Assessments That Promote Collaborative Learning

Students practice classroom norms and take responsibility for one another's learning.

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As the algebra teacher called a student up to the overhead projector to share how his group had solved a problem, the student anxiously asked, "What if I do it wrong?" The teacher immediately responded, "Then everyone will help you." Then she addressed the class: "Help Rodney be as clear as possible. If he does something that you're not sure about, make sure you raise your hand and ask him a question." Rodney took a deep breath and dove into explaining how his group approached the mathematics.

In this vignette, Rodney (all names are pseudonyms) shared his group's thinking publicly to the class, even when he was unsure of himself. The teacher excelled in reassuring students who communicated anxiety about the challenging content and invoking "team" talk to encourage her students to help one another.

This article discusses assessments that this teacher and teachers in her department use to help encourage a collaborative classroom community, in

which students help one another learn mathematics. We describe participation quizzes and explanation quizzes as assessment tools that encourage students to work together, share specific questions on challenging mathematics problems, and take responsibility for their own and one another's learning.

PARTICIPATION QUIZZES

What does a participation quiz look like? While students explore a problem in small groups, a teacher takes notes about the nature of students' participation in mathematical conversations on an overhead or a projected piece of paper. The teacher then reviews the results of the participation quiz publicly with the whole class.

Norms for Working Together and Raising Status

Teachers can hone in on various focal points to help students work effectively together during a participation quiz: body positioning that promotes equal access to the conversation and the materials, enactment of group roles, explanation of reasoning, and persistence. When students' tables are preconfigured so that the students face one another, the seating arrangement helps foster communication. In classrooms where chairs attached to desks need to be brought together to form groups, it is essential that the tables touch, so that students can see and hear one another. Having one's back turned to a teammate shuts out the teammate from participating in the conversation. Moreover, students must have access to the manipulatives in the middle of the tables (Staples 2008). This physical arrangement reinforces the idea

Students, seated in small groups of four, are to build arrangements that have the following perimeters: $2y + 2x + 4$; $2x + 4y$; $4y + 4$.

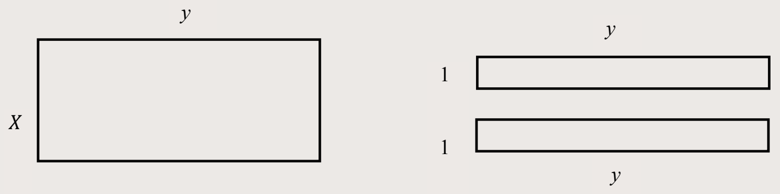

Fig. 1 Students create structures for the given perimeters.

Group 1 Reading together. "Do you understand?" "So this y is minusing that y."	**Group 2** Reading and listening. "Why is it $4y = 2x$?" "I got it!" Other people touching the pieces.
Group 3 "Does that look right?" "I don't know how to do it." "How did we get rid of the y's?"	**Group 4** "Can you get the blocks out, please?" "How did we do it last time to get $6y$?" "So it needs to go somewhere on the side."
Group 5 "I don't get it." "I don't get it." "How did you get $2x + 4y$?" "See, you have to subtract from 2 sides."	**Group 6** "If you do that, where will the other x come from?"

Fig. 2 Snapshots of discourse during a participation quiz are projected for students to see.

that students are engaging in a group task.

Other areas to which a teacher might direct attention are how effectively students enact their group roles—facilitator, resource monitor, recorder or reporter, and team captain—and how students "explain their reasoning" (Horn 2012, p. 58). Teachers can listen for the word *because* or look for students who use the manipulatives while articulating their thinking process to represent understanding in multiple ways.

To direct attention to a particular norm, a teacher can tell students ahead of time the focus of the participation quiz (Horn 2012). A teacher can also elaborate on how students will earn scores. Consistent enactment of group roles by all team members, for example, may earn a score of 10/10 on a particular day.

Participation quizzes are effective when the teacher's notes are publicly visible; the written comments on the overhead warn groups about off-task behavior and praise positive interactions and perseverance. Students take pride when teachers highlight their positive contributions for the whole class to see. When the class recognizes their contributions, they want to participate more. Feeling valued is very important. And when they feel safe, students are more likely to take risks—for example, stating they do not understand or putting out an idea that may not yet be well formulated.

