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Using Strategic Interruptions to Effectively Integrate Whole Class and Small Group Instruction in Mathematics

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Abstract: In this paper we explore a new way to think about the use of group work in mathematics instruction through what we refer to as strategic interruptions. Strategic interruptions involve frequent and often rapid transitions between whole class and small group instruction. Through analyses of video of Algebra I teaching, we identify patterns in the frequency, timing, rationale, and instructional practices related to the use of and switching between whole class and small group instructional formats. We postulate that use of strategic interruptions has the potential to be a powerful and easily implementable form of group work that may be especially appropriate in secondary classrooms.

Keywords: Group work; Whole class instruction; Strategic interruptions; Secondary school; Ambitious instruction

Introduction

In the US and elsewhere, research and policy in mathematics education have attempted to articulate a set of instructional practices that are believed to optimally support the development of students' understanding of mathematics. Implementing these instructional practices, which some have deemed "ambitious instruction" (Franke, Kazemi, & Battey, 2007; Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010), is challenging. Ambitious instruction in mathematics incorporates many forms of pedagogy that some teachers may feel are outside their comfort zone, including monitoring the emerging understanding of all students, ensuring that all students are appropriately challenged, incorporating new instructional technologies, and using a variety of instructional groupings such as small group work. Yet ambitious instruction is important because it appears to represent our best efforts to ensure that all students can and will achieve to their potential for learning mathematics.

The use of cooperative group work is generally recognized to be a core component of ambitious instruction. For at least the past 30 years, extensive research on cooperative groups has been conducted, with the general result that the use of group work in mathematics classes has both academic and social benefits to students

(Boaler, 1997, 2006, 2008; Cohen, 1994; Slavin, 1980; Yackel, Cobb, & Wood, 1991). Although there are many ways that group work can and has been used in mathematics classrooms, one very typical way that some teachers utilize this instructional practice is for students to work on an often rich and open-ended task in small groups, often for a substantial period of time within a single lesson.

Despite its promise, the use of group work poses particular instructional challenges. For example, students may not work cooperatively, status issues may interfere with learning, academically heterogeneous groups may be difficult to manage, and the teacher's role in monitoring and supervising group work may be confusing and uncomfortable. Furthermore, the teacher must be mindful of the "groupworthiness" of the task assigned (Cohen, 1994), create classroom norms to facilitate positive group functioning, and ensure that classroom management is kept under control while monitoring accountability and participation of all members of each group.

Anecdotally, the use of group work seems to be more common in the elementary and middle grades, as compared to in secondary schools. There may be a number of reasons for this disparity; for example, secondary mathematics teachers may be under greater pressure to quickly move through topics and thus may feel there is insufficient instructional time for pedagogies such as group work. Secondary teachers may be less comfortable implementing group work and/or may have less experience with this form of instruction.

In this paper, we explore a new way to structure and think about group work in mathematics instruction that may be especially promising at the secondary level. In an analysis of Algebra I teachers whose students performed well on a standardized assessment, we compared the teaching in these high-gain classrooms to other classrooms with much lower gains and searched for aspects of teachers' instruction that were perhaps linked to students' gains, or lack thereof. Of particular interest was how the high-gain teachers used whole class and small group instructional formats. Here we explore how, when, and why teachers moved from whole class to small group and from small group to whole class instruction, with particular interest in what we call *strategic interruptions*. We postulate that the use of strategic interruptions, with frequent transitions between whole class and small group instruction, has the potential to be an easily implementable form of group work that may be especially appropriate and powerful in secondary mathematics classrooms.

Group Work, Whole Class Instruction, and Effective Teaching of Mathematics: A Review

Arguably, group work is one of the most well-researched and reviewed forms of teacher pedagogy, at least in the past 30 years. Drawing from Dillenbourg (1999), here we define group work as students talking and/or working with one or more peers, including partnerships of two or triads of three. Note that some scholars distinguish between *cooperative* and *collaborative* group work: The adjective *cooperative* appears to be more widely used to refer to group work in elementary school settings, while term *collaborative* is more typically used for group work in university settings. A central aspect of cooperative learning holds individual students accountable for learning collectively without competition; the teacher creates roles for students, intervenes throughout group work, and explicitly teaches students the social skills to work together productively (Cohen, 1994; Johnson & Johnson, 1987; Sharan & Sharan, 1992). Collaborative learning is less structured and shifts responsibility to the groups rather than the teacher (Bruffee, 1995, 1999; Panitz, 1999); collaborative group work assumes that university students are socially equipped to work productively and by shifting responsibility to the groups lessens the hierarchical nature of the professor-student relationship to encourage active engagement of students rather than passive memorization of professor lectures (Bruffee, 1999). Although the distinction between cooperative and collaborative group work is not central to the present paper, our vision and definition of group work more closely aligns with the use of the term *cooperative* group work.

