

# Tracing the Inquiry of an Opportunistic Group in a Grade 5 Knowledge Building Community

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**Abstract:** This study investigates how a line of specialized inquiry was initiated and developed over time in a fifth-grade science knowledge building community featuring opportunistic collaboration. Specifically, this study examines the initiation and deepening of the inquiry on vision and eyes, which involved three core inquirers and 18 other contributors. Drawing on multiple data sources including audio recordings of classroom discussions, field notes, students' notebooks, online posts, and interviews, the qualitative analysis traced advances in four emergent inquiry threads related to eyes and revealed essential processes sustaining opportunistic collaboration and interactions.

**Keywords:** knowledge building, opportunistic collaboration, student-directed inquiry

## Introduction

To address the society's need of a citizenry who can create and work productively with knowledge, various inquiry-based collaborative learning programs have been developed (Barron & Darling-Hammond, 2008). Designs to scaffold inquiry and collaboration often adopt a prescriptive approach that uses pre-designed sequences of inquiry topics, tasks/sub-tasks, and activity steps to structure student inquiry. Responsibilities for different components are further assigned to different small-groups that are fixed for the duration of an inquiry. Scripts are provided to specify what need to be done, by whom, in what ways and formats, and by when. This prescriptive approach is effective for relative short inquiry activities to be conducted by students new to inquiry learning over a few lesson hours. But it becomes problematic when the focus is on fostering long-term, sustained, collaborative inquiry in established knowledge building communities in which the inquiry goals and sub-goals, processes, responsibilities, and interactions are largely emergent. In real-world communities that engage in sustained, authentic knowledge creation, members engage in emergent and opportunistic interactions that are largely self-organizing (Gloor, 2006). Therefore, knowledge organizations need to develop organic, adaptive structures that encourage collective responsibility, distributed control, and emergent collaboration (Gloor, 2006; Williams & Yang, 1999).

To explore dynamic classroom configurations for sustained knowledge building, our recent research developed a principle-based, adaptive structuration approach that engages students' high-level agency for structuring shared knowledge goals, processes, and participatory structures to sustain deep inquiry and knowledge building (Author et al., 2011, 2015). For example, a three-year design experiment was conducted in a Grade 4 classroom (Author et al., 2009). Students of each year worked as a knowledge building community to study light using Knowledge Forum: a collaborative online environment for knowledge building (Scardamalia & Bereiter, 2006). The results demonstrated increasingly effective collaboration and knowledge advancement corresponding to three designs: fixed specialized-groups in Year 1, interacting-groups in Year 2, and opportunistic collaboration in Year 3. In opportunistic collaboration, apart from assuming the collective cognitive responsibility (Scardamalia, 2002) of identifying problems and gaps, planning what to do, and monitoring their progress., students chose whom to work with and for how long at their own discretions to address the emergent needs of inquiry in their community. Small groups formed, disbanded, and re-grouped, and whole-class conversations convened, at the volition of students based on perceived needs. Among these three designs, opportunistic collaboration resulted in most productive advancement in understanding a wide range of optical concepts and broad diffusion of knowledge among students beyond their own focal interest of inquiry (Author et al., 2007; 2009). Later research conducted by other researchers confirmed the benefits of opportunistic collaboration in generating deep questions and ideas (Siqin, van Aalst, & Chu, 2015). However, further research is needed to shed light on the specific mechanisms and processes of knowledge building through opportunistic collaboration and on the strategies to foster sustained productive interactions (Author et al., 2009; Siqin et al., 2015). To address this need, this research analyzes rich classroom data to understand how students develop sustained inquiry and understand emergent interactions in a knowledge building community featuring opportunistic collaboration. Specifically, we look into the development of an opportunistic group that initiated and deepened a specific line of inquiry, "how do we see", in a fifth-grade science classroom that studied human body systems. Our research question asks: How was this line of inquiry initiated, deepened and sustained over time through students' spontaneous interactions without extensive pre-scripting by the teacher?

