Transforming Thought to Verbalizations: Supporting Verbal Communication in Middle School Collaboration Activities

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Abstract

Collaboration is an important 21st century skill that students must master as they progress through school and into their careers (National Research Council [NRC], 2012). Collaboration is also an integral part of STEM learning and is included in many recent learning standards for students (such as the Next Generation Science Standards). From our analysis of over 200 middle school students working collaboratively in groups, we developed instructional guides for teachers and students. We show how students worked together to solve problems by (1) negotiating what the task was asking, (2) understanding what other group members were contributing, (3) working through disagreements, and (4) converging on a solution. Finally, we provide markers that teachers can use during instruction to determine students' collective progress as collaborators.

Helping Students With Group Talk in Collaborative Learning

No scientist works in a vacuum. Most science depends on collaboration, an important 21st century skill that students must master as they progress through school and begin their careers (National Research Council [NRC], 2012). Further, collaboration is an integral part of STEM learning and is included in many recent learning standards for students (such as the Next Generation Science Standards). In classrooms, students often solve problems or design artifacts as a group. However, collaboration continues to be a challenging skill for students to develop. Students do not come to the classroom knowing how to effectively share ideas, ask questions, acknowledge others' contributions, negotiate meaning, and agree on conclusions. In this white paper, we analyze 2 years of data from over 200 middle school students who collaboratively solved math problems. We extend these results by providing instructional guides for teachers who use collaboration for problem solving and artifact design in science. Our goal in developing this support is to help build students' ability to effectively communicate while working in groups. This approach has shown to be useful in our work with students working in groups of 3 to solve open-ended problems.

Using Communication Effectively in Collaborative Groups

Collaboration and Communication in Next Generation Science Classrooms

The Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) and the *Framework* (NRC, 2012) highlight the need to integrate science ideas with engagement in science practices as a way to promote the development of student proficiency. With the adoption of NGSS across the country, students are expected to put their knowledge of science into use, particularly through science practices that are based in collaboration and communication. In the science classroom, when students work together and share their ideas, it provides opportunities for students to explore ideas, refine their thinking, and ask new questions (Chi et al. 1994; Chin & Brown 2000).

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In a collaborative setting, which is characterstic of authentic scientific inquiry, students can make their ideas public to the other group members, who can then critique, extend, or agree and disagree with those ideas (Chin & Brown, 2000; Kagan & Kagan, 1994). Such interactions require and promote the development of important communication skills and scientific thinking processes, such as the scientific practices "Engaging in Argument from Evidence" and "Obtaining, Evaluating, and Communicating Information," as specified in NGSS. According to the *Framework*, students must learn how to identify the strengths and weaknesses in a proposed line of reasoning and provide options for alternative explanations. In addition, students must be able to defend their explanations, examine their own understanding and the comments of other students, and collaborate to formulate explanations for phenomena being investigated. Science requires students to communicate what they know, how they know it, and what it means.

Collaboration as a Teaching Practice

In most science classrooms, teachers use collaboration to support student learning. Group collaborations are a common teaching practice, and have shown to be beneficial for the development of science practices and the learning of content. Collaboration sometimes helps students develop higher level thinking, problem solving, and content specific skills and results in other positive student outcomes , like increased test scores (e.g., Bricker, Tanimoto, & Hunt, 1998; Slavin, 1991; Sung & Hwang, 2013; Van Laar, Van Deursen, Van Dijk, & De Haan, 2017). Additionally, when teachers encourage collaboration among their students, they shift the responsibility of communicating ideas through social interactions to the students. In this way, group collaboration steers away from positioning teachers as the knowledge authority in the classroom and promotes students' ownership of their learning.

However, collaboration is not necessarily an intuitive skill. Students need guidance and direction in organizing their thoughts, interacting with peers, eliciting and attending to other group members' ideas, and communicating with their group while working collectively to solve problems. Educators have developed a variety of strategies that can support collaboration. For example, classrooms can foster and nuture collaboration through norms that encourage interactional and intellectual risk-taking (Marx et. al., 1997). These norms might include students trusting that their ideas are valued, listening while other group members are talking, and participating equally in the classroom (Penuel, Moorthy, Beauvineau, & Allison, 2012).

