Productive Participation in a Small-Group Mathematics Task: Comparing Individual Turn-Taking and "Collaborative-Play"

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Abstract: To disrupt patterns of marginalization that play out through small-group interactions, we need to understand more about how specific participation structures, like turn-taking, are taken up by students and impact their opportunities to participate. In this study, I examine how one group of 9th grade students enacted turn-taking instructions during a small-group Algebra task. Patterns of participation evolved over time, from individual turn-taking to "collaborative-play" as the need to consult with peers to address challenges arose organically. Analysis reveals turn-taking and collaborative-play supported different types of productive student participation. Turn-taking supported *individual* contributions by slowing down task completion and by distributing access to the conversational floor across students. Collaborative-play supported *joint* contributions by shifting responsibility for issue resolution from an individual to the group. Findings suggest the two modes of participation supported complementary, and most likely interdependent, types of productive participation during small-group work.

Introduction

Educational inequities come in all shapes and sizes and are enacted through classroom interactions in many different ways. Macro-level institutional inequities connected to race, gender, and socioeconomics undoubtedly shape students' mathematical experiences (Esmonde & Langer-Osuna, 2013; Herbel-Eisenmann, Choppin, Wagner & Pimm, 2011). While teachers alone cannot fix these deeply rooted injustices, they *can* disrupt patterns of marginalization by supporting more equitable interactions among students (Boaler & Staples, 2008). In this paper, I focus on micro-level issues of equity related to student participation in mathematics classes. I examine how opportunities for participation are constructed and taken up during periods of turn-taking and "collaborative-play," as four high school students work together on a small-group Algebra task.

Small-group learning tasks hold the potential to address issues of equity by promoting meaningful content engagement by all students while also supporting students in building positive identities as thinkers, learners, and members of communities (Boaler & Staples, 2008; Cohen & Lotan, 2014; Hand, 2012). While the potential benefits are substantial, implementing successful small-group learning is not an easy task (Barron, 2003). Unsuccessful implementation can cause unintended negative effects on student learning and on students' perceptions of themselves and their peers as capable learners (Salomon & Globerson, 1989). Educators need to pay particular attention when selecting tasks for small-group work and when deciding how to regulate (if at all) participation within groups. While there is wide-spread support for the concept of *group-worthy tasks* (Cohen & Lotan, 2014) among math teachers and researchers, less is known about how best to structure participation while students are working on group-worthy tasks. Sometimes teachers choose not to impose any explicit structure; instead, they rely on established classroom norms to shape participation. Other times, teachers give students explicit instructions about how to participate, such as when using jigsaw techniques (Aronson & Bridgeman, 1979), assigning group roles (Cohen & Lotan, 2014), or implementing turn-taking routines (Sacks, Schegloff, & Jefferson, 1978). Improving our understanding of how specific participation structures, like turn-taking, are taken up by students and impact students' learning experiences will help educators and researchers plan for, implement, and reflect on small-group learning tasks aimed at combatting issues of equity within mathematics classrooms.

This study explores the interactions of four 9th grade students working a small-group mathematics task. I pay particular attention to the ways in which students' participation differs between periods of turn-taking and "collaborative-play." The research questions for this study are: 1) *How did the focal group of students enact turn-taking instructions during a small-group mathematics task?* 2) *How did turn-taking as enacted seemingly support or inhibit productive participation by the students in the focal group?*

Theoretical framework

My work draws on sociocultural and situated theories that claim learning happens through participation in cultural activities (Lave & Wenger, 1991; Wenger, 1998) and considers language and discursive practices as central to developmental processes (Lerman, 2001). In this study, my perspectives on equity, learning, and participation are based on those described by Esmonde (2009). Esmonde asserts that "in the context of cooperative group work and participation in mathematical practices, equity can be defined as a fair distribution of opportunities to learn or opportunities to participate" (p. 1010). She views mathematical learning as referencing both the development

of content-related understandings *and* the development of productive positional identities. Esmonde takes a broad view of participation, noting that "Although talk is a valued form of participation in many mathematics classrooms, there may be other valuable forms of participation that are less visible" (p. 1033).