## Method

### Classroom Context and Participants

This study was conducted in a fifth-grade science classroom with 22 students (11 boys and 11 girls) from diverse ethnic backgrounds. The teacher had over ten years of teaching experience, and was in her third year of teaching science using knowledge building pedagogy and Knowledge Forum (KF, Scardamalia & Bereiter, 2006). Following knowledge building processes, the students investigated human body systems using KF over a whole school year, with two science lessons in each week. The inquiry began in mid-September, 2015 with a kick-off event during which students participated in outdoor activities that required students to use certain body parts to achieve challenging goals. Students then shared their reflections and questions about the human body, which was identified as the focus of their science learning. The inquiry process then unfolded based on student-generated questions and ideas that gave rise to shared inquiry directions. Specifically, students participated in a whole class meeting to share their individual questions and ideas, reflect on connections, and formulate an initial list of collective wonderings (e.g. how do we see?). Each student identified a wondering area as his/her initial primary focus while having the freedom to contribute to other inquiry areas, initiate new inquiry areas, and collaborate with any peer as needed. Their learning activities in class included reflective book-reading or video-watching, group and whole-class discussions, crafting models, doing demonstrations, making presentations, and so forth. On KF, students engaged in continual asynchronous discourse to share new understandings and questions. Deeper questions were generated as progress was made, leading to the advancements of the existing lines of inquiry as well as formulation of new wondering areas (e.g. how DNA works and how cancers develop). To facilitate knowledge sharing and idea building across various theme-based areas, whole class meetings were organized for students to share their knowledge, advances and problems of understanding, to connect ideas on different body systems, and to identify deeper goals for further research. A culminating event was conducted for students to share their journeys of thinking with their classmates as well as students from three parallel classrooms. During the inquiry, students were encouraged to spot the edge of their knowing, engage in various inquiry activities advancing understanding, and share their knowledge within the whole community. Throughout the year, groups emerged and dissolved spontaneously based on individual choices and the community's needs. The teacher acted as a fellow co-learner and facilitator. She assisted students in generating inquiry progresses, making connections with other inquiry areas, planning for future research and so on. To provide a detailed account of the interactive knowledge building processes in this community featuring opportunistic collaboration, this study zoomed into a specific line of inquiry focusing on how people see, which had productive questions and ideas.

### Data Sources and Analysis

The first author acted as a participant observer (Creswell, 2013) in the classroom to trace students' knowledge building work as a community over a whole school year, with a rich set of data collected. Based on the observations of the classroom and online discourses, we identified the vision inquiry as a "telling case" (Mitchell, 1984) because it involved productive contributions over an extended time period, with rich face-to-face interactions documented. Four students—referred to as A, B, C, D—formally identified eyes as their primary focus of inquiry. Among them, A, B, and C emerged to be the core inquirers. A and B contributed the most to the eyes inquiry and collaborated most intensively; C contributed moderately and sometimes worked with A and B forming a triad; D seldom worked with the other three students and mostly contributed to this inquiry on KF. A total of 17 other students whose primary focuses were on other areas made occasional contributions to the inquiry of eyes, in class or on KF.

Our data sources included classroom observation notes, audio recordings relevant to the inquiry of eyes, posts in the KF view of Eyes, the four eyes inquirers' personal notebooks, slideshow about eyes created by the triad, and interviews with student A, B and C. The individual student interview was conducted at the end of the human body study focusing on their experience with the collaborative inquiry. The audio recordings of the classroom discussion and interviews were fully transcribed. The data analysis included two phases: first to construct a whole picture of the eye inquiry and, then, to zoom into selected productive inquiry threads to understand the specific processes and patterns of interactions. To construct a whole picture of the eye inquiry, the first author browsed classroom observation notes and audio transcriptions, identified and chronically organized the critical events related to the eyes inquiry. She then read the transcriptions and students' KF posts over and over, coded the inquiry focuses and summarized them as five salient themes of inquiry (see Table 1). These themes were further validated through checking students' notebook entries and slides. Using Idea Thread Mapper, a collective discourse mapping tool (Author et al., 2015), we mapped posts addressing each of the themes as an idea thread extending from the earliest to the latest discourse entry (Author et al., 2007), showing an overall picture of the eyes inquiry on KF. To further explore the nature of KF notes, we coded KF notes based on content analysis (Chi, 1997). Considering both

classroom and KF data, the students' inquiry of eyes mostly focused on the following themes or subthemes: (1) brain-eye connection, (2) image formation at eye level, and (3) eye parts and functions, which includes two sub-foci investigating (3a) pupils and (3b) red cones. Therefore, a more detailed analysis was conducted to depict the development of the students' inquiry on these themes/subthemes. Using each of these themes/subthemes as a "tracer" (Roth, 1996), we traced student interactions and contributions related to each theme/subtheme over time as reflected in different sources of data and used a narrative approach to generate a thick description (Greetz, 1973) about how each inquiry thread was sustained and deepened. To triangulate and validate data analyses, we examined the interview data pertinent to the interviewees' reflections on their inquiry of eyes.