In addition to reinforcing norms for working together, participation quizzes can be useful in raising the status of students. Status is about how others perceive you and how you perceive yourself (Cohen and Lotan 2014). Status has many dimensions—academic and social—and status can change in different contexts. Cohen and Lotan's research (1997) indicates that when there are status problems in small groups, students participate inequitably on a conceptual task.

Unequal participation is often due to a combination of high-status students ignoring contributions from group mates they do not value and low-status students lacking academic self-confidence; together these result in infrequent verbal participation. Research demonstrates that unequal participation leads to uneven learning gains (Cohen and Lotan 1997). To identify high school students who may have low status, teachers might review their rosters, thinking about students who do not verbally participate in problem solving. Then, during a participation quiz, teachers can pay special attention to these students. What is that student doing in the small group? What student actions or words can the teacher observe and highlight? Public acknowledgment of the student's intellectual contribution that helps his or her small group can raise the student's academic status in the classroom (see more on status treatments in Cohen and Lotan [2014] and Horn [2012]). Teachers can shift students' status in a meaningful way only when students exhibit mathematical thinking through ideas or good questions, but praise for helping the group work together may provide the student with more confidence to volunteer a mathematical contribution.

The purpose of participation quizzes is for students to think, "I have two jobs. I have to help the group interact in a positive way, and I have to take mathematical risks to solve the problem and understand the mathematics." Teachers can use participation quizzes to praise both. By highlighting mathematical contributions, teachers also raise student status.

A Participation Quiz in Action

As students configure the manipulatives shown in **figure 1** in different arrangements, exploring whether the perimeters align with the desired outcomes, the teacher writes her observations and key quotes from the students and projects these overhead (see **fig. 2**). A few students point to the overhead projection, clearly aware that the teacher is listening to their mathematical conversations.

After students have had time to solve the problem, the teacher reports back to the entire class how the groups did on the participation quiz:

***Teacher*:** Group 1, you were solid all of the way through. I particularly liked this statement: "So this y is minusing that y. You didn't just say, "So it's minusing." You were specific about your ys, and overall you stuck together and asked lots of good questions. You get 10 points.

Group 2, you started off rough. Giovanni was sort of running the show, and the rest of you were along for the ride, but, halfway through, Jadirah stepped up. She figured something out that Giovanni couldn't figure out, and there was this big "I got it." Then by the end, other people were touching the pieces, and you guys were thinking together. So you didn't start off as well as I wanted you to, but you recovered well, so you still got a 9. That's still an A.

Group 3, I heard a lot of questions like, "Does this look right?" [and] "I don't know how to do it." [and] "How do we get rid of the ys?" I like this question the best: "How do we get rid of the ys?" Those early questions were good; they get people talking, but they're not the best. [*She points to the "How do we get rid of the* y*s?" question on the overhead projection.*] These are the kinds of questions I want. . . .

The teacher continues, discussing the progress of groups 4, 5, and 6.

When the teacher discusses the results of the participation quiz with students, she communicates specific norms for working together and for what students need to do to be successful. First, she critiques the balance of verbal participation in group 2's performance. Second, students learn that the teacher would like to see several students working with the physical manipulatives. Third, the teacher praises groups 1 and 3 for questions that are specific and have the potential to prompt new mathematical thinking. The teacher emphasizes that she values contributions that are questions, since questions can "unstick" a group. For example, "How do we get rid of the ys?" is a specific question that suggests a potential strategy for the small group to consider.

One issue that may arise is whether points attached to the participation quiz have the potential to humiliate students for off-task behavior. As much as possible, we encourage teachers to use participation quizzes to highlight positive norms or note a positive change, as the teacher did in her comments to group 2. In addition, if the teacher notes something negative, she often says to the small group, "Make sure you fix it." When they fix it, she crosses it off. Then, during the debrief, the teacher gives extra praise to the recovery by saying, "Starting strong and staying strong is easier than when things start rough and then a group recovers."

The teacher raises students' status twice when she shares the results of the participation quiz. First, she notes that Jadirah figured out something that her teammate could not. Now, the entire class expects that if Jadirah is in their group when the composition of the small groups changes, she will likely help them with the problem. The teacher promotes the status of another student in group 4. The student who asks, "How did we do it last time to get $6y$?" gets the group "unstuck." The teacher highlights the contribution first to her teammates, who initially dismissed her question, and then reiterates the praise to the whole class, thereby raising the student's status not just in the small group but also in the entire classroom.