One key part of combatting participation inequities is understanding how opportunities for participation are constructed and taken up through classroom interactions. If opportunities for participation are unfair, then it is reasonable to assume participation (the process through which students learn) will be inequitable as well, since a person's participation in learning activities is a function of the opportunities that person is given to participate (Gresalfi, Martin, Hand, & Greeno, 2009). And those opportunities for participation are shaped by the roles and responsibilities that a student is assigned through acts of positioning (van Langenhove & Harré, 1999) and the access he or she has to the conversational floor (e.g., Erickson, 2005; Lemke, 1990; Sacks, Schegloff, & Jefferson, 1978). Equitable learning processes require that each and every student be positioned as a competent learner and doer of mathematics who has ideas worth sharing and from whom her peers can learn (Schoenfeld, 2014). Students positioned with competence and authority have more opportunities to participate in consequential and influential ways during student interactions, and, therefore, have better access to opportunities for rich mathematical learning in terms of content and identity development (Cohen & Lotan, 2014; Engle, Langer-Osuna, & McKinney de Royston, 2014; Gresalfi et al., 2009; Langer-Osuna, 2011).

Methods

Data collection

Study participants consisted of four students, two girls (Becca & Paloma) and two boys (Kyle & John) from an Algebra 1 class in an urban, public high school. Names were changed. This class used CPM curriculum (cpm.org) and worked in groups on a daily basis. I designed the task and lesson plan featured in this study, and the students' regular math teacher taught the lesson. The math task, called Searching for Sequences, addresses content related to linear growth patterns. Task materials include 16 pattern cards and a playing board, shown in Figure 1. The image below shows the focal group's final task solution.

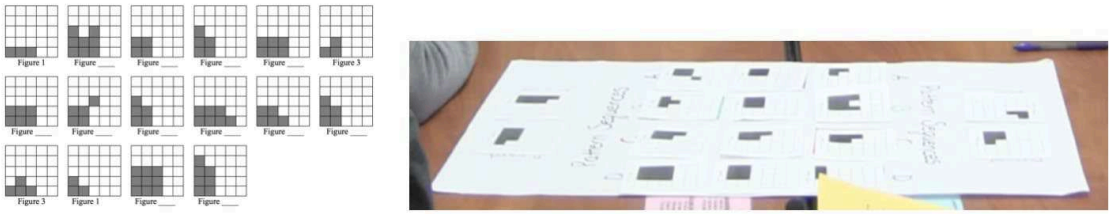


Figure 1. Searching for Sequences task - pattern cards and playing board.

At the start of the task, four pattern cards were dealt to each student and kept hidden from the other students. The task card instructed students to take turns placing (or moving) one card at a time on the board to create four 3-card pattern sequences. Students were asked to justify each card placement by explaining patterns they saw. Cards were designed to allow for multiple correct solutions. Video recorded participants' speech, gestures, body movements, and eye gaze as they worked to complete the task. The video was 15 minutes long, the time it took the focal group to complete the task.

Data analysis

Video was transcribed for speech, card placements, and salient gestures. To get a general sense for the distribution of verbal participation, I totaled the number of words spoken by each person. To account for non-verbal mathematical contributions, I totaled the number of card placements made by each person. A *card placement* was when a pattern card was placed on the board from someone's hand, a card was moved from one location on the board to another, or a card was removed from the board. I also coded each placement as either *noticed* or *unnoticed* by peers. Placements were coded as *unnoticed* if no one, other than the student placing the card, gave an indication of knowing that the placement had been made. Knowledge of placement was based on eye gaze, body position, and subsequent talk.

Periods of turn-taking were then identified by reviewing the video transcription and by re-watching the original video. A *student turn* is defined as a period of time during which one particular student holds the conversational floor in preparation for making a card placement. Building on Engle, Langer-Osuna, & McKinney (2014), for this particular study I define conversational floor as "an evolving, socially negotiated space" (p. 256)

in which one student is allowed (and expected) to present a contribution to the on-going mathematical "conversation" in the form of a card placement. Turns were often signaled by explicit turn-taking language (e.g., "Whose turn is it?" "It's your turn next"). During periods of turn-taking the group focused on one particular student as that student decided what card to place or move on the board to complete their turn; this focus was indicated by students' talk, actions and/or physical positioning. Turns ended when a card placement was made and discussion about that placement ceased. As I started to identify when specific student turns began and ended, I came to realize that there were times when control of the conversational floor was not necessarily held by one particular student. Instead, access to the floor was opened up and contributions (verbal and non-verbal) from other students were welcomed and, in fact, actively solicited by students. This realization led to the identification of what I am calling collaborative-play participation. Periods of *collaborative-play* occurred when the group stopped focusing on one particular student's next card placement and instead focused on answering a question posed by someone in the group or on addressing an identified challenge that emerged from the task.

