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ORIGINAL ARTICLE

Funneling Versus Focusing: When Talk, Tasks, and Tools Work Together to Support Students' Collective Sensemaking

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ABSTRACT

Rigorous and responsive science teaching is based on supporting all students in making progress in their understanding of important science ideas over time. In this article, we explore how did classroom talk patterns of funneling and focusing support student sensemaking. We share how talk, tasks, and tools within classroom activity work together to either funnel students toward reproducing normative scientific answers or focus students on deepening their understanding about unobservable causal mechanisms of phenomena. We use classroom examples from two science lessons where students used data to describe and communicate about how and why stars change over time. By recognizing these funneling and focusing patterns in classroom activity, teachers can attend to and modify the talk, tasks, and tools to improve and support opportunities for students' sensemaking about important science ideas while they make progress on revising their own ideas over time.

KEY WORDS: Classroom talk; secondary schools; responsive teaching; phenomena-based teaching

INTRODUCTION

Rigorous and responsive science teaching is based on supporting all students in making progress in their understanding of important science ideas over time (Thompson et al., 2016). This happens when teachers are responsive to the substance of student thinking, treating students' ideas as legitimate resources and structuring opportunities for the class to build on, reason with, and revise these ideas over time in light of new evidence and information. In this article, we explore the following research question: How do classroom talk patterns of funneling and focusing support student sensemaking? We share how talk, tasks, and tools within classroom activity work together to either funnel students toward reproducing normative scientific answers or focus students on deepening their understanding about unobservable causal mechanisms of phenomena (Herbel-Eisenmann and Breyfogle, 2005; Franke and Kazemi, 2001; Osborne et al., 2004; Sohmer et al., 2009; and Wood, 1998).

We use classroom examples from two 9th grade integrated science lessons during their astronomy units where students used data to describe and communicate about how and why stars change over time (Thompson et al., 2016). The focus of this article is not specifically on the teaching and learning of astronomy; rather the emphasis is on how students make sense of scientific ideas in classroom activity. With this broad focus, ideas from this study can be applied across science domains. Furthermore, by recognizing these funneling and focusing patterns in classroom activity, teachers can attend to and modify the talk, tasks, and tools to improve and support opportunities for students' sensemaking about important science ideas while they make progress on revising their own ideas over time.

LITERATURE REVIEW

Funneling Versus Focusing: What is Happening with Ideas?

Funneling and focusing patterns in classroom activity are distinguished by examining what is going on with ideas. Which ideas are prioritized and legitimized? How are ideas treated by the community? Funneling and focusing are more than just a set of discursive moves; they are practices embedded in larger activity system frameworks. We unpack these activity systems below by contrasting the object of work (Braaten and Windschitl, 2011), the role of the teachers and students, and nature of the talk, task, and tools (Engle and Conant, 2002; Leinhardt and Steele, 2005; Herrenkohl et al., 1999; Mercer, 2008; Sohmer et al., 2009; and Thompson et al., 2016). The object of work for funneling is to have students reproduce an idea, or provide the correct answer based on the teachers' or textbooks' explanation of a scientific phenomenon. Focusing functions to support students in constructing meaningful explanations based on collective ideas and ways of reasoning with a scientific phenomenon. By necessity, focusing requires that the teacher and other students hear more ideas about how others are processing ideas, thus allowing for new connections among ideas and the development of multiple productive variations for a scientific explanation.

Funneling Students' Ideas

Funneling privileges science knowledge over students' ideas (Herbel-Eisenmann and Breyfogle, 2005). Talk, tasks, and tools are designed to reinforce reproducing facts and explanations by treating science as a static, final-form body of knowledge. A telltale sign of funneling is that all students provide nearly identical responses in a discussion or on an assignment. In our study, analyzing rigor and responsiveness in 222 science lessons in 37 secondary science classrooms, we observed that when funneling occurred, it limited what students did, missing out on opportunities for potentially rigorous interactions, and resulting in low-rigor, low-responsiveness, and fact-driven classroom episodes (Thompson et al., 2016).

