counter-hypotheses. Doubt and uncertainty created a space for further deepening their understanding.

Regulation of uncertainty involved the practice of questioning and challenging others' claims. Doing so required participants to direct attention and react coherently to one another's argument as shown in the turn sequence that follows, which occurred a few weeks after the discussion about light and heat absorption:

Student 1	You're saying that you need lights to um, to for the carpet to be green. But if it's green it does not um ah it's not like it changes color or anything.
Student 2	Well, it's without the lights; black through your eye is still green on the ground. You don't need the lights for it to be green. You need the light for it to be green to you, to your eyes.
Student 3	Well, you don't need the light to make the carpet green, you just need the lights to see that the carpet is green.
Student 1	Exactly, so how come everyone is saying that you need green light to make this carpet green (…).

In this episode students deepened their focus on light and color. In the first turn of the sequence the speaker paraphrased another member's claim, "You're saying that…" before noticing an anomaly in it, introduced by the discourse marker "But if…". In the subsequent two turns students 2 and 3 tried to address the puzzlement and refined the initial idea – they clarify that light is not as much needed for the carpet to *be* green rather to *appear* green to one's eyes – thus giving a stronger evidence for negotiating understanding. Student 1 wrapped up the sequence reiterating the former contradiction, as a way to validate that the explanation offered by students 2 and 3 was now satisfactory. Likewise, students purposefully gave voice to uncertainty in their own ideas challenging part of the content as in the following turn:

Student	If you, if this room was totally black, the carpet would still be green, the floor would still be that color but you wouldn't see it because there's no light to bounce off of it so you couldn't see the color. [Name] are you understanding, does that make any sense to you? Because it's not like a green light bounces off it so we can all see it, it's the lights that's um. *But how come you can't see it? Then how come when the lights are off…?*

Here the student first displayed how she understood the colors as being an intrinsic characteristic of objects, independent of the ability of seeing them when light is on. While articulating this explanation though, she raised uncertainties, monitoring her own understanding, as reflected in the last two questions.

Addressing uncertainty through socially embedded practices of inquiry

As uncertainty became a shared and accepted focus among peers, it encouraged adaptation of initial ideas by directing a greater attention to the chain of reasoning behind students' theories and by finding more refined grounds for their ideas. Carrying on experiments was one of the ways to respond to uncertainty. Theories about reflection and absorption of light and heat, for instance, were further tested through an experiment in the schoolyard to observe differences in how snow melted on a white and a black panel. Likewise, to address suspicion

about having green color contained in light, a student stood up, went to the chalkboard and drew a prism. Pointing to the ceiling light he explained that when the light shines through the prism it splits up into different colors thus helping his peers understand that light is made up of different colors.

Discussion

The present investigation sheds light on the role that imagery, uncertainty, and adaptation play in sustaining and regulating a joint deepening focus in collective inquiry. Findings illustrate that the use of embodied cognition is a central characteristic that shapes knowledge building discourse. Students developed, monitored and refined their understanding of abstract concepts such as light reflection and absorption by leveraging objects and experiences from the real world. Embodied representations of conceptual thinking served to maintain a shared focus in the moment-to-moment interaction and beyond through the online discussion in Knowledge Forum. Furthermore, students were encouraged to think and speak imaginatively and to dare exposing doubts or formulating tentative explanations in their knowledge advancement efforts. If learning is not about memorizing authoritative ideas or treating scientific knowledge as definitive conclusions (Ford & Forman, 2015), teaching should support dialogic discursive practices that promote uncertainty as a collaborative space for monitoring understanding, sparking further questions and prompting discernment through appropriate scaffolds during class and online dialogues. A deeper analysis of classroom videos, online notes and teacher's journal is under way to further understand how patterns of shared regulation evolve from shorter to longer timescales of activity.

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Acknowledgements

This research was sponsored by National Science Foundation (#1441479). The views expressed in this article are those of the authors and do not necessarily reflect the views of the funding agency. We thank the teachers and students at Dr. Eric Jackman Institute of Child Study for their creative work enabling this research.