Once participation was segmented into periods of turn-taking and collaborative-play, I looked for patterns of productive student participation. For the purposes of this study, I define *productive participation* as verbal and non-verbal student engagement that seemingly supports mathematical learning, both in terms of developing conceptual understandings and productive positional identities (Esmonde, 2009). My analysis focuses on the following four types of productive participation: engaging in individual think time (Gambrell, 1983), paying attention to what peers' say and do (Flanagan & Addy, 2019), participating in collective sense-making (Engle, 2012), and offering verbal feedback and suggestions to the group (Phielix, Prins, & Kirschner, 2010).

Findings

Results of this study are organized around the two research questions. I will first describe how the focal group of students enacted or "took-up" the turn-taking instructions that were called for in the task directions and illustrate how turn-taking evolved into collaborative-play. I will then share some ways in which the group's enacted turn-taking seemingly supported productive mathematical participation by group members and some ways in which productive participation was seemingly better supported by collaborative-play.

Evolution of turn-taking into collaborative-play

The Searching for Sequences task card directed students to "Take turns placing one card at a time on the playing board." The instructions also said that students were supposed to explain their reasoning and justify each move they made. After the task card and other lesson materials were distributed, the focal group spent approximately fifteen minutes working on the task. After the task set-up phase, the remaining thirteen minutes of work time was characterized as either periods of *turn-taking* or periods of what I am calling *collaborative-play*. Figure 2 shows how the periods of turn-taking and collaborative-play were distributed over time. The group's work time is divided into four phases of participation: 1. task set-up (2 minutes), 2. strict turn-taking (3 minutes), 3. turn-taking & collaborative-play mix (5 minutes), 4. all collaborative-play (5 minutes).

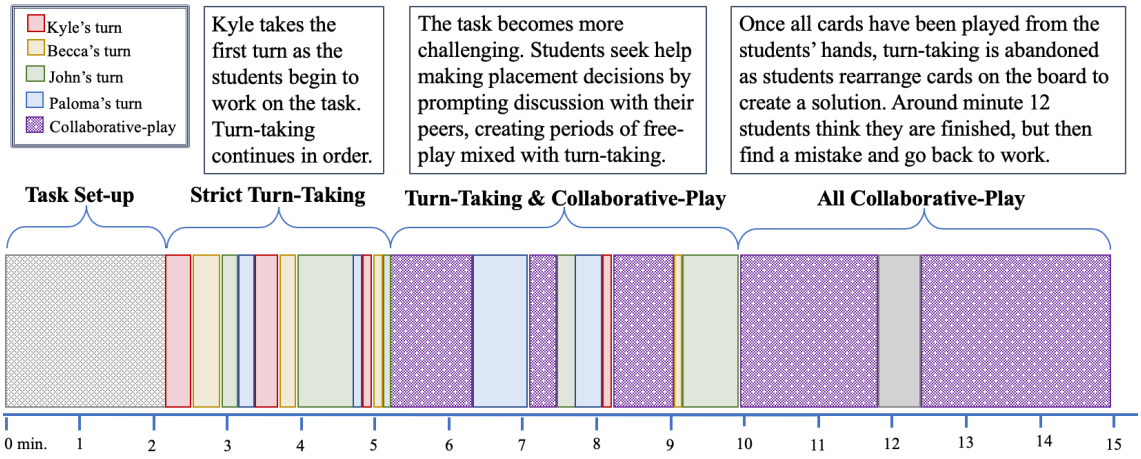


Figure 2. Distribution of turn-taking and collaborative-play over the course of task completion.