Focusing Students' Ideas

On the other hand, focusing patterns emphasize working on students' ideas as the goal (Herbel-Eisenmann and Breyfogle, 2005). The community treats student ideas as resources for collective reasoning and inquiry (Engle and Conant, 2002; Leinhardt and Steele, 2005; Herrenkohl et al., 1999; and Thompson et al., 2016). By necessity, focusing requires that everyone be responsive to the ideas that are in-play by listening to how others are processing and understanding and making connections and comparisons between ideas. Focusing results in students developing productive variations of the scientific explanation for a given phenomenon. We found that focusing was associated with students' engagement in more rigorous interactions that were responsive to and explicitly worked with and on students' understanding (Thompson et al., 2016). Students demonstrated active listening, adding onto and challenging one another's ideas, and pressing for "how and why" levels of explanations for real-world scientific phenomena. Table 1 summarizes how patterns of funneling and focusing play out within talk, tasks, and tools in classroom activity.

METHODOLOGY

Data featured in this study is a subset of data from a larger study (Thompson et al., 2016). For the larger study, data were collected from multiple secondary schools across 222 science lessons taught by 37 secondary science teachers. Data collection included classroom observations and student and teacher artifacts (Merriam, 2009; Yin, 2009). Classroom observations consisted of transcribing all classroom discourse. A subset of data that focused on how student ideas in classroom talk, tasks, and tools were used to deepen their understanding about unobservable causal mechanisms of phenomena. Using multiple case study methods, data analysis consisted of coding classroom talk for teacher responsiveness to students' science ideas and level of scientific rigor reached by students (Thompson et al., 2016; Yin, 2009). Data analysis revealed two themes of directing students toward reproducing normative science ideas and working with students' ideas to press for deep levels of explanation of real-world phenomena.

Table 1: Describing funneling and focusing patterns with talk, tasks, and tools

Funneling pattern	Focusing pattern
What it looks/sounds like: Students reproduce an idea or provide a correct answer based on the teachers' or textbooks' explanation. Multiple students participate but not in ways that connect, build, or revise ideas	What it looks/sounds like: Students communicate and compare their ideas to advance understanding of key science ideas. Multiple students contribute to constructing/revising explanations of an intentionally selected phenomenon
Talk	
Talk aimed at a "right answer" where there is only one acceptable response to a question. Teacher may revoice, restate, or even ask follow-up questions, but no attempts made or taken up to bring ideas together or highlight disagreements for resolution 9th grade Astronomy example: Students each shared properties of light to the group. Responses were evaluated/recognized by the teacher. Talk was in support of the task purpose (i.e., listing properties)	Purposeful talk with elaborating, questioning, and reorganizing of ideas is the goal. Students' ideas are uncompromisingly treated as intellectual resources. Talk is used as a way for students to voice their understanding and work on it with others. The goal of the talk is to make progress on ideas 9th grade Astronomy example: Students compared and built on/off ideas about causal factors for star formation. Multiple student contributions moved the conversation forward to explain star birth (the task)
Tasks	
Task stands alone. No attempts to make connections between activities and/or real-world events. Task is used to demonstrate a scientific principle or "proof of concept," and not an opportunity for student sensemaking. Student ideas treated as answers 9th grade Astronomy example: Students created a list of the properties of light from stars	Complex and content-rich tasks support student learning about science ideas. Multiple tasks fit together like puzzle pieces to support students' evolving understanding. Student ideas are surfaced in tasks and treated as resources for reasoning 9th grade Astronomy example: Students observed photos from a star cycle and explained how stars formed
Tools	
Handouts are resources but do not function as tools. They emphasize procedural steps for task completion, funneling toward normative, and singular responses 9th grade Astronomy example: Data on star luminosity, apparent brightness, and distance (did not help students analyze, interpret, make claims. Therefore, data were a necessary resource, but not a tool)	Tools are structures and scaffolds that help all students engage in the intellectual work required of the task and talk. Tools decompose and make explicit the demands of scientific practices required within the task 9th grade Astronomy example: Three-part scaffold with prompts, plus a checklist helped students articulate levels of depth in their explanations of star birth

FINDINGS

Funneling Example: Listing and Evaluating Individual Contributions

Funneling patterns direct students toward reproducing an accepted idea or providing correct answers based on the teachers' or textbooks' explanation of a scientific phenomenon. At times this most recognizably manifests in an IRE (initiate, evaluate, and respond) pattern of talk where the teacher initiates (What process within the Sun releases energy?), a student responds (nuclear fusion), and the teacher evaluates (good). However, in our study, we found funneling was often subtler, like in the following example.