Participation quizzes can give students reasons to take risks, communicate productively (speaking, listening, and rephrasing), and work persistently. For example, when the teacher praises group 1 for reading the problem aloud right away, it is easier for another student to say, "Oh, group 1 is doing it. We better do it, man. I want to get my points." In the end, points are not the driving motivator for most students, but earning points can give students initial excuses to do what they want to do, which is to learn mathematics. Participation quizzes attend to the social nuances of learning, where teachers are aware of how students negotiate their social and academic identities as they interact with their classmates about mathematics.

Participation quizzes can be used to increase inclusive body language, equitable verbal participation and use of manipulatives, enactment of group roles, explanation of reasoning, specificity of questions, on-task talk, and student status.

Keeping the stakes for the explanation quiz low, especially at the beginning of the semester, helps students buy in to the practice.

EXPLANATION QUIZZES

An explanation quiz is another example of an assessment that helps encourage students to collaborate. Members of a small group work on a task until all group mates feel ready to explain the group's problem-solving process to the teacher. The teacher then randomly calls on a student in the group to explain, and the student earns a score for the whole group. If the student is unable to explain the group's thinking, the teacher gives the small group another chance to reconvene, reassess, and redo the explanation quiz.

Assessment for Accountability and Reasoning

The first purpose of an explanation quiz is that it holds students accountable for their own and one another's learning. Students have to verbally explain their reasoning; therefore, teachers can assess student performance and understanding on the spot. Follow-up questions offer the teacher opportunities to examine whether students have a strong conceptual understanding of the material or are just regurgitating a procedure.

One consideration is whether it is fair to give a single grade to all members of a small group. Creating interdependence among group members is important for promoting collaborative interactions (Cohen and Lotan 2014). Successful attainment of a group product—in this case, everyone's ability to explain his or her problem solving on a group quiz—relies on each member of the group. By designing a task with a group product, teachers motivate students to be responsible for not only their own learning but also others' learning.

Another consideration that teachers might think about is whether the explanation quiz needs to be assigned points or whether the pressure to perform well for their peers is enough of an incentive for students to work collaboratively. One alternative is to weigh the grade for the explanation quiz less in terms of point value or percentage of overall grade compared with other criteria for grading, such as individual tests. Keeping the stakes for the explanation quiz low, especially at the beginning of the semester, and allowing students to retry without losing points can help students buy in to the practice.

An Explanation Quiz in Action

During the fifth week of instruction, students work together in small groups of four, first building the arrangement shown using blocks in the middle of the table (see **fig. 3**). At the base of the problem, the teacher has written, "When every person in your group can explain how you arrived at your answer, call me over to get your next challenge." Students know that the smallest squares have a length and width of 1, that the longest piece in the arrangement has a length of y, and that the shorter piece has a length of x.

Students Jadirah, Alejandra, Benjamin, and Giovanni prepare for an explanation quiz:

***Jadirah*:** OMG, I'm scared.

***Alejandra*:** Me, too.

***Jadirah*:** The thing is, we do know how to explain it, but we don't know what question she's going to ask, so we never know. I wish she could just tell us the question so we could study.

***Teacher*:** [*walks over to the small group*] Okay, I'm going to pick a number. Do you want one more second to practice, or are you ready? Because you are welcome to have as much time as you need.

***Students in group*:** [*simultaneous talk*] No, I'm ready.

***Teacher*:** Okay, I'm picking a number: 1 through 4. And whoever picks my number is going. [*The teacher writes a number on a piece of paper under the table.*] Go.

***Jadirah*:** 4.

***Teacher*:** 4. You are psychic. [*The teacher uncovers her piece of paper, and Jadirah smiles, looking at her group.*]

***Benjamin*:** Woo, woo. [*He pumps his fists in the air to cheer her on.*]

***Teacher*:** Okay, go ahead. Anywhere you want to start. Do you want a fresh piece of paper just so that all of these little writings don't confuse you?