There have been over 900 research studies supporting the effectiveness of cooperative group learning over individual or competitive learning (Johnson, Johnson, & Stanne, 2000). Based on this literature, cooperative learning has been advocated for several reasons. First, student motivation is increased through cooperative learning (Johnson & Johnson, 1987; Slavin, 1990). A group reward system where individuals can only attain their goals through the success of the group facilitates an environment where students encourage each other's attendance, effort, and learning, unlike a more competitive class where individuals are rewarded at the expense of others (Deutsch, 1949; Johnson & Johnson, 1987; Slavin, 1990). Cooperative learning has been found to create norms where equity is promoted and students gain social status through their academic achievement (Boaler, 2008; Cohen & Lotan, 1995; Cohen, Lotan, Scarloss, & Arellano, 1999; Slavin, 1980). Secondly, group work builds upon the cognitive theories of Vygotsky's zone of proximal development and Piaget's social arbitrary knowledge where interactions with others are essential to learning (Slavin, 1980). Third, group work provides opportunities for student talk to improve student learning (Barnes & Todd, 1977;

Yackel, Cobb, & Wood, 1991). In addition to achievement gains, group work has also demonstrated improvements in interracial relations (Boaler, 2006, 2008; Slavin, 1980), self-esteem, attitudes toward school, and peer friendships (Johnson & Johnson, 1987).

However, despite the academic and social affordances of group work, successful implementation of group work can be quite challenging. In particular, research on group work has identified a specific set of features that should be present for group work to be optimally beneficial to students. For example, Johnson and Johnson (1987, 1999) suggested five elements for positive group work: positive interdependence, individual accountability, face-to-face promotive interaction, social skills, and group processing. Similarly, Slavin's (1990) review of 60 studies on cooperative learning reveals increases in student achievement only if group goals and individual accountability are incorporated in classroom practice. Various formal structures for group work have been created, in the attempt to make the inclusion of these necessary features easier for teachers. These formal structures include Student Teams Achievement Divisions (Slavin, 1990), Complex Instruction (Cohen, 1994), Cooperative Learning Strategies (Kagan, 2009), Group Investigation (Sharan & Sharan, 1992), and Constructive Controversy (Johnson & Johnson, 1987). In addition to these specific group structures, scholars suggest attitudinal conditions (Williams & Sheridan, 2010), status treatments, multiple abilities perspectives, and role assignments (Cohen, 1994) to address the challenges of implementing group work.

This great complexity of setting up positive group learning experiences raises the question of the feasibility of frequent and successful teacher implementation of group work. Despite the documented benefits of group work, the literature suggests that successful implementation is not especially common. Teachers' actual use of group work in the classroom often does not resemble cooperative learning (Antil, Jenkins, Wayne, & Vadasy, 1998). Some suggest that implementation difficulties may be due to a lack of teacher understanding of the principles necessary for optimal use of group work (ibid.), while others propose that teachers understand what good group work looks like but merely have difficulty in orchestrating and integrating all of the necessary components such as designing appropriate tasks, individual accountability, and group goals (Vermette, 1994).

Of particular interest here is another complementary explanation for challenges to teachers in implementing group work, namely, teachers are unclear *how*, *why*, and *when* they should intervene during group work. Our experience suggests that many teachers believe that group work is optimally implemented by giving students rich tasks and then providing significant chunks of relatively uninterrupted class time for

groups to work. Yet the literature is clear that group work is most effective when teachers interact with students while they are working in groups, including intervening, questioning, and clarifying (e.g., Chiu, 2004). When teachers fail to interact with students who are engaged in a group activity, group work is a much less effective instructional strategy (Ding, Li, Piccolo, & Kulm, 2007). Indeed, student involvement can drop as much as 50% (Fisher et al., 1978, as cited in Bennett, 1991). Teacher interventions during group work can improve student cooperation, time on task, and depth of explanation (Meloth & Deering, 1999). Ding, Li, Piccolo, and Kulm (2007) noted that interventions during group work can be at the individual level (e.g., teacher has a one-on-one conversation with one member of a group), the small group level (e.g., teacher has a conversation with one of the student groups in the class), and whole class level (e.g., halting group work to bring the whole class together); each of these types of interventions can help answer questions that many groups have, clarify the tasks, and reduce confusion to promote students' thinking. Similarly, Dekker and Elshout-Mohr (2004) observed that students benefit when teachers' intervention during group work can focus on both the dynamics of group functioning (*process-help interventions*) and the mathematical content (*product-help interventions*). Appropriate intervention into student group work is difficult, and we hypothesize that group work has failed to be implemented effectively for many teachers, at least in part because teachers do not know how, why, and when to intervene.

In this paper, we propose an alternative conception of group work that we believe can result in similar affordances yet possibly avoids common pitfalls by paying close attention to the issue of teacher intervention during student group work. Here we explore the possibility that frequent, brief periods of cooperative group time, interspersed throughout whole class instruction, can achieve many of the benefits of group work, without imposing as many of the above-mentioned implementation challenges. We arrive at this alternative potential use of group work by observing the teaching of successful teachers (as we describe in more depth below). These teachers did not use any of the scripted group structures previously mentioned, nor did they appear to attend to the strategies suggested by the literature, such as assigning group roles, ensuring group worthiness of the task, using a multiple abilities treatment, or creating interdependence amongst members (Cohen, 1994; Johnson & Johnson, 1999). Rather, their instruction was characterized by frequent, brief moments of cooperative time, interspersed throughout their whole class instruction. Rather than provide students with long periods of relatively uninterrupted time for working in groups, these teachers tended to frequently transition back and forth between whole class instruction and small group work. Our findings suggest that this may be an effective instructional practice.