Another form of group work is cooperative learning (Johnson & Johnson, 1999). In cooperative learning students are less likely to exhibit individual competitiveness and more likely to show cooperative problem-solving group behavior (Johnson, Johnson, & Holubec, 1998; Marzano, Gaddy, & Dean, 2000). Although cooperation is not the same as collaboration, it serves as a useful step towards supporting students' efforts in collectively building knowledge. Johnson and Johnson (1999) have shown that assigning roles during cooperative learning activities can help distribute the labor tasks or cognitive tasks in the group. Labor tasks might include collecting the papers or passing out lab materials, while cognitive tasks might include asking questions, summarizing, and explaining.

Supporting Communication in Collaborative Groups

Collaborating in groups requires students to communicate their ideas clearly. We suggest supporting students by working to coordinate their thinking process with what they articulate to their peers (Vygotsky, 1986; Michaels, Connor, Hall, & Resnick, 2002). Table 1 provides students with metacognitive questions to ask themselves and oral questions to ask others in a

collaborative group setting. In the "What I Am Thinking" column, students do not explicitly communicate their thought process, but instead engage in a mental vetting process of their ideas. In the "What I Should Communicate to the Group" column, students openly discuss what they are thinking, communicating how they think the problem should be solved or how parts of the problem should be addressed. In this way private thoughts becme publicly processed ideas for group vetting. In response to thoughts that have been verbalized, other students may contribute to the problem solving conversation.

Table 1 shows four parts of a collaboration: Getting Started on the Problem, Understanding Other Group Members, Showing Agreement or Disagreement, and Converging on a Solution.

Table 1: Group Collaboration Prompts for Students

What I Am Thinking	**What I Should Communicate to the Group**
Getting Started on the Problem	
What is this problem asking me to do?	I can read the problem out loud, and you listen and starting thinking about how to start the problem.
	What is the goal of the problem? Or- What are we trying to solve in this problem?
	What potential solutions can I share?
	What problem solving techniques can I share?
Understanding Other Group Members	
What are my groupmates suggesting?	Can you explain your idea?
	What do you mean by that?
	Can you show me how to do that?
Showing Agreement or Disagreement	
Do I agree/disagree with my groupmates' ideas?	If I agree: Can I repeat what you just said, to make sure I understand you?
Why do I agree/disagree with my groupmates' ideas?	If I agree: Do you think that you and I are saying the same thing?
	If I agree: Let's make sure we agree on this. Let me repeat what you just said. Or- Please repeat what I just said.
	If I agree: This is great. Let's check our answer and make sure we agree.
	If I disagree: Can you show me why you think that?
	If I disagree: Let me show you what I think.
Converging on a Solution	
Do I think I have the right solution?	What do you think the solution is?
What solutions do my groupmates have?	Let's try everyone's ideas and determine whether it works.
	I think you had a good point when you suggested your idea, but let me show you why I think it didn't work.
	I am not sure why my ideas are not working, can you help me understand?

Getting Started on the Problem

To begin the collaboration, a student–let's call her Erika–can read the problem out loud to the group. This step is an open invitation to the problem-solving process. As Erika begins to think through the problem, she may refer to the "What I Am Thinking" column and ask herself, "What is this problem asking me to do?" This is a question that Erika asks herself before engaging with the rest of the group. From this question, she can study the problem more closely, then think about additional questions that would help her engage the rest of the group. Erika can ask the other group members the questions from the "What I Should Communicate to the Group" column. For example, Erika might ask another group member, "What are we trying to solve in this problem?" This kind of question invites the other group members to participate in and contribute to the initial thinking towards solving the problem or creating an artifact. During this part of the collaboration, teachers might look for (1) joint attention, where students are looking at the same things, and (2) mutual engagement, where students become invested in solving the problem.

Understanding Other Group Members

As other members of the group begin to think about and voice their ideas about the problem or artifact, Erika might be working to synthesize and make sense of the ideas and additional questions being presented, as shown in the the "What I Am Thinking" column. As a result, she might want to consider the questions in "What I Should Communicate to the Group" column. This step is particularly important because as students share the goal, propose solutions, or present ways to solve the problem, each member of the group connects previous experiences to recent experiences as a way to promote more complex understanding. The group must be able to navigate the learning space as well as negotiate potential solutions with their groupmates. Such navigation and negotiation requires students to engage in verbal thinking (Vygotsky, 1934), the process of transforming thoughts into words that other people can understand and respond to. As members of the group process information, they discuss how they are thinking about the problem, allowing other members of the group to evaluate and provide feedback on their thought process. In our work, we found that when students spent more time vocalizing their thinking, the quality of their collaboration improved. In other words, when students utilized the knowledge and skills of the other students in their group by including them in their thought processes, this created opportunities for students to work together and reach consensus more effectively.