During the first 2+ minutes of the task, the group read the instructions, dealt out the pattern cards, and figured out who was going to take the first turn. After the two minutes of task set-up, John pointed at Kyle and said, "Ok, you go first." The group then proceeded to take turns following an agreed upon order for the next three

minutes of work time: first Kyle, then Becca, then John, and then Paloma. During these three minutes of strict turn-taking, there were eleven explicit mentions of turns. Most of these mentions were made by John as he identified whose turn it was (e.g., "Now it's your turn," "It's my turn," "Yeah, it's your turn"). Kyle and Paloma also made mention of turn-taking, but in the form of asking questions as opposed to giving directives ("Did you go?" "So, whose turn is it?"). At 5:18 John posed a question to the group at the beginning of his turn, prompting the first period of collaborative-play. He asked, "Does anyone else have a card that says figure one?" It seemed that he did not know what card to play during his turn and, therefore, was seeking additional information from his peers. For the next five minutes the group alternated between periods of turn-taking and periods of collaborative-play. Just as with the first collaborative-play episode, the collaborative-play periods that followed coincided with times the group encountered specific challenges or confusion. Every shift from collaborative-play back to turn-taking was prompted by an explicit mention of turn-taking after the issue at hand had been resolved: at 6:19 John pointed at Paloma and said, "Ok, it's your turn right now," at 7:22 Kyle asked, "Whose turn is it?", and at 9:01 John pointed at Becca and said, "Ok, it's your turn." Once all pattern cards had been placed on the board with still no coherent solution to the task, students abandoned turn-taking altogether. During the last five minutes of work, the four students worked together in collaborative-play mode to complete the task by rearranging cards on the board until a mathematically valid solution was reached. Around minute 12, students thought they had found a solution. They sat quietly with hands raised waiting for the teacher, but as they sat there, John continued to look at the board. At 12:20 John exclaimed, "Oh wait, hold up. This one doesn't really make sense." The students then went back to work rearranging the cards in collaborative-play mode until the issue identified by John was resolved.

When aggregated, the group's work time after task set-up was split roughly in half between turn-taking (approximately 6 minutes) and collaborative-play (approximately 7 minutes). Participation evolved over time, starting with all turn-taking and eventually ending with all collaborative-play. All members of the group seemed to buy-in to the turn-taking instructions right from the beginning of the task, working together to coordinate turns and respecting (for the most part) that whoever's turn it was had control of the board. John took on the most authoritative role in regulating the group's turn-taking, being the one who most often said whose turn it was and being the one who responded to the other students' questions about turn-taking. It should be noted that while all members of the group cooperatively took turns placing cards on the board, they rarely justified their card placements as the instructions had asked them to do.

Productive participation supported through turn-taking vs. collaborative-play

In this section, I will start by highlighting two aspects of productive participation that were seemingly supported by turn-taking (i.e., engaging in individual think time & paying attention to peers' card placements). I will then share two other aspects of productive participation that were seemingly supported better by collaborative-play (i.e., the group's collective sense-making & Becca's verbal participation).

Turn-taking

The routine of turn-taking seemed to slow down the pace of task completion, providing space and time for individual students to think about what their next card placement might be. Data show students participated in extended *think time* when it was their turn, but also when it was someone else's turn as they considered what their next move might be when it came to be their turn. Evidence for this claim can be found by examining an episode that began at 6:19. Following a period of collaborative-play, John pointed at Paloma and said, "Ok, it's your turn right now." Biting her fingernail, Paloma looked down at the board and then at the pattern cards she held in her hand. Kyle chimed in, "I think I have one that might go with this one," pointing toward Sequence A on the board. Pointing toward the same sequence, Becca added, "I have one that goes- I think." Paloma shared, "But I have- it doesn't make any sense." Kyle then asked, "Whose turn is it?" Paloma responded, "Mine, but I don't know what to move." After 35 seconds more of consideration, Paloma placed a card from her hand in a discard spot on the board. During this turn, Paloma was unsure of what card to place. She spent time staring silently at the board and at the cards in her hand. Instead of making a random placement without thinking much about it, Paloma took time to consider various possibilities before eventually deciding on her next move. Paloma's speech, her actions, and the length of her turn support the claim that she engaged in extended think time. The comments made by Kyle and Becca suggest that they, too, were engaged in their own individual think time as they considered what their next moves might be after Paloma's turn. The turn-taking structure held the space and time needed for Paloma to come to her decision and make her placement. Without that structure in place, it seems likely that Kyle and/or Becca would have placed their cards on the board ahead of Paloma, perhaps not allowing Paloma to resolve her confusion or complete her thought.