We are aware of the possibility that this alternative instructional strategy of frequently transitioning between whole class and small group work may introduce its own difficulties; certainly transitioning between instructional formats is itself challenging for teachers. In fact, transitioning between activities has been found to consume as much as 25% of non-learning activities (Fisher et al., 1978, as cited in Bennett, 1990), and disruptive behavior often occurs during transitions (Arlin, 1979; Kounin, 1970). However, successful transitioning routines that are simple, quick, efficient, and easy to implement have been devised by numerous researchers and practitioners (Arlin, 1979; Emmer et al., 1980; Lemov, 2010; McIntosh et al., 2004). In addition, some research has suggested that the most effective teachers employ the most transitions per class lesson (Smith, 1985).

Among the potential benefits that can occur through frequent and successful transitions between group work and whole class instruction are increased opportunities for formative assessment, or activities used by teachers to gain feedback to modify teaching and learning (Black & Wiliam, 1998). The use of formative assessment has been found to be linked to increases in student learning (Black & Wiliam, 1998; Wiliam et. al., 2004) by improving student motivation and metacognitive skills through ongoing interactive feedback (Crooks, 1988; Shepard, 2005). Frequent transitions between whole class and small group work allow teachers to communicate shared expectations for student performance and gather data on current performance, with the goal of closing the gap between students' current and goal performance (Black & Wiliam, 1998). In the rest of this paper, we describe several vignettes of these strategic interruptions.

Method

Participants

The participants were 74 eighth and ninth grade classroom teachers from public and private middle and high schools in urban, suburban, and rural communities in the state of Massachusetts who participated in a larger study evaluating the impact of a supplemental Algebra I curriculum. Teachers volunteered to participate in the study, where participation involved attendance at a weeklong summer professional development institute, periodic use of a supplemental Algebra I curriculum, and regular videotaping of their instruction. They were provided with a small video camera, videotaped themselves as they taught, and then uploaded the videos to a secure project website. They had complete discretion as to which lessons they videotaped; the research team did not indicate a preference for what types of classes the teachers should videotape.

In addition, teacher participants administered and submitted assessments of student learning, including a standardized commercially available Algebra I readiness examination, at the beginning and end of the Algebra I course. Teachers were randomly assigned to control and treatment groups, with treatment teachers implementing the supplemental Algebra I curriculum and control teachers using their "business-as-usual" district-mandated curriculum. Both treatment and control teachers submitted videotapes of their lessons. Control teachers were asked to submit one video each month, while treatment teachers were asked to submit two videos each month: one where the lesson included the use of the supplemental Algebra I curriculum and one where the lesson did not use these supplemental materials.

Our interest here is in possible differences in instruction between teachers (in both the treatment and control conditions) whose students achieved relatively high gains on the end-of-year assessments, as compared to teachers whose students achieved relatively low gains. For the purposes of this analysis, we included only the 62 of the 74 teachers in the larger study whose students had completed both the pretest and the posttest of the algebra readiness assessment. We began by selecting the teachers whose students had the highest and lowest gains (post-test score minus pre-test score) on the algebra readiness assessment. Across the entire sample of 62 teachers, students on average achieved gains of 6.0% on the algebra readiness assessment. We then selected the 10 teachers whose students had the highest gains on this measure and the 10 teachers whose students had the lowest gains. We created a subset of five high-gain and five low-gain teachers, such that each group of five teachers had submitted a minimum of four non-treatment videos and also contained a mix of treatment and control teachers as well as 8th grade and 9th grade teachers. As shown in Table 1, the five high-gain teachers' students had average gains of 11.3% on the algebra readiness measure, while the five low-gain teachers' students had average gains of -1.2% (i.e., students' scores at post-test were lower, on average, than their pre-test scores).

Data sources and analysis

The analysis of the videos was conducted collaboratively by members of the research team, including both authors. The goal of the analysis was to determine whether there were any types of instructional practices that seemed to be especially prevalent among the high-gain teachers' instruction and largely absent in the low-gain teachers' instruction. Each researcher began by independently watching all high-gain teachers' video, attempting to identify instructional elements that appeared to be frequently occurring in high-gain teachers' lessons. The members subsequently met to discuss these emergent themes in the data, followed by a re-viewing of the high-gain teachers' videos to search for evidence and counter-

evidence of the presence of common and frequently occurring instructional practices among high-gain teachers. This analysis of high-gain teachers' videos continued iteratively, leading to several hypotheses about potentially promising features of high-gain teachers' instruction. At this point, all members of the research team watched (for the first time) all low-gain teachers' videos, with the goal of identifying which (if any) of the promising instructional features in high-gain teachers' lessons were also present in low-gain teachers' instruction. As before, the members met to discuss emerging analysis of low-gain teachers' videos and then re-watched these videos.

Table 1
Description of High-gain and Low-gain Teachers

	All teachers (*n* = 62)	**High-gain teachers (*n* = 5)**	**Low-gain teachers (*n* = 5)**
Mean gains, algebra readiness assessment (post-pre)	6.0%	11.3%	-1.2%
No. of Treatment teachers	38	2	2
No. of Control teachers	24	3	3
9th grade teachers	22	2	3
8th grade teachers	40	3	2
Average no. of non-treatment videos submitted[a]	5.0	5.6	6.6

[a] Treatment teachers also submitted videos where the supplemental Algebra I materials were used. But for the present analysis, we only viewed videos submitted by treatment teachers that did not include the use of the supplemental curriculum materials.

As a result of this iterative process, the most salient difference that was identified between high- and low-gain teachers' instruction concerns the ways in which teachers interrupted and transitioned between both whole class and partner or small group instruction, in particular, features of interruptions and transitions between whole class and small group instruction that were especially prevalent in high-gain teachers' instruction and largely absent in low-gain teachers' lessons. The members then returned to the videos to try to identify examples and non-examples of these types of interruptions, in an attempt to begin to formulate a theory of strategic interruptions, as described below.