In the following example (Table 2), 9th-grade students were learning about light waves from stars by finding evidence for the inverse square relationship between star luminosity and apparent brightness. The teacher tasked students to create a list describing properties of light waves from stars (e.g. bright stars have more energy). Students used textbooks and their data table from luminosity and apparent brightness investigation. The following excerpt (Table 2) opens with the teacher asking a small group of students to consider which items on their list were most important to studying star evolution. However, the conversation soon shifts to naming terms (initiated by a student) and naming a correlation (introduced by the teacher). In addition, notice how the teacher rotated around to each student individually, evaluating responses (lines 14, 18), yet there was no discussion of ideas between students or prompts to have students compare their lists of wave properties.

The teacher made sure each student contributed a response, yet these were treated as distinct and separate ideas ("all lights travel with the same speed, but with different amounts of energy," "apparent brightness is affected by distance and luminosity," and "color is energy"). Nothing in the talk, tasks, or tools supported students in doing anything more with these ideas, so this episode missed potentially fruitful opportunities for students to collectively reason and deepen their scientific explanations about important science ideas. Instead, talk was used to get students to articulate canonical science knowledge about an inverse relationship and name properties. After a short exchange with student 1 about items on her list, the teacher tacked on new information ("Let's say you know apparent brightness based on a light meter. What can you determine?" lines 11, 12) to point to the normative scientific relationship between luminosity, apparent brightness, and distance, which was the teacher's goal. Student 1 responds with a guess, "You can figure out…. How much energy the star has?" (line 13). This right answer was confirmed by the teacher, "That was a really good guess" (line 14), with no further press for how or why that would be. Once the teacher left the small group, students continued adding to their lists silently and independently to complete their task.

From this funneling example, we see that ideas were treated as discrete answers, both in the talk (going from one student to the next, listing separate ideas, and teacher evaluating them) and the task (making a list). Overall, this episode was low-rigor because there were no opportunities to explore causal explanations about the role of energy in light waves to explain the inverse square law. The next episode, in contrast, illustrates how talk, tasks, and tools in classroom activity can work together to create opportunities that support students' collective reasoning about explanatory mechanisms.

Focusing: Supporting Students in Constructing a Causal Explanation Together

This next example was also part of an astronomy unit about star cycles. The purpose of the explanatory task in this featured

Table 2: Funneling example: Student contributions treated as answers

Line	Discourse between teacher (T) and students (S)
1	T: Ok, what's the relationship with these guys (luminosity and apparent brightness)? Why are these important when studying stars?
2	S2: (*Mumbling, quietly*) Without matter light will not travel
3	T: The light won't travel through matter? What do you mean by that?
4	S2: It won't travel as far no matter how much energy the star has. And I just put that…
5	T: Ok. Alicia, what do you think? Do you have a checklist goin'?
6	S1: Yeah, um. I said the medium affects the wave
7	T: So, you think that's pretty important?
8	S1: Yeah, and the strength of the star in that medium. And I said the star in at-a-glance stellar parallax lab was very important
9	T: Why?
10	S1: It told us that closer stars have a bigger shift while farther stars have a smaller shift
11 12	T: Ok. So, if you know, if you know that-- If you make that measurement, and you have a distance. And then let's say you know apparent brightness based on a light meter. What can you determine?
13	S1: You can figure out.how much energy the star has?
14	T: Were you guessing? That was a really good guess. (*Teacher turns to the next student*) Henry, so you got anything?
15	S3: What?
16	T: What is goin' on with your checklist? What would be important?
17	S3: Closer star equal brighter, further star. (*trails off*)
18	T: Good, keep going
19	Students work silently and individually on their lists after teacher moves to the next group

lesson was for students to understand how and why stars evolve. Students made observations about five color images of stars from different phases of their life cycle and were tasked with arranging them in the order of their cycle. Then, the teacher had students focus on a particular phase of the life cycle to describe how and explain why the star was changing. Groups of students had a worksheet that functioned as a scaffolding tool that helped students develop an explanation. It helped students differentiate and articulate three levels of depth in their explanations: (1) What the star looked like at that phase, (2) how it was changing, and (3) why it was changing. Each section of the worksheet included word/phrase banks to focus students on explanatory ideas such as prompts about forces, friction, and energy.