In addition to providing space for think time, the routine of turn-taking also distributed access to the conversational floor across group members and encouraged students to pay attention to the card placements made

by their peers. As turns rotated from student to student, the group's collective focus shifted accordingly; students waited and watched as their peers placed one card at a time on the board. Twenty out of the 21 card placements made during periods of turn-taking were noticed by peers (assumptions of *noticing* were made based on students' eye gaze, body positions, and subsequent talk). The one placement that was made without being noticed by anyone in the group was made by Becca during one of Paloma's turns. The group had been talking about the option of placing cards in the discard locations on the board. A split second before Paloma discarded one of her cards, Becca slipped one of her own cards out of her hand onto a discard spot in front of her on the opposite side of the board from where the rest of the group was focusing on Paloma's placement. Throughout the duration of task completion, Becca spoke considerably less than the other students in the group (see Table 1); John spoke *ten times* as many words as Becca.

Table 1: Number of words spoken over the course of task completion

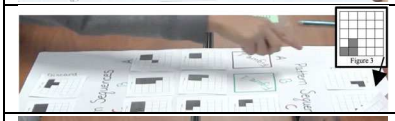
	Kyle	Becca	John	Paloma
Turn-taking	109	25	328	230
Collaborative-play	107	47	342	248
Total	216	72	670	478

In fact, Becca made her first three card placements without saying a single word about any of them. Despite the silence surrounding these placements, all three were noticed by her peers because she made these placements during her turn and the group's attention was focused on her. Although Becca did manage to make one *invisible* placement during periods of turn-taking, it seems reasonable to suspect that more of her placements would likely have gone unnoticed without the turn-taking structure in place. It is worth noting that Becca made five card placements during collaborative-play that went completely unnoticed by her peers.

Collaborative-play

Episodes of collaborative-play developed organically out of students' need to consult with their peers before making card placements. It is therefore not surprising that periods of collaborative-play were characterized by episodes of collective sense-making by the group. As the students shifted from turn-taking to collaborative-play, responsibility for making a decision or resolving an issue transferred from an individual student to the group as a whole. This sense of shared responsibility offered more support for the student in the designated turn-taking "hot seat." One instance of the group's collective sense-making is illustrated by the episode in Table 2.

Table 2: An episode of collective sense-making by the focal group

	Kyle takes his turn by placing a card in a Figure 3 spot. Paloma smiles and responds, "We need two figure ones." It should be Becca's turn now, but no one looks to her. Instead, they focus on the Figure 1 dilemma.
	A few seconds later Kyle suggests, "Oh, maybe that one goes here. It's increasing by one." As he speaks, he points to one of the cards in a discard spot, then points to the empty Figure 1 space in Sequence A.
	Paloma chimes in, "No, that's figure, that's figure-," pointing to the card Kyle suggested moving. She was protesting Kyle's suggestion since the card is labeled "Figure 3," making it ineligible for the Figure 1 spot.
	John cuts off Paloma, saying, "Orrrr, what if we're taking away squares?" Before anyone has a chance to respond, John continues, "No. No- can't do that. It only adds squares."
	Kyle builds on John's idea adding, "Yeah, maybe this one is 3, 4, 5," as he points first to the Figure 1 position, then Figure 2, then Figure 3. When Kyle says "3, 4, 5" he is referring to the number of squares in each figure.
	Paloma repeats her protest from earlier saying, "No, but it's figure 1 and that doesn't-." She points first to the Figure 1 spot on the board, then to the card in the discard spot, then gestures toward Figure 3.

	Responding to Paloma, Kyle says, “Oh! I think I got it.” He moves the Figure 3 card to the Figure 1 spot, then points to the discarded card. “And that's figure 3, so that here,” pointing to the newly opened Figure 3 spot.

