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Opportunities for Learning-based Conversations in High School Mathematics

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Conversations as moments for interpersonal and intimate turning round of ideas for the purpose of growth are well-defined within curriculum inquiry. Interactions among grade 12 students in this study demonstrate the possibility of learning to learn mathematics through conversation. Attending to opportunities for learning-based conversations, constructivist grounded theory supported developing a Model of Providing Opportunities for Learning-based Conversations. Four features of preparation, presence, mode, and pacing represent a space where students could improve their learning through connectedness among conversational moments. Understanding how conversational opportunities were offered could empower others to engage in learning-based conversations with their students.

La recherche pédagogique explique clairement comment les conversations peuvent représenter des discussions interpersonnelles et intimes, des moments qui favorisent l'épanouissement. Cette étude a trouvé que les interactions parmi des élèves de la 12e année peuvent illustrer dans quelle mesure les conversations aident à apprendre comment apprendre les mathématiques. Attentifs aux occasions d'entretenir des conversations reposant sur l'apprentissage, nous nous sommes appuyés sur la théorie constructiviste pour développer un modèle visant la création d'occasions pour les conversations reposant sur l'apprentissage. Les quatre composantes–la préparation, la présence, le mode et le rythme–représentent un espace où les élèves peuvent améliorer leur apprentissage en tissant des liens entre leurs conversations. En comprenant comment offrir des occasions pour le développement de conversations reposant sur l'apprentissage, nous pouvons habiliter les autres à participer aux conversations reposant sur l'apprentissage avec leurs élèves.

Mathematics education reforms (National Council of Teachers of Mathematics, 2000, 2014; Western and Northern Canadian Protocol, 2008) have emphasized students' personal development of mathematical ideas through conversation (e.g., Chronaki & Chrisstiansen, 2005; Elliott & Kenney, 1996; Herbel-Eisenmann & Cirillo, 2009; Hufferd-Ackles, Fuson, & Sherin, 2004; Pimm, 1984). Absent from these reforms and from experiences in many high school mathematics classrooms is explicit discourse about the processes of learning—both identifying the strategies students use to learn (e.g., homework, taking notes, test preparation, study groups) and then how to individually adapt those strategies.

Within mathematics education literature, it has been suggested that attending to learning processes could improve learning mathematics (Dahl, 2004; Fischer, 1992). Watson (1994) offered that "pupils should be given opportunities to develop their learning skills" (p. 57), yet scholarship has focused on descriptions of students' strategic (in)capabilities (Anthony, 1996)

rather than on designing learning opportunities for students to improve their learning strategies (c.f. Smith, 1999). The research being reported in this article addresses the need for proactive engagement of students in learning to learn mathematics through the use of conversations. Moving from metacognition (Flavell, 1979) and through metalearning (Goodchild, 2001; Novak & Gowin, 1984), I adopt an ontological approach (Packer & Goicoechea, 2000) to learning to learn mathematics that attends not only to growth in learning processes, but growth in the learners themselves.

With the paucity of examples available, in this article I suggest and explore ways in which students engage in conversation about their processes of learning and how learning-based conversations support improved mathematical learning. The research being reported in this article is part of a larger study that addressed the question: *What is the nature of students' learning when they engage in conversations to shape their personal processes of learning high school mathematics?* In particular, I examine the qualities of opportunities students were invited to participate in as a way to experience growth in awareness of their learning processes, improve their approaches to learning mathematics, and view themselves as capable learners of mathematics.

Theoretical Perspective on Conversations

The notion of conversation has been thoroughly explored in curriculum inquiry literature from a variety of philosophical orientations. In surveying curriculum inquiry literature, I identified several familiar and distinctive perspectives. Hermeneutics and hermeneutic-phenomenology use *conversation* to point to the engagement of curriculum inquirers in deep and thoughtful understanding of educative experiences for students, an inquiry stance (Gadamer, 1965/1975; Jardine, 1992; van Manen, 1997). Narrative inquiry (Clandinin & Connelly, 2000) builds on the idea of narrative ways of knowing (Bruner, 1986) to demonstrate how conversations can be seen as a way of being and as a way of collecting data for research.