In the following excerpt (Table 3), this group began to reason with why stars formed. Students had not yet learned about fusion as an energy source but had learned about forces and used that knowledge to hypothesize about causal mechanisms. The excerpt below features talk from one group of four students when the teacher came over to check-in. All four were English Learners with varying degrees of competency in speaking and writing in English. This example illustrates collective sensemaking showing how multiple students build on one another's ideas.

In this example (Table 3), students responded to each other's ideas and the teacher's questions, leading to more rigorous interactions involving multiple students working to explain how and why a star is born. The teacher was responsive to student thinking, not only revoicing students' ideas but also by adopting students' words and ideas as part of facilitating the discussion. The teacher purposely revoiced specific key statements that were crucial for the students to continue to make sense of lines 10, 17. She intentionally drew attention to the observables from the photos and how students were talking about them. The teacher encouraged students to respond to peers' ideas and students respond to other group member's partial understandings and both build on and critique the ideas offered by other. At this point in the conversation, the teacher left, and students continued to synthesize an explanation on their own, shown in the transcript below (Table 4). The worksheet continued to serve as a scaffolding tool because it supported the students in rigorous talk as students began the metacognition of differentiating between a what, how, and why levels of explanation. In terms of rigor, students built on the earlier ideas about the role of pressure and friction as an opposing force to the forming of the nebula. In this next section of small group talk, note the high level of students' responsiveness to each other's ideas throughout and how they used and referenced the tools (i.e. checklist and worksheet) provided to advance their conversation.

In this example (Table 4), the theoretical underpinnings for "why" the phenomenon (i.e., star formation) occurs are the basis of this rigorous conversation. The construction of the causal explanation was not defined by instructional moves the teacher made, but rather by the students making sense of the phenomenon using their ideas as resources along with the intentionally designed task and purposefully designed tools. These tools helped students to break down observable features of the phenomenon "We see a star forming. We still

Table 3: Focusing Example: Features multiple students coconstructing a hypothesis

Line	Discourse between teacher (T) and students (S)
1	S4: (Comparing pictures of a star that appears to be "glowing" vs. one that is not) Probably it's (referring to non-glowing star) like the stars, like
2	being born
3	T: The stars like being born? Why do you think stars would be born from that? Why do you think that that's [what's happening]?
4	S4: Because like…because it looks like there's a light coming out of it
5	T: Looks like there's light coming out of it. Is that what you see? Do you remember from when we did the presentation about how stars form?.
6	Do you have in your notes somewhere where it talks about how stars form?
7	S2: Stars [form] a dust cloud
8	T: Okay, why? Why do you think that happens?
9	S4: Uh…
10	T: What do you think is happening when you say a "dust cloud"? What do you think the particles in the cloud are doing?
11	S2: Pulling to each other by gravity
12	T: So you think that gravity's pulling it together?
13	S3: Yes
14	S2: But then it's like not very even. So it's just kind of like pulling [this]…
15	S3: Lumpy
16	S2: Yeah
17	T: So it's lumpy? Okay. And then eventually. Can you tell me a little bit of why you think that is this next?
18	S3: Oh, because it's spinning. As it spins, it makes the gases turn…um…so as it spins it grows bigger because the gases- it's burning gases
19	inside. So as it spins, it's burning more gas, and then it grows bigger-
20	S2: Concentrates in the center
21	S3: Yeah
22	T: Concentrates in the center. Okay
23	S2: Yeah. It grows more gases inside and as it grows big what it's doing it started as in the main sequence