Table 1. Salient Inquiry Themes about Eyes Captured in Various Data Sources

Theme	Specific issues	Example (minor spelling errors have been corrected)
1. Brain-eye connection	The physical and functional connection between brain and eye; brain-related visual problems.	"You can see because certain part of the brain helps you see and if that part is damaged you can go blind. Also you have a part of your eye that helps the brain form a picture." [KF] "Light sensing cells give your brain messages. Your brain probably sends back (messages), so your eyes now how to react." [notebook]
2. Image formation at eye level	Visual acuity; location and function of relevant parts (lens, cornea and retina); visual acuity problems caused by optical reasons.	"Why do people wear glasses?" [KF] "B: Sometimes when kids are born, their eyes are shaped in different way, shaped in more oval. And it kind of like, I cannot think of the word for it, just like, it makes their vision little different. A: And I think objects appear blurry. B: Like this [showing a picture in the book] and I think it's called astigmatism." [Transcription]
3. Eye parts and functions	Eye parts; location, function and feature of pupil, iris, rod and cone; colorblindness; sty.	"There are multiple parts of the eyes like the pupil, the iris, the lens, the fovea, the macula, the optic nerve, cornea, sclera, and the conjunctiva and there are many more parts of the eyes than I thought" [KF] "The color of your iris is determined by melanin and OQ2. Melanin is the protein that produces skin, iris, and hair color." [notebook & slideshow]
4. Tears	Eyes watering	"ST: you guys might think crying is bad for you. But actually it's good for you...When you get allergies, your eyes get really dry. Then what I did is, I just thought about something sad...I started crying...and then it's like, 'ok, I think I'm better now.'" [Transcription]
5. Blindness	Severe vision loss	"Blindness can be caused by the cataract" [notebook]

## Results

### Understand the Whole Picture of the Eye Inquiry

In the first week of the human body inquiry, student A, B and several other students were interested in how the brain controls the human body. A and B were friends and they worked together from the very beginning. On September 22, when reading a book about the brain, they saw an illustration of the brain regions and their functions. Noticing that the vision center was in the back, B became puzzled about how the back of the brain was connected to and controlled eyes. Considering that brain was a fairly complex organ connected to various human body parts, eyes were identified as an accessible starting point for inquiry, marking the unofficial beginning of the eyes inquiry. In another lesson, C overheard A and B's discussion and shared her eyes-related reading. Shortly afterwards, C joined A and B in their inquiry of eyes. Hence, this inquiry group was first expanded through unplanned idea contacts with other students who showed similar inquiry interests. On September 29, the community discussed how the student-generated questions related to one another and formed collective areas of wondering, with eyes identified as one of the wondering areas. Each student indicated his/her primary interest on the list and those with shared primary interests co-generated an overarching question as the focus of their inquiry. In addition to A, B, and C, student D also indicated an interest in eyes. With the teacher's help, A, B, C and D named their area of inquiry "How do we see?" or "eyes" for short. The eyes group was thus expanded and "formalized" through the community's practice to cluster individual students' interests around collective wonderings. Even though students formed groups with different inquiry concentrations, they were encouraged to collaboratively advance the whole inquiry of human body

regardless of their primary concentrations and to build connections across various lines of inquiry. After this lesson, a set of KF views (workspaces) was created based on the list of collective wonderings so that the students could collaboratively work on each line of inquiry, including the inquiry of eyes. During their subsequent learning, A and B collaborated consistently; C sometimes studied with the dyad; D rarely communicated with the rest of the group and joined some other students in the inquiry of brain at a later point. Over time, the eyes inquirers built understanding about brain-eye connection, image formation at eye level, eye parts and function, tears, and blindness. They shared questions and ideas within and beyond the inquiry group in class and on KF that was accessible to all students. Students focusing on other inquiry areas worked with the eyes inquirers occasionally, and read and posted their questions and ideas on KF. In November, feeling that they had learned a lot, the eyes inquirers proposed to lead a whole class meeting. On November 13, in a whole class meeting themed “eyes,” A, B and C shared their knowledge and ideas, and other students actively participated in the discussion. The triad continued the eyes inquiry after the meeting and created a slideshow about eyes that was shared on KF. Based on their inquiry on the brain-eye connection, these three students wanted to learn more about the brain. Considering that the topic was huge, they decided to focus on a specific brain-related issue: dream.