From the perspective of dialogic reality (Bakhtin, 1986; Shotter, 1995), conversation is a communicative act that grows out of the responsiveness and relationality of dialogue. From a moral perspective (Noddings, 1984), conversation is seen as a moral way of being with others (Ernest, 1993) as there is a mutual openness in genuine sharing and reflecting. Epistemological models (Baxter Magolda, 1992; Belenky, Clinchy, Goldberger, & Tarule, 1986) explore how conversations allow individuals to build knowledge by drawing on personal experience to connect relationally with others which allows openings for emergent ideas. Enactivism (Maturana & Varela, 1988; Varela, Thompson, & Rosch, 1991) theorizes about the coemergence of knowledge among individuals in the bringing forth of a reality in moments of interaction, such as conversations.

Etymologically, conversation means a "(mode of) living, dwell, dwelling habitually; familiar discourse; exchange words; acquaintance ... turn round" (Hoad, 1986, p. 96). These perspectives, taken together, use *conversation* to point to a particular form of communication in which there is an interpersonal and intimate nature of turning round ideas for the purposes of growth, as well as a way of being in the world.

The various perspectives in curriculum inquiry literature inform research in mathematics education. Through a synthesis of mathematics education literature which draws on the range of curriculum inquiry approaches (Bauersfeld, 1995; Cobb, Boufi, McClain, & Whitenack, 1997; Davis, 1996; Ernest, 1993; Gordon Calvert, 2001; Sfard, Nesher, Streefland, Cobb & Mason,

1998), I constructed five characteristics of conversation which I perceive as important orientations to conversations in mathematics classrooms that could support learning. The characteristics include: withness, listening, dynamic, uncertainty, and form. I briefly elaborate on each of these characteristics below.

Withness, the first characteristic, highlights the space of conversation where the interpersonal is valued in a way where a mutual sense of trust and equality is negotiated among members. Within a setting where the interpersonal is valued, relationships are formed through an ethic of care. Living within these relationships, individuals meet each other ethically as they mutually negotiate a sense of trust where they feel both safe to talk with others and responsible to be responsive as they nurture the relationship through their interactions. The (inter)connection entails a notion of intimacy that provides space for individuals to learn in collaboration.

A second characteristic is listening—where each member is present, open, and responsive to the other for sense-making—marks the active participation of non-speakers. The act of listening is integral to the conversational space, being present and responsive to the other. It is within the listening stance that all participants can come to a significant understanding of themselves, others, and the focus of the conversation.

Conversations can also be characterized as being dynamic, relating to both the topic that is under consideration and the flow of the conversation. There is a certain fluidity in the course of a conversation, where the mutuality and relatedness of the participants provides space for the conversation to coemerge. The focus of the conversation, something of mutual concern to all participants, often develops within the conversation, rather than being directed at the outset. The investment in the conversation by all participants anticipates personal change and growth occurring through active participation.

Uncertainty, as a fourth characteristic, portrays a sense of where the conversation leads participants and how the conversation is understood afterwards as indeterminate. Because the conversation and the focus emerge among the participants, a destination is not determined at the outset, nor is there a sense of what specific elements would be achieved at the end of a conversation. In interpreting a conversation, an exophoric approach (Florio-Ruane, 1991) values the interconnectedness of participants and ideas in a conversation. The meaning of the conversation, then, is held within the community.

The fifth characteristic of conversations is the form, where conversation can be in both oral/aural and written form. Most commonly, conversation is used to point toward oral/aural exchanges. However, the other four characteristics of conversation can exist as conversational participants engage in writing.

The related literature served to sensitize me as a researcher to five particular conversational features: withness, listening, dynamic, uncertainty, and form. These five features were present in the conversational moments with students in the research project; in other words, they guided a way of being in conversation. As a researcher, the conversational features also guided the ways in which I attended to conversation moments and informed the generation of a model representing opportunities for learning-based conversational spaces.