Toward a Theory of Strategic Interruptions

We define *strategic interruptions* as follows. By *interruptions*, we refer to moments in a teacher's lesson where he or she stops what students are doing and transitions the class from one instructional format (whole class or small group) into another instructional format (small group or whole class). With *strategic*, we indicate that the teacher's move from one instructional format to another is deliberate and

thoughtfully related to the instructional goals of the lesson. We use the term *interruption* rather than transition to signal that the switch into another instructional format may be very brief, even as short as 30 seconds or less, before the class returns to the original instructional format. For example, a teacher may engage in a strategic interruption of small group work after noticing a common mistake or misconception that he or she wants to highlight for all students. Conversely, a teacher may strategically interrupt whole class instruction by asking students to talk with their partner for a minute about a question that has just been posed to the class. However, an interruption is *not* strategic when a teacher calls attention back to whole class instruction simply because students have completed their work in small groups; switches in instructional format that occur at the natural termination of an activity are an instructional transition but lack the deliberateness that we feel is the hallmark of a strategic interruption. Similarly, we do not consider an interruption to be strategic when a teacher makes a transition to or from whole class instruction without explicitly indicating a preference for what should happen next, such as when a teacher moves students out of whole class instruction without explicitly stating a preference for whether students subsequently work individually, with a partner, or with a group. As before, greater deliberateness is key to our conception of strategic interruptions. Table 2 provides a summary of the defining features of strategic interruptions.

Table 2
Defining Features of Strategic Interruptions

Defining feature	**Is…**	**Is not…**
Interruption	A brief period (e.g., up to 2 minutes) spent in a new instructional format (to or from group/partner work) followed by a return to the original instructional format.	A transition to another instructional format, where students spend more than two minutes in the new format.
Strategic	The switch to new instructional format is deliberate and prompted by data gathered through formative assessment or is motivated by a desire to gather data through formative assessment. Intended to address student misconceptions or questions and/or highlight student questions and/or thinking.	Purpose of interruption is solely logistical or accidental.

There are two types of strategic interruptions: interruptions of whole class instruction and interruptions of small group work. These are described below.

Strategic interruptions of whole class instruction

These interruptions occur during whole class instruction, where the teacher may interrupt his or her whole class instruction, pose a question or task, and ask students to work with a partner, before returning as a whole class. These interruptions tended to be very brief, approximately 30 seconds of "turn and talk with your partner for a bit", after which the class returns to whole class instruction.

This type of interruption may be very useful for several reasons. First, as suggested above, short periods of partner communication afford the teacher a means of formative assessment to gather real-time feedback for use in fine-tuning and adjusting instruction to students' learning. Second, the feedback and anecdotes obtained by the teacher can be used when returning to the whole class instruction (e.g., "I heard John and Paul talking, and they raised a good question …"), providing opportunities to make student thinking public to highlight model questioning, raise the peer status of a student, or increase engagement through inclusion of student voice. Third, this type of interruption can allow for the opportunity for students to talk (to each other) to explore, learn, and solidify their understanding of the mathematics (Cohen, 1994; Johnson & Johnson, 1987; Labinowicz, 1987; Yackel, Cobb, & Wood, 1991).

We also see challenges to implementing this form of strategic interruption. In particular, it may be difficult for the teacher to regain students' attention back to whole class instruction after the brief partner chat. Second, students may not use the brief period of small group time productively, such as by not discussing the assigned prompt given by the teacher. Third, these quick small group interactions require that the teacher gives very clear and concise questions or tasks that can be reasonably accomplished in a short period of time. In order to make strategic interruption of whole class instruction more concrete and also to showcase its potential affordances and constraints, we provide three illustrative vignettes below, two from high-gain teachers and one from a low-gain teacher.

Ms. Bennett was an 8th grade mathematics teacher from a small urban public K-8 charter school where 61.3% of students qualified for free or reduced lunch. During the whole class portion of a lesson on solving systems of linear equations, Ms. Bennett wrote the following equations on the board:

1. $a + b = 9$
2. $a = 9 + 4a$ $\qquad$ $b - 4 = 9$

Ms. Bennett then interrupted whole class instruction with a brief period of partner work by asking students to

> Talk to your neighbor real quick. What is the difference between problem 1 and the two different problems for problem 2? Why is it really easy to find the answer to problems in 2 and really impossible to find one specific answer for problem 1?

Ms. Bennett gave student groups 25 seconds to consider these questions while she circulated; she then resumed whole class instruction by saying,

> Snap your fingers once please. Let's look back at $a = 9 + 4a$ (from problem 2), and let's see if we're positive, because Khari said it was negative 3 and then he said positive 3. Does somebody want to tackle this, how can we make sure that we've got the right answer here because Luisa definitely doesn't agree. So I don't know. Luisa's right? Khari's right? Somebody's right. Travis what do we have here, we have $a = 9 + 4a$ what do you think we should do?