On the KF view of Eyes, a total of 60 notes were contributed by 16 students and the teacher. The teacher posted four notes, suggesting how to name a note, prompting note-writers to construct personal understanding and facilitating the eyes inquirers to plan their future learning. Student A, B and C collaboratively wrote two summary notes reviewing their knowledge about eyes and helpful learning resources. The rest 54 notes were interactive discussions. These discussion notes were first coded based on the five salient inquiry themes, then they were analyzed based on content. Figure 1 shows the temporal distribution of the notes addressing each theme, as an idea thread. Most of the notes (80%) were posted before the whole class meeting in mid-November. While 13 (24%) of the notes were generated by the four “official” members of the eyes inquiry group, 41 (76%) were created by others (12 students) whose primary inquiry concentrations were on brain, digestion, breathing/lungs, and left-handedness, etc. On the KF view of Eyes, 21 students participated in reading notes, with each note read by an average of nine students excluding its author. As for content, Table 2 shows that students posted discussion notes mostly to pose explanatory questions (23%), to respond to peers’ questions (34%), and to share knowledge (30%). Explanatory questions and references came from students’ existing or newly-learned knowledge. And they actively addressed peers’ questions with brief or elaborated responses.

Table 2. Content analysis of students’ fifty-four discussion notes on Knowledge Forum

Categories	Sub-categories and/or defining features	Examples (minor spelling errors have been corrected)	Count
<i>Factual questions</i>	Questions to be answered with factual information or “yes/no”.	“[I need to understand] What muscles are in the eyes?”	4
<i>Explanatory questions</i>	<i>Experience-based:</i> Questions asked based on personal experience	“What happens when you don't blink and your eyes get blurry? Why does it do that and how?”	7
	<i>Knowledge-based:</i> Questions asked based on knowledge acquired from peers or external sources	“How do the eyes connect to the brain?” “What are eye sockets important for?”	6
<i>Explanations</i>	Simple: Answers directly addressing a question	“Eyeglasses have clear lenses so you can see clearer.”	11
	Elaborated: Answers involving mechanism or process.	“[My theory] is that - I think that we need to get glasses because probably some of your eye pupils could get broken up or not staying in the right spot so when you get glasses the light would reflect on the lens of your glasses and that would shine on your eyes so the pupils see better.”	8
<i>References</i>	<i>Experience-based:</i> Descriptions of personal experiences	“Glasses are very helpful to your eyes” (posted by a student wearing eye glasses)	3
	<i>Knowledge-based:</i> Descriptions of knowledge from external resources	“Inside your eye is a lens like the lens in a camera. Its job is to focus light”	14
<i>Social comments</i>	Emotional expressions	“Wow, thank you. I didn't know that...”	3

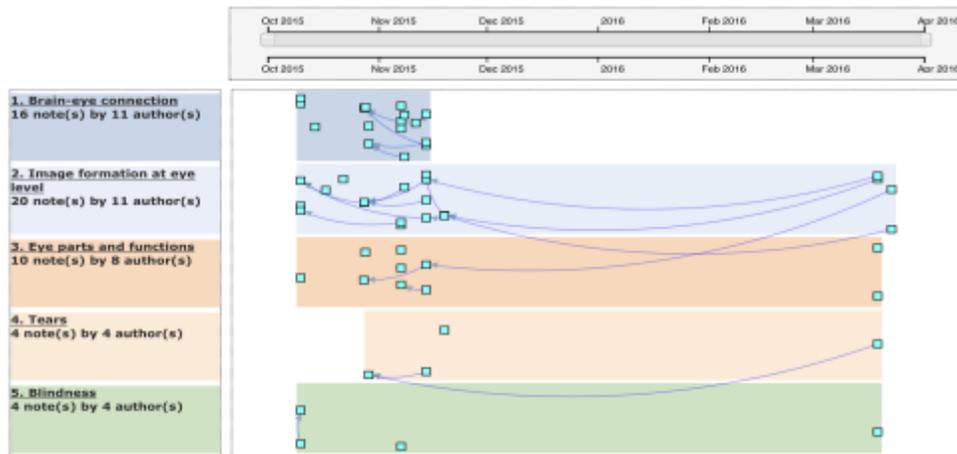


Figure 1. Five idea threads developed in the online discourse.

### An Elaborated Account of Initiation and Advancement of the Eye Inquiry

For deeper analysis of how the eyes inquiry was deepened and sustained, we traced the students' inquiry on the first three themes, with # 3 further elaborated as two subthemes (pupils and red cones). Figure 2 shows major activities and progressions of the inquirers' understanding about these themes or subthemes. Each knowledge building thread began as and was driven by a student-generated question.