***Jadirah*:** Can you ask me a question, and then I can answer it?

***Teacher*:** Absolutely. Okay, why don't you start walking around [the arrangement] and tell me what each side is and how you know. [*The teacher points to the perimeter of **fig. 3**.*]

***Jadirah*:** This is y because it's long. This is 1 because it's like 1 square. And this is x because it's a small one, and this is 1 because it's 1, and this is x because it's small, and this is 1. Then this side is x, and these are 3, and then this side is x, and this side is 1.

***Teacher*:** And this is 3, and this is 1? [*The teacher points to the middle of **fig. 3**.*]

***Jadirah*:** Yeah.

***Teacher*:** So the only side you haven't mentioned . . . I like how you saved the hardest part for last. The hardest part you haven't mentioned is that. [*She points to the arrows in **fig. 3**.*]

***Benjamin*:** Is it $2y$?

Teacher*:* It's not you. Okay, what's that?

***Jadirah*:** y.

***Teacher*:** OK, but is it all of y? I mean, this is all of y. [*She points to the top of the arrangement.*] That [*arrow section*] looks shorter than y. [*Jadirah* *looks at Giovanni for clues. The teacher looks at the paper.*]

Jadirah: [*smiles and looks again at Giovanni*] Minus 3?

Teacher: Why is it "minus 3"? [*Jadirah looks at Giovanni again. The teacher looks up at Giovanni and shoots him a "you know it's not your turn" look. Jadirah laughs.*] You know what? I know you've got it in your head. You're just a little nervous. I'm not taking off points. I'll let you practice that, okay? But let me tell you what I'm going to come back and ask. After you explain to me what this length is, I'm going to ask you why it's $2y$, why it's $4x$, and why it's 8. [*The teacher circles the final solution written on the small group's scratch paper*.] I'll ask you those individually. I'll give you 60 more seconds to practice with your group. You've done beautifully so far. It's okay, because you all get nervous. [*The teacher smiles, and Jadirah sits down.*] You get 60 more seconds with your group, and I'm quizzing you.

[*As soon as the teacher leaves, the small group leans in, reengaged.*]

When the group members raise their hands to indicate that they are ready, the teacher comes back to the small group to hear Jadirah explain her problem solving. Jadirah is successful, and the students earn full points for the explanation quiz.

This transcript offers strong evidence that these students feel that they are part of a collaborative community. First, when Jadirah expresses her anxiety about the group quiz, Alejandra concurs, letting her know she is not alone. When Jadirah is picked, a group mate pumps his fists in the air to cheer her on. When the student struggles, others try to help, even though they are not supposed to. As soon as the teacher leaves, the group dives into the middle of the table to help Jadirah understand. In addition, the teacher uses reassuring language to ease Jadirah's nervousness both before Jadirah begins and when she is not able to answer the teacher's question. The teacher later confirms that "this group was made up of students with very different status. But all of them had experienced a shift in status and a trust and an appreciation for each other beyond status."

To make explanation quizzes more achievable, the teacher is forgiving to Jadirah, allowing her to earn full points on the explanation quiz even on the second try. In addition, the teacher allows groups to determine when they are ready for the explanation quiz, increasing the probability that students will succeed (Staples 2008). Finally, another tool that the teacher uses is tailoring her question to the student she randomly picks. If the teacher had picked

Students are to discuss how to find the perimeter of the arrangement, making sure that everyone understands.

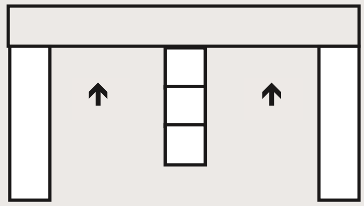

Fig. 3 Students find the perimeter of a given structure.

Giovanni, she may have pressed him on a hard problem first, because his confidence was high and he had engaged most in explaining to others. On the other hand, with Jadirah, the teacher asks her to begin anywhere she wants to start. The teacher gives Jadirah the opportunity to show her competence with a low-stakes question, a question that she could answer her own way. The teacher built Jadirah up to the challenging question.