Travis then told Ms. Bennett what to write on the board to substitute 3 for a in the equation to check to see if both sides equal each other. Ms. Bennett wound up with $3 = 21$ and then asked if Travis thought that it was the right answer. Ms. Bennett then substituted -3 in for a arriving at $-3 = -3$. She then interrupted whole class instruction again for a brief period of partner work, saying,

> Luisa, nice job catching that. You had the right answer and then you were convinced, by somebody. Take a second and write down what you think for that first question. Why can't we determine a in the first equation, and why can we determine it in the second equation? So please take a second and write down a sentence that answers that, that you agree with. Why can't we tell for sure what a is here but we can tell for sure what a is down here? [She points at the different equations.] What's the difference between those two equations?

Students were expected to write down their response to this question and to share it with their partner. Ms. Bennett continued her instruction in this manner, frequently alternating between whole class discussion and partner work; she interrupted her whole class instruction 10 times in the course of this single lesson.

We highlight this particular example of Ms. Bennett's use of strategic interruptions because it illustrates several of the affordances outlined above. First, Ms. Bennett used the partner chat interruption as an opportunity to formatively assess and gather feedback by circulating, listening to, answering questions, and speaking with pairs of students. Second, Ms. Bennett shared the feedback that she gathered with the

class, highlighting two students' thinking by name and thus attributing the ideas to them. Third, she explicitly instructed students to speak with a partner and provided a clear and manageable task for students to complete in a short period of time.

Additionally, this vignette illustrates how Ms. Bennett tried to address some of the challenges of using this form of strategic interruption. She used a "snap your fingers once please" routine to quickly and efficiently regain students' attention. She kept the partner chat time to a brief 25 seconds. (In other instances, Ms. Bennett consistently allowed for a maximum of 30 seconds for this type of interruption, which appears to contribute to students' staying on task). She also maintained accountability and possibly gained engagement by highlighting students' thinking when reconvened as a whole class. Her routines and consistency appear to have created socio-mathematical classroom norms around this type of activity, where students expected these brief and frequent interruptions of whole class instruction to confer with a partner to question, conjecture, and further understand the mathematics.

A second teacher, Ms. Robbins, provides another example; she was also a teacher whose students achieved high gains on the algebra assessment that was administered at the beginning and end of the year. Ms. Robbins was an 8th grade mathematics teacher in a low poverty suburban public middle school and had been teaching for 11 years. She used partner chats so frequently that she did not appear to need a specific routine, like the finger snap used by Ms. Bennett, for calling the class back to whole class instruction. She simply said, "Ladies and gentlemen," to regain their focus as a whole class. She too had created norms and expectations for partner chats as strategic interruptions of whole class instruction. In fact, Ms. Robbins used strategic interruptions as her preferred technique for posing questions to the class. During whole class instruction, she typically asked a question and, rather than calling on a student to answer, she explicitly told students to talk to their partner about the question. After students had approximately 30 seconds to confer with a partner, she called attention back as a whole class and solicited responses from individual students. For example, in one of her lessons, she introduced the day's material with an overview and goal. This was followed by an interruption of whole class instruction to check to see whether students understood what the goal of the lesson was:

> Okay, ladies and gentlemen, what we are going to work on today is adding in how we use absolute value into an equation. So we're good at solving equations, we're good at absolute value, and we're going to put those together. In the beginning we're just going to use common sense and guess and check, but we want to develop a method that is more efficient than

> guess and check, so when you start with some easy problems I want you to think about what am I doing here and how can I apply this to a more complicated problem? Okay, so put that goal into your own words to make sure that we are all on the same page. Tell your partner what our goal is.

A short period of partner work (about 20 seconds) was followed by whole class instruction again. Ms. Robbins then explained the new directions regarding the projected problems on the white board.

> So let's see what this means. Your choice whether you write this down or you just talk about it. What are the possible values for x, y, and z on the board, what are the solutions and why is it different? Talk and/or write it down. $|x| = 3;\ |y| = -17;\ z = 0$

With these instructions, Ms. Robbins again interrupted her whole class instruction to allow for students to have a brief discussion with their partners for 50 seconds, before she called attention back to whole class instruction simply by saying, "All right, so what are solutions for *x*? What did you think about that?" She called on students to go over the three problems. Soon thereafter, she moved on to the next problem: $|x + 3| = 4$.

She again used a strategic interruption and asked, "So what is the value that *x* could be? Talk to your partners." She gave them 18 seconds to confer with a partner and then called them back by saying, "Okay, so how did you think about this? Because the answer is 4 or negative 4." This pattern continued. In this lesson, she interrupted whole class instruction with brief periods of partner work a total of eight times; the length of each strategic interruption averaged 48 seconds.

Ms. Robbins's use of strategic interruptions showcases both similarities and differences to Ms. Bennett's. In terms of similarities, both interrupted whole class instruction in order to allow students to talk to and listen to each other. Ms. Robbins also viewed strategic interruptions as a time when students could share their emerging understanding of the mathematics with each other. However, Ms. Robbins did not appear as actively interested in formatively assessing students during these brief periods of partner work; she did not circulate to student groups and (likely as a result) did not use students' own ideas and strategies to highlight student thinking in the subsequent whole class instruction.

As an example of a low-gain teacher who struggled to implement this type of interruption, consider Ms. Smith, a high school teacher who taught in low poverty suburban public school and had 4 years of experience. Similar to several other low-

gain teachers, Ms. Smith often posed questions to students such as "Does that make sense?" or "Do you have any questions?" only to be met with silence and blank stares. In such situations, she usually continued to talk, answering her own questions or moving on. For example, in one class, when reviewing homework problems, she read the following problem out loud to the class:

> A car rental charges $29 to rent a car per day and $13.95 for GPS. Customers are charged for the full tank of gas at $3.80 per gallon. A car has a 12 gallon tank and a GPS. Write a rule for the bill.