Table 4: Focusing: Students continue coconstructing a hypothesis

Line	Discourse between teacher (T) and students (S)
30	S2: Why is it happening is because of gravity, it's pulling on it, it's pushing together the gases making it solid
31	S1: We see how…So we were to talk, ya know
32	S3: We see that gravity is pulling on…(writing on 3-part explanation worksheet)
33	S1: Gravity is pulling all the particles and ele…elements, elements?
34	S2: Yeah, gases. Hydrogen, oxygen, helium, all that, all the gases together to make a new star
35	S1: It's spinning. Just kinda try to bring all the ideas together and if you get stuck just let us know. Um, and eventually it just like a concentrated
36	amount of energy in the center
37	S2: Into its core
38	S3: Has energy in the middle?
39	S2: Are you saying why in that box? I thought you were supposed to put why right there (pointing at worksheet). WHY IS IT HAPPENING. Yeah,
40	it says why is it happening
41	S1: Is how and why kinda like the same question in this situation?
42	S3: How is it happening and then why
43	S1: We can switch it around then
44	S3: Oh, how is it happening, it's swirling. And why is because the gravity is pulling all the particles.
45	S1: And you could put how because we messed up. There
46	S1: No, this is what we see
47	S3: What we see and how. This is how, swirling
48	S1: Swirling, oh darn, we are pretty much done, ah
49	S2: Um, is there anything on….(students looks on idea checklist)
50	S1: Yeah, friction, friction, pressure when it's swirling it has more friction in there
51	S2: But doesn't friction make it slow down, but is friction on…it makes it slow down only a little bit because…to make a star form, you need
52	tons of speed to make a star form as it grows and as it spins it grows because of gravity is um pulling on the gases that can combine together
53	because it's growing. But a little bit of friction into it but not a lot.
54	S1: It's all lumpy. So, it's all swirling around each other
55	S2: But as it turns it's not so lumpy
56	S1: It's kinda smooth
57	S3: Is it pressure that pushes down?
58	S1: Pressure pushes particles into center
59	S3: Can you read this? (pointing to sheet) The gravity of pressure is pulling and pushing the molecules
60	S1: Anything else? We see a star forming. We still see a glowing orange, yellow circle in the middle. We still see remnants of the nebula swirling
61	around this glowing center and that's how. The why is the gravity and pressure is pulling and pushing all the particles and elements together to
62	make a new star. There is a concentrated amount of energy in the middle, and that's why it is glowing. When it's swirling it has a little bit of
63	friction. It's good

see a glowing orange, yellow circle in the middle. We still see remnants of the nebula swirling around this glowing center and that's how" (lines 60-61); and then hypothesize about unobservable processes are used as justification for observable components of star formation "The why is the gravity and pressure is pulling and pushing all the particles and elements together to make a new star. There is a concentrated amount of energy in the middle, and that's why it is glowing. When it's swirling, it has a little bit of friction" (lines 62-63). Through careful orchestration of talk, task, and tools, students were positioned as sense-makers, coconstructing explanations for the star formation phenomenon resulting in a high rigor interaction that was responsive to student thinking.

IMPLICATIONS

Aligned with the Next Generation Science Standards vision, students should experience less memorization and learning about concepts disconnected from a phenomenon (NGSS Lead States, 2013). To move away from these traditions, teachers can assess and reflect on how ideas are treated in their classrooms by looking at the patterns of talk, task, and tools. Consider focusing students on building and revising their ideas in classroom activity instead of funneling them toward reproducing authoritative explanations. Try this:

- Talk: Use talk moves, norms, and routines that work with and on ideas. Respond to students by asking them to compare ideas with each other, to elaborate or add-on to a prior idea. Teacher self-reflection prompts:
  - Talk purpose: What was the purpose for student talk during the task(s)?
  - Planned versus enacted: What was planned for or anticipated in student talk? What happened with ideas? Why?
  - Student thinking: Did talk moves help *all* students talk with each other to build or revise ideas?
- Task: Re-design tasks to support students in constructing and revising evidence-based discussions, synthesizing information from multiple sources, including investigations driven by their questions, to develop a deep understanding of core scientific ideas. Teacher self-

reflection prompts for lesson task(s):

- Purpose: What was the purpose or aim for engaging students in this task?
- Planned versus enacted: What were students asked to do? What did students actually do? Examine student work.
- Student thinking: How were all students' ideas elicited, treated, or used during the task? Did students discuss their own understanding or did they only state science facts or correct answers?

- Tools: Consider how tools, such as scaffolds and checklists, are designed to support intellectual work and helping them engage in and use science practices to work on their ideas together. Teacher self-reflection about tool(s):
  - Tool purpose: What tool(s) did students have or use to support their engagement in the task and talk?
  - Planned versus enacted: How did you expect students to use the tool(s)? How did students use them?
  - Student thinking: Did the tool(s) support all students' intellectual work? Why or why not?

We end with a question for teachers' reflection and to engage in conversations with colleagues when planning for or reflecting on classroom activity: How are talk, task, and tools used to create and shape a scientific community of learners that make progress on ideas together?

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