Examining the Positioning of Ideas in the Disciplines

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Abstract. We present a qualitative analysis of a group of students working through a task designed to build connections between biology, chemistry, and physics. During the discussion, members of the group explicitly index some of the ideas being presented as coming from "chemistry" and from "physics." While there is evidence that students seek coherence between outside knowledge and in-class knowledge, the evidence of the group's progress in co-constructing these ideas is subtle. In this paper, we present evidence that the progress students make in addressing and coordinating each other's ideas can be understood through a positional lens. We examine how students position ideas as having value for the discussion.

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INTRODUCTION

In many of our physics classrooms we incorporate collaborative group work as a centerpiece of the educational environment. Research comparing collaborative group work to individual problem-solving has generally found that group-work leads to favorable learning outcomes [1]. However, less work has been devoted to understanding *how* a group makes progress during the process [2]. This paper presents a descriptive account of how interactions between group members facilitate the group's attempt to seek coherence [3] between two competing models of what happens to the energy when a protein unfolds.

METHODOLOGY

The data for the study comes from the pilot year of an introductory physics course for biology students. The course is designed to be interdisciplinary; students are encouraged to draw upon knowledge from their biology, chemistry and physics backgrounds in the discussion, lab, and lecture components of the course. In particular, the recitation sections were designed as group problem-solving sessions with tasks designed to help students build connections between chemistry, biology, and physics. An example of this type of problem is exemplified in the data presented here of one video-recorded group who work together to understand the energy transformations in the process of a protein unfolding. In this paper we are interested in understanding how interactions between group members facilities the coherence-seeking process.

Theoretical Framework

We take up an analytic lens that focuses on the positioning moves students make during the group discussion. Positioning provides a language for examining how interactions add or take away value or importance to people or ideas. One way to use positioning in this type of analysis is to focus on how individuals position one another with an eye to expert-like and novice-like identities [4]. Another way to use positioning, and the one we take up in this work, focuses on how individuals work to position ideas [5]. In group-work students are commonly faced with deciding which ideas hold value to the argument at hand [6]. In this paper, we present an analysis of two different ways students position particular *ideas* as having value to the discussion, and examine how this contributes to the progress of co-constructing [2] ideas that "hang together" [7] from the students' perspective.

An underlying assumption in our work is that knowledge construction is fundamentally a social endeavor and therefore studying the interaction of students provides insight into how learning occurs and how progress is made [8]. In doing so we do not mean to imply that the students' conceptual progress is not important, but that studying interaction yields different insights into the phenomenon being studied. For this reason we draw on the analysis of the conceptual ideas students bring to the discussion in other work [3]. We believe that students weigh ideas using a variety of strategies, and describing the ways students interact with these ideas may yield insight into how these decisions are made [2,9]. In this paper we present an analysis of two different ways students position particular *ideas* as having value to the discussion. We present this analysis in the context of understanding the progress the students make in building and articulating two opposing models [3].

DATA & RESULTS

The data we present here comes from a recitation section of the course where students work in small groups on a problem designed to be interdisciplinary. The problem the students were focused on involved examining the effect of a protein being stretched by optical tweezers. Students were presented with a graph of the force exerted by the tweezers versus the distance the protein was stretched. In the dialogue we analyze, the students focus on a question that asks them to decide if the energy of the unfolded (or stretched) protein is smaller or larger than the energy of the folded (or unstretched) protein. The instructors designed the question so that students would see that work was done on the protein and conclude the stretched protein must have higher energy than the unstretched. However, as we can see in this clip, the students were not provided with sufficient information to readily decide if the energy stayed inside the system. (We comment on whether the question's ambiguity was a feature or a flaw of the question in the concluding section.)

In the focal episode, the students, Camille, Anya, Hollis, Marge, and Kavita (all names are pseudonyms) are seated around a rectangular table with individual worksheets in front of each of them. Just prior to the start of the episode, the students were off-task, and Anya had reoriented them to the question about energy.

We present the following discussion between the group members broken in two segments of transcript. (Note the transcript is presented in breath-turns. A // indicates where a statement was interrupted and a / indicates the start of the interrupting statement.) We do not focus the analysis in this paper on the ways students position particular ideas. We do not mean to imply that the conceptual work is completely divorced from the positioning moves students make in the group, but rather that the two can be separated for the purposes of analysis. Again, the focus of this paper is on how conceptual *ideas* gain value or are dismissed from the discussion through the ways that students respond to them.

The Story of Hollis and Marge

Prior to the data presented here, Camille and Marge decided that because the bonds in the folded protein must be broken in order for the protein to stretch, energy must be released (Model 1 in [3]). They reason, therefore, that the unfolded protein must have less energy than the folded protein. Anya expresses some disagreement with the reasoning, but then declares, "But in physics terms we must say what you said," indicating her agreement with moving forward. There is some discussion that follows among the group about what kind of energy is released. They conclude that it is possible that thermal energy is released when the protein is stretched. As we enter the discussion, Camille is writing on her paper, while Anya and Marge are looking at the group.