She then tried to initiate a conversation with her students, but struggled to gain their participation:

> So 12 gallons times how much per gallon? [*Brief pause*] $3.80 per gallon. So they're going to have to pay for that. They'll have to pay for a full tank of gas, 12 times 3.80. They're going to have to pay $29 per day and $13.95 per day. So the GPS is $13.95 per day, just to rent the car is $29 per day and then you have to pay for the 12 gallons of gas at $3.80. So if you add those together how much are you paying per day for the car and the GPS? [*Brief pause*] $42.95 per day. And how much to fill up the gas tank? [*Brief pause*] $45.60. So that's how much your bill is going to be. Did anyone get that one? Anyone alive today? [*Audible sigh*] So I don't know if people don't care right now, but this is a possible problem that could show up on your test. It's very doable for you to figure out. You have to pay for the gas, the GPS, and rent the car.

One student then asked, "So you're pretty much just adding them all together?" Ms. Smith responded,

> Yeah so if you're getting the GPS and you're renting the car, each day is $29 plus the $13.95, so each day will come to $42.95 then you're responsible for filling up the tank. If you have a 12 gallon tank and each gallon is $3.80 then this is how much you'd pay for gas.

She then waited for 13 seconds of silence and then continued on to the next problem. The entire class period was spent in this manner, in whole class instruction.

As this episode indicates, Ms. Smith did ask students questions, apparently seeking their input and wanting to gauge their understanding. But when students were not willing to respond, she answered her own questions and moved on. Clearly there

were multiple opportunities where Ms. Smith could have asked students to chat with a partner for 30 seconds to discuss one of the many questions she posed. Incorporating strategic interruptions of whole class instruction would appear to be a relatively easy and time-efficient way to encourage greater student participation and also to add formative assessment to gauge student understanding prior to making an instructional decision to move on to a new topic.

We believe that strategic interruptions of whole class instruction can potentially provide many of the same benefits as group work in its more typical implementation, for example, letting students work in groups for much longer periods of time. The brief partner chat interruptions allow the teacher to formatively assess understanding, utilize this feedback in instruction, and provide opportunities for student talk. We speculate that teachers who are reluctant to try group work may be more willing to incorporate strategic interruptions to their whole class instruction, because of its relative ease and quickness. As noted above, challenges still exist with strategic interruptions, such as calling students' attention back to whole class instruction and ensuring accountability for addressing the assigned task during their partner chat time. However, strategic interruptions of whole class instruction can take up considerably less time in a lesson than a large uninterrupted block of group work. For instance, Ms. Robbins asked students to turn and talk to their partner eight times in one lesson. The total class time spent in these eight interruptions was only 6 minutes and 25 seconds, perhaps making strategic interruptions more manageable and attractive for teachers to attempt than longer periods of group work.

Strategic interruption of group/partner work

These strategic interruptions of group work are brief teacher announcements, after which students return to their work in groups. They are deliberate and instructional in nature and may address a misconception the teacher notices, highlight a question that a student asks the teacher individually, or provide scaffolding to keep everyone on the right trajectory of the lesson. These interruptions are concise and quick, where students quickly return to their original mode of independent partner or group work.

These strategic interruptions of group or partner work may afford several benefits. First, it can clarify the task to make group time more productive. Second, the teacher may be able to more successfully maintain cohesion of the class. Group work often results in students working and thinking about many different aspects of a mathematical task; while this may be desired, it also poses managerial challenges to the teacher. Third, short interruptions of students' group work can afford the teacher more control over the progression of the lesson, increasing the teacher's

confidence that groups are moving in the desired directions. Fourth, like interruptions of whole class instruction, interruptions of group work allow the teacher opportunities to highlight student anecdotes, incorporating students' voices to engage the class.

This type of strategic interruption to group or partner work poses its own set of challenges. First, in an interruption, it can be difficult to provide clarification of the task without reducing its cognitive demand. Second, norms and/or routines may be necessary for quickly gaining students' attention and focus. Third, determining if and when to interrupt students' independent work is challenging, and at times perhaps the interruption may only be necessary for a few or some of the pairs or groups. Finally, there may also be other means of communicating to each group without an interruption, such as calling over one member of each group to relay the message of task clarification or extension question to their own groups.

We illustrate below one vignette of a high-gain teacher who demonstrates the benefits and addresses challenges of this type of strategic interruption and a less successful example from a teacher with low gain scores.

The successful example is from Ms. Bennett's class again. In this lesson, students were learning systems of inequalities through the use of a word problem that consumed the majority of class time. A student named Jasmine read the problem out loud for the class.

> Jasmine is planning a party to celebrate our fantastic work on the SSAT. She has 28 dollars to spend to buy chips and bottles of water. Each bag of chips costs $4 and each bottle of water costs $2. How many bags of chips and bottles of water can she buy?

After engaging in a whole class discussion with examples of possible solutions, Ms. Bennett instructed students to work with their partner for five minutes to come up with all possible combinations of bags of chips and bottles of water. (Note that we consider this to be a *transition* to partner work rather than an interruption, because the partner work lasts a relatively long period of time.)