Mode of Inquiry

Constructivist grounded theory (CGT) (Bryant & Charmaz, 2007; Charmaz, 2006, 2009, 2014) returns to the symbolic interactionist root of grounded theory while looking through a

constructivist lens as an interpretive process for inquiring into dynamic phenomena. Within this postmodern orientation, theory is constructed by a researcher on a provisional basis and contingent to the context. There is an "emphasis on processes, making the study of action central" (Charmaz, 2006, p. 9), recognizing that shifts in people's actions and experiences signify growth and changes within the people and their interactions. The researcher, seen as a subjective knower, is immersed in the research setting while co-constructing qualitative data with participants. As data are analyzed abductively, the researcher moves from rich empirical data through levels of abstraction toward developing a mid-range interpretive theory. Processes like coding, memoing, categorizing, theoretical sampling, saturation, and sorting are offered as "systematic, yet flexible guidelines for collecting and analyzing qualitative data ... rather than formulaic rules" (Charmaz, 2006, p. 2). The reflexivity of the researcher results in explicating the theorizing as both process and product, enabling other researchers to apply and extend the work.

The focus of this research, students' experiences of learning to learn mathematics, is supported by CGT's framing to notice and interpret individuals' growth. Grounding interpretation in students' experiences, rather than applying extant theoretical frameworks, supports the uniqueness of the study in attending to the development of mathematical learners. Theoretically, constructivism is the predominant epistemological orientation to the teaching and learning of mathematics (Bishop, 1985; Davis, Maher & Noddings, 1990), often used in conjunction with symbolic interactionism in mathematics education research (Cobb & Bauersfeld, 1995; Sierpinska, 1998; Voigt, 1994). The use of CGT responds to the growing importance in theorizing to make progress within the field of mathematics education (Hiebert, 1998; Proulx, 2010).

Research Context and Participants

The study was situated in an academically-focused suburban school in a city in Western Canada. Thirteen grade 12 students who were taking a pure mathematics course volunteered to participate in the study. Their pure mathematics courses were offered in a didactic format where the teacher lectured, students copied out worked solutions to examples, and then worked through similar questions independently as homework. The school culture tended to be achievement focused, where students defined educational success as attaining high marks. Because some students struggled to meet the expectations of an academically-demanding school, the school offered a support course for mathematics learning.

The students who participated in the study were enrolled concurrently in a course, *Mathematics Learning Skills*, that provided support for their mathematical learning. The students acknowledged that the course provided a productive workspace for mathematics homework and had a relaxed rhythm where they had the time to develop mathematical understanding. *Mathematical Learning Skills* counted as a regular credit course, being timetabled in the same way as other full courses in the school (four classes per week) and assigned a grade for each student. In the class, students were self-directed as they chose what homework (mathematics or other courses) to work on individually or in small groups, and often requested help from the teacher. The teacher made herself available to answer mathematics content questions, provided extra practice questions, and on a couple of occasions led the class in setting study goals. I attended every *Learning Skills* class, over a four month period, as a participant-inquirer. I spent the entire class time assisting students with mathematics questions,

developing relationships with students through conversations, and coaching students to improve their approaches to learning mathematics while simultaneously collecting data. My immersion in the context enabled a finely nuanced understanding of students' experiences. The teacher also participated in the study to provide contextual information and offer her perspective on emerging analysis.

Data Construction

Data construction occurred over four months. I use the phrase "data construction" deliberately, to emphasize that data are interpretive (re)constructions of lived experiences. This is a consistent perspective in CGT, where Charmaz (2006) states, "*people* construct data" (p. 16). After observing each class, I wrote detailed field notes of students' (inter)actions in the class and descriptions of daily informal conversations with the teacher. Students took part in bi-weekly interactive journal writings (Mason & McFeetors, 2002). They responded to prompts about the progress of their learning strategies, and I replied in order to interact with their ideas, modeling thinking about learning and fostering a relationship with each student.

Students were placed into one of three small groups with a focus on developing a learning strategy as a group (transitioning from notes to homework, developing big ideas from completed homework, and studying for unit tests by creating summary sheets). Each small group met for three to five sessions of approximately 30 minutes each, and were audio-taped and transcribed. The students in the small groups collaborated on developing a learning process, which included conversation about the mathematical topic, trying out the process, making suggestions, listening to peers, refining the process, and sharing their process with other students.