As we present the discussion and interaction among four of the five students in this group (Kavita does not verbally participate in this discussion) it is easy to focus the attention on the talk between Camille and Anya. However, we also draw the reader's attention to the positional moves of Hollis and Marge as important to the group taking up and treating as valuable particular ideas offered in the discussion.

1 **Anya:** Wait, so delta H for breaking bonds is um less right? It takes energy to break bonds. And you gain energy, so we know from yeah chemistry already that.
2 **Camille:** Well yeah the energy you have to pull them.
3 **Anya:** Yeah, we put energy into the system. So the unfolded should be higher energy.
4 **Camille:** What?
5 **Marge:** Ok so you are saying,//
6 **Anya**:/Right?//
7 **Marge:** /because of this it gains energy right here? {circles something on her paper}
8 **Anya:** You have to put energy into the system to break the bond.
9 **Hollis:** To break the bond is what she is saying. {looking at Camille}
10 **Anya:** So therefore it's less, like whatever the product is should be like…
11 **Camille:** Yeah. But, isn't it you have energy and then the end product is you have thermal energy plus the energy of the system and they are only talking about the system, so that thermal energy is nixed so the end product//
12 **Hollis:** /So the energy would be the sam-
Camille:/ - would be smaller.
13 **Anya:** I don't know, we would have to see the energy diagram.
14 **Camille:** I hate energy…//
15 **Marge:** /Wait, I kinda agree you {looking at Camille} said it would be less right?//
16 **Camille:** Yeah.
17 **Marge:** Yeah. Now that I am thinking about it, I think it would be less.

In this clip we see two sets of ideas offered to the group. First we see Anya in turns 1 and 3 offer the idea that energy must be put into the system to break the bonds, thus the energy of the unfolded protein should be higher. Later in turns 11 and 12 we see Camille provide an explanation that describes thermal energy being lost from the system.

Early in the story we see Marge and Hollis play roles that support both of these ideas, taking them up and probing them for further information. In turn 3 Anya offers the idea that the unfolded protein has higher energy, which Camille expresses confusion about, but Marge supports in turns 5 and 7 by asking where the energy would go into the system. Marge's request leads Anya to clarify in turn 8. Similarly Hollis supports and extends Anya's explanation that breaking the bonds requires an input of energy in turn 9. Hollis also demonstrates her attention to the idea Camille presents in turn 11 by finishing Camille's sentence in turn 12. When Anya and Camille begin to change the focus of conversation to an energy diagram in turns 13 and 14, Marge refocuses the conversation on the two explanations in turns 15 and 17 by stating that she thinks the end product would have less energy. Throughout this first segment we can see the moves made by Marge and Hollis as positioning the ideas presented with value. Indeed Hollis responds to Marge's support for one idea in turn 15 and 17 by asking Camille to explain further in the next segment.

18 **Hollis:** Ok, explain that again.

19 **Camille:** Ok, really it's like blob energy and it goes to blob, broken blob with lost thermal energy, so thermal energy//

20 **Anya:** /She is trying to say thermal energy is outside that.//

21 **Camille:** /And then you have E//

22 **Anya:** /I am saying that because you put energy in therefore there's gotta be greater energy in the end.

23 **Anya:** But she is saying oh nonono it's all thermal energy. But you are not releasing energy. If you look at delta H, that's released or put in energy right? The thermal energy you are talking about would be if it released energy and it didn't. It's an endo...//

24 **Camille:** /It broke!//

25 **Anya:** /Nonono, but this is an endothermic reaction, you put in//

26 **Hollis:** /Energy to break the bonds.//

27 **Anya**: /Heat.

28 **Anya:** You put in energy, you put in heat. To make a break.

29 **Camille:** You put in heat?

30 **Anya:** Yes.

31 **Camille:** No you just did tension.

32 **Anya:** Whatever. But you know what I am saying in terms of chemistry stuff, right?

33 **Marge:** In terms of chemistry, you do need energy to break stuff down.

In this short segment we see Anya begin to do the work of separating the two ideas from one another. As Camille responds to Hollis' request for elaboration by explaining how thermal energy is lost from the "broken blob," in turns 19 and 21, Anya interrupts and begins contrasting the two ideas. She starts in turn 22 by re-stating the idea that if energy is put into the system the end product must have a higher energy, and contrasts this with the idea that thermal energy is released. In turn 23 we see Anya use the contrasting language of, "But she is saying," and, "The thermal energy you are talking about," thus putting separation between the ideas, as well as putting ownership on who is offering the idea. Up to this point in the segment, Anya has primarily put value on ideas by placing the idea that thermal energy is lost in contrast to the idea that no energy is lost.

In turns 24 to 31 Camille begins to participate in the co-construction of ideas, by interjecting into Anya's stream of reasoning by responding with "It broke!" and "You put in heat?" Anya responds to each of these interjections by clarifying her reasoning. In turn 31, however, when Camille responds to the idea of putting in heat with, "No you just tension," Anya dismisses this comment in turn 32 with, "Whatever." Anya follows this dismissive comment immediately by asking if they know what she's saying in terms of chemistry.