To highlight the multiple solution paths to the same complex problem, the teacher routinely calls on at least two groups to come up to the front of the classroom to explain their differing problem-solving strategies. For a perimeter challenge problem such as that shown in **figure 3**, some students, like Jadirah, first write down each side of the model (e.g., $y + 1 + x + 1 + x + y - 3 \ldots$) before combining like terms. Others begin by counting the same lengths across the whole figure (e.g., they count total number of x lengths). Jadirah learns this second technique from her teammates, and she is able to articulate this strategy during her retake of the explanation quiz. Another strategy is to look at the model physically, noting that if you add 3 at the base of the figure but subtract 3 at the top, that is just the length of y. Share-outs provide students an opportunity to appreciate the different ways to approach a problem and learn more efficient techniques.

The task must allow multiple intelligences to shine; there must be many skills required to complete the task successfully and different ways to present the information.

CHOOSING TASKS FOR PARTICIPATION AND EXPLANATION QUIZZES

One caveat to implementing participation or explanation quizzes is that the nature of the task must be "group worthy" (Lotan 2003). The group task has to be conceptually challenging enough that it requires a small group to investigate together, and the task must be open-ended in terms of having different ways to solve or represent the problem and solution (e.g., see Staples 2008). The task must allow multiple intelligences to shine; in other words, there must be many skills required to complete the task successfully and different ways to present the information. For example, manipulatives are a tool that students can use to visually conceptualize the problem. Group-worthy tasks have a group product, but, in addition, there should be individual accountability, where each student must also demonstrate his or her understanding after completing the group task (Lotan 2003).

The benefit of these types of group-worthy tasks is that students gain a strong conceptual and numerical understanding instead of just procedural knowledge. Students have to try many ways to solve problems and discuss how they got their answers. (For more resources on group-worthy problems, see Horn [2012], Evans [Watanabe 2012, p. 22], and Nasir et al., eds. [2014].)

COLLABORATION FOR LEARNING

Developing a collaborative classroom community requires many components. It requires the mindset that all students can develop mathematical thinking skills (Horn 2006) as well as a teacher disposition that encourages students. It requires classroom norms, such as taking turns; expecting confusion as part of the learning process (Horn 2012); and taking risks by asking questions or proposing a strategy, even if students are unsure (Evans, quoted in Watanabe 2012, p. 22). It requires modeling how to build on student ideas in nonassessed, whole-class collaborative discussions; the teacher asks students to explore connections or inconsistencies in strategies presented to the whole class (Staples and Colonis 2007). These discussions help students learn to validate, question, and provide productive feedback to peers, resulting in more advanced, collective mathematical thinking. Developing a collaborative classroom community also requires a group-worthy task and attention to status issues (Cohen and Lotan 2014). It requires assessment tools that encourage collaborative work between students.

Assessment tools such as participation quizzes and explanation quizzes are just one piece of the puzzle to support collaborative learning. Our hope in writing this article and including detailed transcripts of student and teacher talk is to provide other educators concrete examples of these particular assessment tools in practice and to recommend their use to promote mathematically productive, collaborative interactions.

REFERENCES

Cohen, Elizabeth G., and Rachel Lotan. 1997. *Working for Equity in Heterogeneous Classrooms: Sociological Theory in Action.* New York: Teachers College Press.

———. 2014. *Designing Groupwork: Strategies for the Heterogeneous Classroom.* 3rd ed. New York: Teachers College Press.

Horn, Ilana S. 2006. "Lessons Learned from Detracked Mathematics Departments." *Theory into Practice* 45 (1): 72–81.

———. 2012. *Strength in Numbers: Collaborative Learning in Secondary Mathematics.* Reston, VA: National Council of Teachers of Mathematics.

Lotan, Rachel A. 2003. "Group-Worthy Tasks." *Educational Leadership* 6 (6): 72–75.

Nasir, Nailah S., Carlos Cabana, Barbara Shreve, Estelle Woodbury, and Nicole Louie, eds. 2014. *Mathematics for Equity: A Framework for Successful Practice.* New York: Teachers College Press.

Staples, Megan E. 2008. "Promoting Student Collaboration in a Detracked, Heterogeneous Secondary Mathematics Classroom." *Journal of Mathematics Teacher Education* 11 (5): 349–71.

Staples, Megan E., and Melissa Colonis. 2007. "Making the Most of Mathematical Discussions." *Mathematics Teacher* 101 (4): 257–61.

Watanabe, Maika, ed. 2012. *"Heterogenius" Classrooms: Detracking Math and Science—A Look at Groupwork in Action.* New York: Teachers College Press.

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