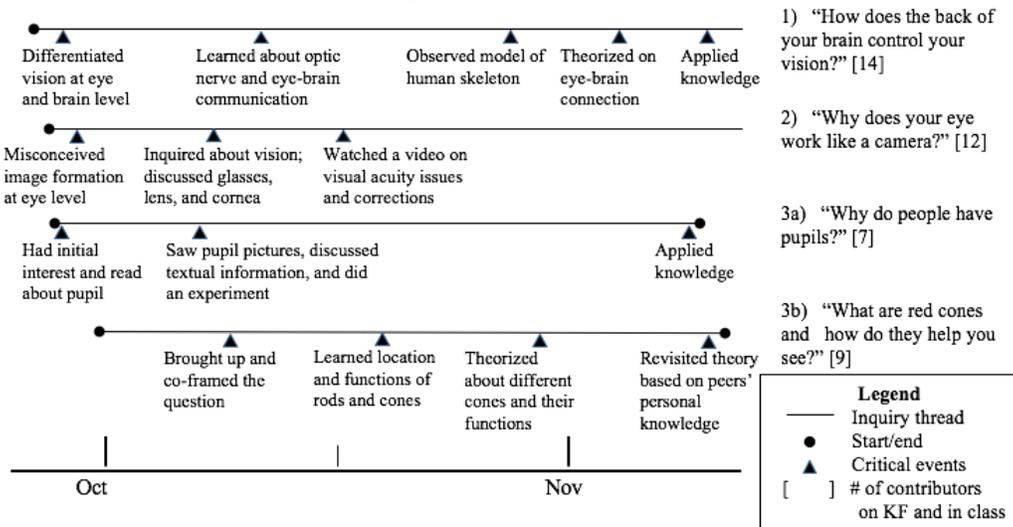


Figure 2. Tracing key activities and progressions of the students' understanding about brain-eye connection, image formation at eye level, pupils and red cones.

The analysis suggests that the inquiry of eyes was sustained by generating progressive questions and ideas about the underlying mechanisms, engaging in various student-crafted inquiry activities (e.g., reflective reading, doing experiments, making observations), and learning from and with fellow inquirers whose primary inquiry focus may or may not be eyes. To meet the criterion about paper length, here we include an elaborated account of the development of the first inquiry thread only.

#### 1) "How does the back of your brain control your vision?"

From a book about brain, A and B accidentally learned that the back of the brain was the vision center. B wondered about the connection and the dyad co-defined the question: "How does the back of your brain control your vision?" Initially they continued reading the brain book hoping to find an answer. Unable to find any helpful information, student A made a guess about the physical connection between eyes and brain, saying:

“You know how guts are, just like one long line, like veins. The brain is pretty much like that except that it is rolled up into that shape. So, I guess, it (vision center) just connects all the way (to eyes) ... that little line [referring to eye muscles in a diagram] just goes all the way.”

The students conducted research using books, magazines and Websites. All the students in the eyes inquiry group, including D who joined in the brain inquiry group at some point, built new knowledge as seen in their discussions, personal notebooks and KF posts. The data documented their understandings that eyes and brain are functionally connected in terms of image perception (images are upside down at eye level but are upright at brain level) and information flow (photoreceptors receive light messages and send the information to vision center via optic nerves; brain sends messages back to eyes likewise to control eyes). In addition, the eyes inquirers differentiated the functions of eye and brain in vision as the former helped form raw images while the latter helped a person be aware of the images. During the whole class meeting on November 13, drawing upon such understandings, A responded to interesting questions and phenomena brought up by student E (whose focus was on digestion) and F (whose focus was on brain). Specifically, E asked why eyes automatically closed when someone was sleepy or tired, and A answered that maybe brain sent the tiredness signals to eyes through optic nerves. F asked about causes of illusion, A responded by differentiating what one saw at eye level and at brain level. Student G (from the brain group) built on this point saying that concussion involving damage of visual cortex might lead to illusion. About the physical eyes-brain connection, student A and B first learned that the shape of eye balls matched that of our skull. Upon knowing this, they touched their eye frames, rolled their eyes to see the edges of their eye frames and shared this piece of knowledge with the students who were sitting nearby. When a model of human skeleton was brought to the classroom, A, B, C and a few others observed the little holes in the back of the eye sockets. By integrating their knowledge and observation, the students thought that optic nerves went through the holes to connect to the brain. On November 6, the first author asked the eyes inquirers about the neural pathways through which optic nerves sent messages to visual cortex. Student B initially thought that information from two eyes was sent back separately and merged at the vision center. Noticing that she saw the same thing in her focus with either and both eyes, she revised her idea and thought that the messages from two eyes merged somewhere and was sent back together. When creating the slideshow, the students found a diagram showing the neural pathways, with which B revisited her idea. Students' KF discussion mostly corresponded to their inquiry in class. Nonetheless, some ideas were brought up only on KF. For instance, student H (from the digestion group) shared that brain controlled eye movements; J (from the brain group) wrote a note stating that some eye parts helped brain form pictures and that damage of the visual region might cause blindness.