After circulating around the room for a couple of minutes, Ms. Bennett's first strategic interruption of partner work occurred 2 minutes and 20 seconds into students' partner time. Ms. Bennett said,

> Snap your fingers once please. Jonathan had a good question. Does Jasmine have to spend all of her money? Can she have a party and say I'm going to

> invite you all to my party and I'm not going to have any water for you, and I'm not going to have any chips? She could. People might not come to the party, but absolutely, she doesn't have to spend $28 exactly, she could. Can she spend more than $28? Can she spend less than it? Okay so you have to figure out all those possible combinations.

This strategic interruption of partner work addresses the three benefits previously outlined. While circulating around the room, Ms. Bennett became aware of possible confusion in the task; in her interruption she provided clarification, to allow for more productive partner work. She chose to interrupt everyone and address this question to the whole class, rather than only answering Jonathan's question individually, as a way to maintain greater cohesion of the class. Ms. Bennett also was able to highlight Jonathan's thinking to the class as a whole, potentially increasing engagement and communicating the importance of student input to the classroom's mathematics community. In addition to these benefits, this interruption is highly instructional as she helped students understand the meaning of linear inequalities using the concrete example of chips and water.

Four minutes and 20 seconds after the first interruption (during which she continued to circulate around the room), Ms. Bennett strategically interrupted partner work again. She asked students to snap their fingers, and said,

> You have one more minute. If you can figure out, I want to see if you can figure out the total possible combinations you could have of chips and of water, the total combinations of chips and total combinations of water. So even if you don't have them all listed, is there a way you can figure out the total combinations? Okay one more minute.

This interruption of partner work is different than the first one, in that with her announcement she changed the focus of the task from *listing* the possible combinations to figuring out *how many* combinations there are. We speculate that Ms. Bennett's choice of questions in the first two interruptions was quite deliberate. In the first, she posed a clarifying question, but in the second, she prompted students to consider a more cognitively challenging and sophisticated question to move toward generalization. By circulating around the room, Ms. Bennett was able to gauge when was the most appropriate time to interrupt students and pose this more difficult question. Again, not only did this interruption afford the benefits of strategic interruptions of group work, but it also provided instructional scaffolding by allowing the teacher to deliberately interrupt with both refinements and extensions of a question and/or with a more complex or challenging task. She regularly used this form of strategic interruption: in this class episode, she

strategically interrupted students' group work a total of eight times. Furthermore, she addressed some of the challenges of strategic interruptions to group work by using a routine to gain students' attention, specifically, having students snap their fingers to gain the class's attention. She also actively circulated during partner work to continuously seek feedback of student understanding, confusion, and questions. This close pulse on her students' progress in real time helped her make sound instructional decisions including the use of strategic interruptions.

We now contrast Ms. Bennett's with Ms. Garrett's (a low-gain teacher) interruptions of partner work. Ms. Garrett was a high school teacher in a suburban public school with 8 years of teaching experience. In one of the videos we observed, she interrupted students' independent work solely for logistical purposes. Certainly some strategic interruptions to small group work may be at least partially logistic in nature, such as when students' confusion of how to gather materials or manipulatives, prevents their engagement with the task and requires clarification. However, the example below suggests that her interruption is entirely logistic and thus *not* strategic.

In Ms. Garrett's lesson on simplifying algebraic expressions, she provided two opportunities for group work, neither of which is considered a strategic interruption. In the first episode, students worked independently for 7 minutes and 35 seconds without interruption. At the end of this time of independent work, she called the class back together to review the answers to the problems just assigned. She then continued whole class instruction. This move from independent work to whole class instruction was a *transition* rather than an *interruption*, because students did not go back to partner work after a short period of time. In addition, this move was not *strategic*, as the transition to whole class instruction was not based on her formative assessment of students' progress but rather occurred when she perceived that all students had finished the assigned work.

The second group work episode occurred 10 minutes after the first, or 27 minutes into the class period. She instructed students, "[For problems] 24 and 25 write down examples for those, right now." Students worked for 30 seconds while she remained at the front of the room. She interrupted their independent work to announce,

> On your paper you need an example of both 24 and 25. Once you have your examples of both 24 and 25 on your paper, you can come write one of your answers on the board. I will let you choose whether you write an example down for 24 or 25. Just remember only one person can be writing on the board at a time. So once you have both written on your paper and you are ready come up choose either 24 or 25 and write down an example.

Her decision to interrupt with a logistical clarification is not based on feedback from students' thinking or progress with the task. She remained standing at the front of the room while students worked individually and did not attempt to gather feedback about students' work or thinking prior to her interruption. Furthermore, her interruption did not afford her an opportunity to manage the pace of the class, as she simply waited until students appeared to have completed the assigned task before ending the period of group work. This is an example of an interruption that is *not* strategic.

Strategic interruptions of group work may further enhance the benefits of group work by providing students with more frequent feedback. One potential aim of group work is to provide students with latitude and freedom to explore a problem. Even if students' independent explorations are not immediately optimal or even correct, learning is presumed to be aided when students have an opportunity to explore and make mistakes. Yet, managing a classroom full of independently exploring groups of students poses significant instructional challenges, particularly the risk that some students or groups will go too far from the anticipated learning trajectory of the task. Strategic interruptions of group or partner work allow the teacher to both give students room to explore but also to more closely monitor their direction and provide corrective feedback at the optimal times, while at the same time highlighting contributions of individual students or teams with the whole class.