This episode of collaborative-play began after Kyle placed a card in a Figure 3 spot. Smiling, Paloma pointed out that the only two spots left open on the board were two Figure 1 locations. Instead of moving on to Becca’s turn, the students responded to Paloma’s comment by trying to identify a card to place in a Figure 1 spot. It was the challenge set forth by Paloma that seemingly distracted the students from the turn-taking routine and called on the group to resolve this issue collectively. Kyle was the first to suggest a solution, which Paloma rejected due to conflicting figure numbers; the card said “Figure 3” but Kyle suggested putting it in a Figure 1 location. John then offered a different idea, suggesting the pattern might decrease instead of increase. Before anyone else had time to respond, John rejected the idea himself. Kyle responded as if he was agreeing with John, but his suggestion did not, in fact, align with John’s idea. Paloma once again rejected Kyle’s suggestion by pointing out the same issue of conflicting figure numbers. Kyle then made a new suggestion, which did align with John’s idea of making a decreasing pattern. He suggested moving the card in the Figure 3 location to the Figure 1 spot, then putting the discarded card into the newly opened Figure 3 spot. After the placements were made, resolving the issue at hand, John asked, “Alright, whose turn is it right now?” The period of collaborative-play ended as the group’s focus shifted back to Becca as it was determined that it was her turn.

The preceding vignette demonstrates how this group of students engaged in collective sense-making during an episode of collaborative-play. After Paloma identified an issue that needed to be resolved (finding a card to place in a Figure 1 spot), the challenge was taken up by the whole group. Even though Becca did not speak during this episode, she appeared to be listening and fully engaged. She leaned in toward the board with her eyes moving back and forth between speakers and the playing board. The other three students shared ideas, identified complications, and eventually agreed upon a solution. John’s idea which he, himself, initially rejected, was ultimately taken up by Kyle and led to a solution to the issue raised by Paloma. The building on and challenging of ideas supported the students in reaching a truly collaborative joint-resolution, followed by big student smiles. These types of collective sense-making exchanges happened throughout the group’s work time and often included verbal contributions by Becca as well. However, they occurred only during episodes of collaborative-play.

Though turn-taking seemed to support Becca’s *card placement* contributions, collaborative-play seemed to provide more support for Becca’s *verbal* contributions. Figure 3 shows all of Becca’s talk and all of her card placements over time. The background colors indicate whether talk and placements occurred during Becca’s turn, during someone else’s turn, during periods of collaborative-play, or while the students waited for the teacher.

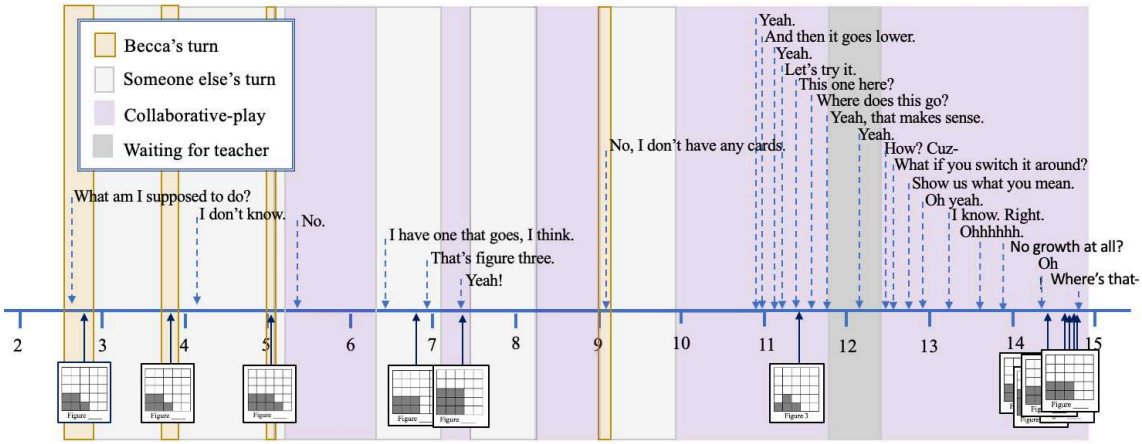


Figure 3. Becca’s speech and card placements over the course of task completion.