The students also participated individually in two interviews as a retrospective look at their progress in shaping their learning strategies. Charmaz (2006) describes these as "open-ended yet directed, shaped yet emergent, and paced yet unrestricted" (p. 28), as I composed questions which had common themes yet were personalized by drawing on each students' previous data. Each interview was approximately 30 minutes and was audio-taped and transcribed. The interviews occurred halfway through and at the end of the study. While the interactions were intended as multiple sources of data, they also afforded students the opportunities to develop learning processes to support their mathematical understanding and to notice improvements in learning. Providing these opportunities was framed by Dewey's (1938/1997) notion of experience, which is characterized by continuity and interaction and where activity is transformed into experience through the reflective act.

Data Analysis

Using line-by-line coding and the constant comparative method (Glaser & Strauss, 1967), I analyzed data by developing codes for students' use of learning strategies across all forms of data. Coding began during the data construction phase of the research and was completed after intensive work with the data at the conclusion of the study. Initial codes, such as "do questions" and "see patterns," remained close to the students' words. As codes were refined through several passes through the data they were abstracted from the data, using phrases like "explain to self" and "seek help." The students' remarks on their opportunities to collaborate with peers and to discuss how they were learning led me to inquire during data analysis into a particular context in their growth as mathematics learners, a conversational context.

Coding data facilitated intimacy with the data, but did not support the elevation of codes to categories. Drawing on Dey's (2010) perspective that "coding does not exhaust the analytic process, one can even question whether it is integral to it" (p. 167) and that "categories emerge initially from a close engagement with data ... later fleshed out by identifying and analyzing in detail their various properties and relations" (p. 168), I constructed categories as provisional concepts with the complexity inherent in meaning-making. The features of opportunities for learning-based conversations, explicated below, are the categories which emerged from engagement with the data. The names of the categories, such as "presence," are explanatory of the students' actions and abstracted from the data. The categories are brought together in a *Model of Providing Opportunities for Learning-based Conversations* through the interpretive act of theorizing.

Results: Features of Opportunities for Learning-Based Conversations

The above survey of curriculum inquiry and mathematics education literature supports a view of conversation as a type of communicative act that could support a thoughtful attention to learning and to (re)forming identity within a personal exploration of turning round processes of learning. In this way, conversation takes up a sense of withness and listening in a dynamic process and with an uncertainty in destination and understanding. Davis (1996) recognizes that a conversation can only be realized retrospectively, "when self and other have been altered" (p. 28), and so through engagement with data I recognized that the students' description of their experiences further informed the qualities of the opportunities for students to engage in conversations which would support their learning to learn mathematics. There is a shift in attention, from the characteristics of conversations—which were still present—to the nature of the opportunities for those conversations.

Within the research project, I engaged in conversations with the students that focused on mathematical content, as well as relationship building. I also observed the range of conversations they had in *Learning Skills* class, which included topics like school activities, their lives, other courses, and mathematics. For the scope of this report, I focus on students' conversations that explored their learning of mathematics. I refer to these conversations as learning-based for two reasons, acknowledging that relationship-building and mathematics were still present in conversations. First, the talking and wondering about the learning of mathematics was foregrounded where the intention was to consider the ways in which the students were going about learning mathematics. Second, the conversations were a space in which students were improving their approaches to learning and growing as mathematical learners. Often, within a conversation there was fluidity between a learning focus and a mathematical focus. A narrowing to focus on examples of learning-based conversations does not negate the importance of all the other conversational foci, taken together, but I can speak through my work to the features of conversational opportunities for students to talk about and improve their processes of learning high school mathematics.

In the following sections, I explicate four features of opportunities for learning-based conversations, including: preparation, presence, mode, and pace. The four features represent the qualities of providing opportunities for students to talk about and improve their learning strategies. The features highlight the occasioning of learning-based conversations, rather than of the characteristics of conversations themselves. As such, it draws attention to the ways in which teachers could provide opportunities for students to talk about how they learn. The

conversational characteristics—withness, listening, dynamic, uncertainty, and mode—are still present as the nature of the conversations.

The features were created by looking at the range of examples from the study and attending to what the students emphasized when they identified conversations about their learning and what I noticed in their conversations through observations in the classroom and interpretation of data that the students did not explicitly identify as conversational moments. Placing these various forms of data together through interpretation informs the way in which opportunities for learning-based conversations could be provided to students. While each of the four features is explored separately for detailed inspection, more than one feature could be present within a singular opportunity for conversation.