Upon hearing a suggested idea, Erika might ask a group member, "Can you show me how to do that?" This type of question shows that Erika is open to hearing other students' ideas about solving the problem. It demonstrates her ability to respect other ideas and thought processes when working in a group, as well as her willingness to expand her knowledge base and skill set. By listening to another student verbalize their ideas, she builds her repertoire of problem solving strategies and her ability to utilize the content. During this part of the collaboration, teachers might look for (1) joint attention, where students are looking at the same things; (2) mutual engagement, where students are actively talking and listening to each other; (3) group action and accountability, where students discuss, develop and create artifacts, or problem solve together; and (4) constructive speaking patterns, where students ask high level questions to advance the understanding of the group, make and acknowledge contributions, find common ground, and provide and receive help.

Showing Agreement or Disagreement

As Erika carefully listens to other students talk about their ideas, she may realize that she agrees with one of the other group members, but disagrees with another. At this time, she asks herself, "Why do I disagree with my groupmate's ideas?" This part of the collaboration presents an opportunity for Erika to clarify her understanding of how other group members make sense of the problem. This part of collaboration can be challenging because students may not know how to disagree productively. If students are provided with specific prompts to help guide their conversations, it can create more constructive learning experiences for the students.

In this case, the student with whom she disagrees might be communicating a common misconception about a particular scientific core idea. As a result, Erika can refer to the "What I Should Communicate to My Groupmates" column to gather ideas for questions. For example, she could ask her groupmate, "Can you show me why you think that?" This invites her groupmate to further share and explain. In addition, it encourages Erika to listen, as her groupmate's thinking may not be too dissimilar from her own. If Erika continues to disagree with her groupmate, she might offer an explanation based on her understanding. She might say, "Let me show you what I think," contributing to the group thinking process while being reflective on her understanding of the problem. During this part of the collaboration, teachers might look for (1) joint attention, where students are looking at the same things; (2) mutual engagement, where students are actively talking and listening to each other; (3) individual agency, where each student has responsibility and opportunity for learning from other members in the group; (4) monitoring and reflecting on what is being shared and discussed; and (5) constructive speaking patterns, where students ask high level questions to advance the understanding of the group, make and acknowledge contributions, find common ground, and provide and receive help.

Converging on a Solution

Over time, through discussion, the group has explored various ideas, approaches, and suggestions for solving the problem. They have various solution candidates and have to determine which solution is the most appropriate. Similar to "Showing Agreement or Disagreement," this part of the collaboration can raise issues among students, especially for those who are competitive. This is when students can utilize the prompts provided in Table 1 to help them communicate effectively while collaborating. For example, Erika might still disagree with her groupmate about the solution to the problem. In this case, rather than insisting that her groupmate is incorrect, she can suggest that they try both solutions and then determine which produces the desired result. She might suggest, as shown in Table 1, "Let's try everyone's ideas and determine which one works best." In the event that Erika's solution was the most appropriate solution, she might offer to explain to her groupmate how she arrived at her solution and gently critique the alternative solution by saying, "I think you had a good point when you suggested your idea, but let me show you why it didn't work." During this part of the collaboration, teachers might look for (1) joint attention, where students are looking at the same things; (2) mutual engagement, where students are actively talking and listening to each other; and (3) group monitoring, where students have measures of progress.

Conclusions and Considerations

Collaborating through communication in science classrooms is not only present in several NGSS practices, but is also a required 21st century skill. Teachers commonly use collaboration strategies to support students in achieving various tasks, like inquiry-based science activities. In this article, we aimed to provide an instructional guide that can help students formulate

statements and questions that contribute to the faciliatation of group collaboration. Our hope is that this will serve as a starting point that teachers can build on and transfer to other subject areas, such as math. Over time, students will be able to come up with their own questions and navigate the collaboration space smoothly.

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