Discussion

The use of small group work offers many potential benefits to learners of mathematics. However, while research consistently touts the academic and social advantages of small group work, implementation challenges can be overwhelming and intimidating, particularly for secondary teachers who teach large numbers of students and may face pressure to "cover" material and prepare students for standardized tests. In this paper, we suggest the use of strategic interruptions – frequent and brief transitions between whole class and small group work – may provide a way to utilize group work in the classroom that is more easily implementable yet offers many of the advantages of this practice. Previous research has found that successful teachers frequently alternate modes of instruction (Smith, 1985), and that novice teachers can easily learn effective transitioning routines (Arlin, 1985).

One form of strategic interruption occurs when whole class instruction is broken up by brief (e.g., as few as 30 seconds) periods of small group or partner work, such as when a teacher tells students to "talk to your partner for a bit." This form of

interruption allows the teacher to formatively assess student thinking; incorporate student anecdotes, questions, and quotes when returning to whole class instruction; and provide opportunities for student talk. These benefits are coupled with the challenges of regaining class attention, student accountability to stay on task during the partner chat time, and the need for clear, concise, and doable partner chat tasks or questions.

A second form of strategic interruption involves pausing small group work with brief periods of whole class instruction, such as when the teacher tries to "get everyone to come together for a minute." This type of interruption allows the teacher to clarify the task to facilitate productive group work, maintain cohesion of the class when groups' progress varies, control lesson progression, and incorporate student anecdotes and voice to share with the whole class. The constraints associated with this type of interruption include difficulty clarifying the task without lowering the cognitive demand, quickly gaining students' whole class attention, and determining if and when to interrupt based on formative assessment feedback gathered while circulating amongst groups. The vignettes in this paper are intended to illustrate ways that teachers wrestle with or overcome the challenges of both types of strategic interruptions to enable students to benefit from its instructional benefits.

Considering both types of strategic interruption, we find it helpful to conceptualize teachers' use of group work according to the spectrum shown in Figure 1. In the absence of any group work, a teacher may use whole class instruction for the entire lesson, as depicted in Figure 1(a), where the black rectangle represents periods of whole class instruction and the white rectangle represents periods of group work. In the other extreme, a teacher might begin the class and end the class with short segments of whole class instruction (which some instructional models refer to as the "launch" and the "summary") but spend the majority of the class in small groups ("explore"), as depicted in Figure 1(f). One reason that some teachers may not be using group work regularly or effectively is that they believe that the use of group work is an all-or-nothing proposition: Adequate use of group work might (in some teachers' minds) mean consistently teaching lessons that look like Figure 1(f). Our experience suggests that teachers may be unaware of all of the ways that whole class instruction and group work may be combined and utilized within a single lesson. The spectrum in Figure 1 is intended to show a fuller range of ways that these two modes of instruction can be integrated. Furthermore, it may be useful to visualize these two modes of instruction as fluid, with the ability to make incremental or small-scale changes in one's practice to experiment with instructional practices that best work for one's students, such as adding strategic interruptions to whole class or small group work. Strategic interruptions of whole

class instruction (e.g., "turn and talk with your partner for a bit") may be more attractive and implementable to teachers because these interruptions consume minimal lesson time while avoiding complications of group work. These interruptions also allow the teacher to maintain his or her preferred form of instruction of whole class discussion while gaining the benefits of group work, such as opportunity for student talk, formative assessment, and gaining student engagement through highlighting student voice when reconvening whole class instruction. This spectrum model of whole class and group instruction with strategic interruptions interspersed throughout may be a means of conceptualizing and encouraging teachers to engage in ambitious mathematics instruction through group work to potentially increase mathematics achievement.

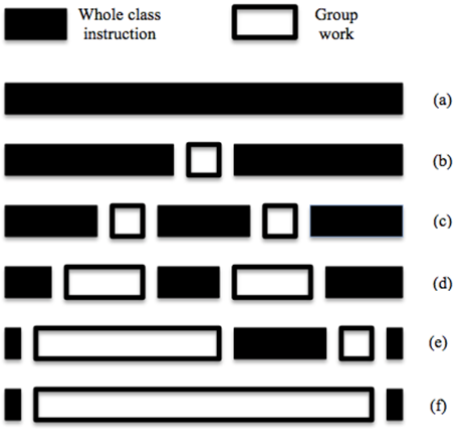

Figure 1. Some Examples of a Spectrum of Whole Class and Group Work Instruction.

Limitations and Future Research

First, it is important to note that our data do not allow us to conclude that the presence or absence of strategic interruptions cause or even is linked with students' gains (or lack thereof). Rather, in the present analysis, we report on trends that seem noteworthy in our exploratory analyses of high- and low-gain teachers' instruction. Future research can begin to explore whether the use of strategic interruptions is indeed linked to student learning gains.

Second, without more in-depth investigation into teachers' lesson planning processes (e.g., by using retrospective interviews with teachers), we can only speculate as to the intentionality of the interruptions that we describe in the vignettes above. In future work we hope to explore the extent to which teachers' interruptions are pre-planned or if they are in-the-moment decisions based on formative assessment of student thinking (and if so, how do teachers decide when to interrupt?).

Third, ease of implementation is another area of interest for future research, particularly because we have hypothesized that implementation of strategic interruptions is more feasible than long uninterrupted periods of group work. Finally, also of interest is the extent to which strategic interruptions may be more or less useful depending on the nature of classroom or lesson tasks, for example, whether a lesson focuses on the introduction of new material or not. We look forward to further analysis and exploration of strategic interruptions and its potential to impact teacher practice and student learning.

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