## Discussion

Expanding findings from prior research (Author et al., 2009; Siqin et al., 2015), this study closely investigated the unfolding process of a specific line of inquiry in a fifth-grade knowledge building community characterized by opportunistic collaboration. The inquiry first emerged based on a few individual's interests. Then students with common interests got together and co-generated an overarching explanatory question (how do we see?) to guide their subsequent collaborative learning. Meantime, the community formally admitted the inquiry topic as one of the collective wondering areas by featuring it in classroom artifacts (e.g. the collective wondering list) and in online space (i.e. the KF view of Eyes), calling upon more students' participation. The overarching question offered a clear yet open-ended direction for an unfolding development of understanding, as it led to inquiries into five eyes-related sub-areas that deeply engaged members of the group as well as students from other inquiry groups. This was achieved because this inquiry was situated in a knowledge building community where each member was expected to focus on a specific topic related to human body for a span of time and yet everyone was accountable for teaching and learning from each other by sharing knowledge and productive practices, and by building upon each other's knowledge and ideas. On Knowledge Forum and during in class discussions students contributed to the advancement of the inquiry by bringing in and making their questions, ideas and knowledge public. As the students continuously identified more issues to be understood, what this inquiry entailed was progressively expanded. Novel and potentially productive sub-areas of inquiry were discovered by the inquirers actively raising questions that reflected their knowledge gaps. In subsequent learning, the goal of improving their understanding on the newly-recognized issues directed the inquirers, particularly the core inquirers, to get engaged in various purposeful learning activities. During the core inquirers' learning, a recurring pattern was that the students constantly examined multiple learning materials about the same topic and took part in exchanges co-reflecting what they had learned, through which they incrementally built up their understandings. Over time, rising above understandings of specific issues, the students drew connections and generated complex understandings about their overarching question.

The students participated in and contributed to the advancement of the eyes inquiry for different lengths of time, in face-to-face or online settings, and in varying forms. Among the core members of the eyes inquiry group, existing social ties and recognition of shared interests contributed to spontaneous collaboration; the community's practice of grouping based on shared wondering areas supported collaboration among students with relatively weak social ties. The eyes inquirers' group- or subgroup-level collaboration was sustained through various forms of shared activities, which in return reinforced their social connections and common interests. Although it was unclear why D switched group, during the interview C revealed that the absence of shared activities with A and B (who continuously studied together) weakened her social ties with them and that the deficiency of social connectedness and a lack of interest eventually led to her leaving the group. During small group learning and discussions, the inquirers shared their questions, ideas, knowledge, personal experiences and learning resources. At the same time, they collaboratively constructed understanding by building onto each other's input to examine and refine ideas, ask deeper questions, and provide constructive critiques. Beyond the core inquirers, the eyes inquiry benefited from other inquirers' ongoing participation and contributions. Such broader collaboration occurred through engagement in asynchronous online discourse, synchronous class meetings during which students share ideas and progresses, and informal in-class talks and resources sharing. The core and the rest inquirers of eyes benefited each other by spreading knowledge and ideas, sharing practices, and actively making connections to peers' inquiry. While the online space enabled students to participate in the eyes inquiry over a span of time, class meetings enabled intensive idea exchange and knowledge building. During KF and in class discourses, students focusing on other inquiry areas actively posed questions to ask for clarifications or explanations about unaddressed eyes-related phenomena. To respond to such questions, the core inquirers revisited their knowledge or used what they knew to make sense of the phenomena, thus strengthening or deepening their understanding. In the next step, we plan to systematically code and perhaps create models to characterize the mechanisms of the sustained development of the inquiry. We also plan to more systematically analyze the interactive moves made by the core inquirers and by the other students in the classroom and online to generate insights in how students interacted within and beyond the eyes inquiry. Hopefully these analyses could be added to the paper before KBSI takes place.

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