In this segment we see the verbal contributions from Hollis and Marge becoming less numerous, but they continue to lend support to the ideas being expressed. In turn 26 Hollis extends Anya's endothermic reaction to mean energy is required to break the bonds, and Marge, in turn 33, assures Anya that she recalls from chemistry that energy is required to break stuff down.

After this point in the discussion, Camille attempts to change the direction of the conversation to focus on the system in question, while Anya continues to try and make the point that no energy is released in the process of stretching the protein. At the end of this conversation, the group turns to the TA to make additional progress in their reasoning.

Throughout this episode, we have observed the students responding to one another in ways that indicate the co-construction of ideas. Additionally, we have also seen how Hollis and Marge lend support to the two sets of ideas that develop in ways that do not allow for the ideas to disappear in the conversation. While Hollis and Marge may not take as many turns as do Camille and Anya, their contribution to the story becomes important for understanding how the two competing sets of ideas gain and maintain value for consideration in the discussion.

Gaining Authority from Outside Ideas

Commonly in school, value is added to ideas through the referencing of authorities on the material (i.e. textbooks, scientific principles, rules)[6,10]. In some of the turns across these clips we see students, in particular Anya, position some ideas as coming from places outside of the physics class. The most explicit of these are references to chemistry directly, such as in turns 1, 32, and 33. However, in additional turns (1, 23, 25) Anya also uses specific language that at this point in the semester has not been associated with material in the introductory physics class (i.e. endothermic, delta H).

We assert that these references may be an attempt to add value to the ideas being presented, as they are often paired with an idea that is in contrast to one that has been previously presented. This pattern begins in turn 1 when Anya presents the idea that the energy of the unfolded protein would be higher than the energy of the folded protein, which is in direct contrast to a previous consensus. When Anya presents this idea in turn 1, she does so couched in the language of delta H and an explicit reference to chemistry. Again in turn 23, we see Anya contrasting the two ideas about whether thermal energy is released in the system. When Anya says, “But you are not releasing energy,” she immediately follows this by, “If you look at delta H….” Further when Camille disagrees and argues against energy being released Anya asserts, in turn 25, that it is, “an endothermic reaction.” When Camille argues that heat is not put in to break the bonds, Anya responds in turn 32 by asking if they know what she means in terms of chemistry stuff (which Marge affirms in line 33). Looking across this pattern of presenting a contrasting argument along with the referencing language from outside the physics class, we may interpret these references as students’ attempts to add value or weight to the idea being introduced or considered.

While we believe Anya expects that couching certain ideas in the language of chemistry lends value or authority to some of the ideas, we note that the language Anya uses is not taken up by others, except when echoed by Marge in turn 33. Further, if there is not a shared understanding of these terms (e.g. delta H), Anya’s use of the terminology may make the ideas more ambiguous rather than adding clarity. Nonetheless, the ideas could still gain added value or weight in the discussion through their indexing to formal terms and disciplinary ideas.

CONCLUSIONS

We set out in this paper to provide a descriptive account of the interaction work involved in students’ coherence seeking among conceptual ideas. We have described how students co-construct two sets of ideas through positioning ideas with value in the discussion. The value is determined both by ways in which students respond and support the ideas, as well as the authority gained from situating the knowledge in principles and rules from outside the physics classroom. This work suggests two lines of further inquiry: (1) We should attend to students who appear to interact minimally with the group and unpack the roles they play in making progress in group work, and (2) when designing interdisciplinary tasks, curriculum developers should consider how specificity and ambiguity in a task may influence the resources students bring into the discussion, and the potential these resources may have for supporting group progress.

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REFERENCES

[1] D.W. Johnson and R.T. Johnson, *Theor.. Prat.* **38**, 67 (1999).
[2] B. Barron, *J. Learn. Sci* **12**, 307 (2003).
[3] C. Turpen, V. Sawtelle, T.-R. Sikorski, and E.F. Redish, Research on Students' Coherence-Seeking across Disciplinary Boundaries, a paper presented at the Physics Education Research Conference, retrieved from (http://umdberg.pbworks.com/w/page/44091749/Papers%20and%20Presentations), (2012).
[4] I. Esmonde, *J. Learn. Sci.* **18**, 247 (2009).
[5] K. Hogan, B.K. Nastasi, and M. Pressley, *Cognition Instruct.* **17**, 379 (1999).
[6] J.L. Lemke, *Talking Science: Language, Learning, andValues* (Ablex Pub, Norwood, NJ, 1990).
[7] M. Buchmann and R.E. Floden, *Coherence, the Rebel Angel* Educ. Res. **21**, 9, (1992), p.4.
[8] B. Jordan and A. Henderson, *J. Learn Sci*. **4**, 39 (1995).
[9] M. Ranney and P. Thagard, *Explanatory Coherence and Belief Revision in Naive Physics* (1988), p. 25.
[10] D. Hammer and A. Elby, *J. Learn Sci*. **12**, 53 (2003).