Becca spoke very little up until the 11-minute mark, and her talk was *individual* in nature. She spoke of herself as one person, separate from her peers, who had individual responsibilities. She used the word “I” five times (e.g., “What am I supposed to do?” “I don’t have any cards”) before her verbal participation changed considerably around the 11-minute mark. She started talking to her peers and continued talking consistently until the end of the task. Her talk-turns remained short, but they were expressive. She gave verbal agreement (e.g., “Yeah”), she made mathematical suggestions (e.g., “What if you switch it around?” “No growth at all?”), and she encouraged her groupmates (e.g., “Let’s try it.” “Show us what you mean.”) During the final five-minute stretch of collaborative-

play Becca's comments were collective or *joint* in nature. She spoke of herself as a member of a group, connected to her peers, who together were sharing responsibility for the task. She used the word "I" only once during this time and that was to indicate agreement with one of her peers (e.g., "I know. Right"). One explanation for this definitive shift in Becca's participation could be that after the final turn was taken around minute-10, the rules of the game changed. All cards were on the board, although they had not yet been arranged in a coherent solution. Cards no longer belonged to individual students; they were open for everyone to see and consider. No one was put on the spot and forced to make a move if not ready to make one. Everyone was confused together; students were no longer confused alone. It was perhaps safer and easier for Becca to verbalize her thoughts during that final period of collaborative-play than it was while turn-taking was still in play.

Discussion

The group of four students featured in this study started the Searching for Sequences task with strict adherence to a turn-taking routine. All members of the group seemed to buy-in to turn-taking, working together to coordinate turns, shifting focus to whosever turn it was. Modes of participation evolved over time, from all turn-taking to eventually all collaborative-play as the need to consult with peers to address challenges arose organically. Analysis shows that the nature of participatory interactions was indeed different during periods of turn-taking and periods of collaborative-play. Turn-taking supported *individual* contributions by slowing down the pace of task completion and by distributing access to the conversational floor across group members (e.g., Erickson, 2004; Lemke, 1990; Sacks, Schegloff, & Jefferson, 1978). The slower pace and the collective focus on the turn-taker allowed time and space for individual student think time (Gambrell, 1983) and encouraged students to pay attention to the actions of their peers. In contrast, collaborative-play supported *joint* contributions by shifting responsibility for decision-making and issue resolution from an individual student to the group as a whole. This sense of shared responsibility and group support prompted the students to engage in collective sense-making (Engle, 2012) and created a safer space for students (especially for Becca) to express tentative thoughts and ideas.

Turn-taking and collaborative-play supported different types of productive student participation; turn-taking fostered individual contributions and collaborative-play fostered joint contributions. Both types of contributions are necessary for students to develop as competent and confident learners and doers of mathematics (Schoenfeld, 2014). I am not making any claims about which mode of participation was better. Rather, it is important to understand how interactions among students differed during turn-taking and collaborative-play and how the resulting opportunities to participate and learn differed as well. Turn-taking and collaborative-play served different functions, which ultimately resulted in a coherent, mathematically sensible solution, a joint-product to which every student, including Becca, contributed. Findings suggest that the two modes of participation supported complementary, and most likely, interdependent types of productive participation during small-group work. Eliciting equitable, meaningful participation among group members is not easy, yet is necessary for supporting the development of rich content knowledge and productive positional identities for every student. Improving our understanding of how specific participation structures, like turn-taking, are taken up by students and how they impact students' learning experiences will help educators plan for, implement, and reflect on small-group learning tasks aimed at combatting issues of equity within mathematics classrooms.

The findings in this paper illustrate how turn-taking played out for this one particular group of students, working on this one particular task, on this one particular day. In order to get a better idea of how turn-taking and collaborative-play, more generally, might support or inhibit certain types of small-group participation, it is necessary to expand analysis beyond one group and one task. In addition, the scope of participation analysis could be expanded. Looking more closely at the content of what was said and done, at how students positioned themselves and each other (van Langenhove & Harré, 1999), and at individual students' sense-making over time would provide a more nuanced understanding of how turn-taking and collaborative-play might have supported each student differently with respect to opportunities for development of content knowledge and positive positional identities. It would also be interesting to have groups of students engage in this task without giving them the explicit turn-taking instructions, allowing them to begin the task in collaborative-play mode. However, it is entirely possible that the collective sense-making and rich discussions that took place during the collaborative-play periods in this study would not have happened without the periods of turn-taking in the beginning. John may have dominated; Becca may not have been able to find ways to enter the conversational space at the onset and may have consequently disengaged. The periods of explicit turn-taking may have allowed Becca the time and space she needed to understand the task, to make sense of the mathematical patterns, and to contribute to the group's collective product in quiet but consequential ways, helping her build confidence and comfort as the task progressed. There is no way to know what would have happened in this case without the turn-taking instructions in place, but it is an interesting question worth exploring in future research.

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