Preparation

The *preparation* feature of opportunities for learning-based conversations points to the varying degrees of advanced planning that took place in providing opportunities for the students to attend to their learning. This feature has a temporal dimension, from spontaneous to deliberate interactions. In this section, I describe the scope of preparation in learning-based conversations, supported by specific examples, and then address intentionality in conversation.

Spontaneous conversations around learning mathematics arose in *Mathematics Learning Skills* class as I filtered around the class each day answering mathematics questions. For example, I recorded in my field notes from early in the study that Teresa (pseudonyms are used for all participants in the study) and I could explore "what it means to ask for help and what kind of help to ask for," as I found her frequently asking me for help with specific mathematical steps. Later in the study, I recorded another interaction in class where Teresa "asked me if it was like a question in her notes ... I encouraged her that she had found a similar question in her notes, and that was a great strategy" for getting unstuck when working on homework. Our one-on-one conversations in class highlight the fluidity of these moments, where Teresa would often ask for help with specific questions in a homework assignment, and I would shift the conversation toward thinking about approaches to learning mathematics which arose in the moment. These spontaneous moments occurred through listening and uncertainty, as characteristics of conversations.

Even when students were studying for other courses, like Grace studying for biology with a content map, I recorded in my field notes how I "wondered about thinking about that for learning math. I told her about Ashley's layering of the examples on her summary sheet, and Shane's layering of the concepts and then examples on his summary sheet. She thought those were neat ideas." I found myself alert to opportunities of voicing wonderings which brought learning into view of the students. These spontaneous conversations are like what Gordon Calvert (2001) perceived as "improvisation" highlighted by being "spontaneous and unpredictable ... [yet] by no means random" (p. 87). The metaphor of improvisation captures the idea that the conversations were at once fluid, unanticipated, intentional, and meaningful.

The *Mathematics Learning Skills* class itself seldom had deliberate opportunities for conversations about learning. I understand the notion of "deliberate" to mean a systematic shaping, in advance, of a conversational focus. Through the data construction elements of interactive writing, small group conversations, and one-on-one interviews, I inserted deliberate interactions with the students focused on approaches to learning mathematics. All interactive journal writing prompts invited students to consider their learning processes. For example, one

entry asked, “What is one thing you have been trying to improve this year, to help you succeed at learning math?” and a later entry asked, “How will you prepare for the final math exam? Be detailed and explain how each process will help you succeed.” In the first small group session for all three groups, I planned for actively constructing a learning strategy. However, without explicit prompts to guide students to consider the ways they had been learning this was not addressed. For the next sessions, I included prompts that directly addressed learning with the specific strategy. Within the deliberateness, the conversations were still dynamic in the fluidity of where the participants directed the focus.

The one-on-one interviews with each student contained a considerable amount of advanced preparation as I authored questions that would provide opportunities for students to attend to their learning and learning processes. Examples include “In the last two weeks, who have you talked with about how you learn math? Are you getting better at learning math? In what ways?” and “In the last interview I asked you if you were getting better at learning math. Do you think you’ve become more aware of how you learn math? What have you done to figure out how you learn?” When personalizing the interview guides for each student, I intentionally selected examples that would be generative in thinking about mathematical learning and demonstrate to each student a deliberate turning round of ideas within a relational space. Grace, upon looking at her list of learning strategies in our first interview exclaimed, “Wow, that’s a lot! ... Oh, I thought I only had two or three ways to learn math, kind of thing. Just never really think about it. It’s like, ‘Oh, I just do this to study math,’ kind of thing.” The deliberate preparation for our conversations about learning mathematics meant that we could explore the processes and meaning for the students rather than remaining at a practical level that often occurred in spontaneous conversations.

Frequently in class and through other research processes, I provided opportunities for learning-based conversations. However, there are examples of students also initiating learning-based conversations. When I asked Kylee in our first interview about the development of her cue cards for learning mathematics, she described that in the stationery store where she worked, “One year we had a display, and they just showed us all these little notes. And I was like, ‘You know what? That’s a really good idea.’” After successfully using cue cards for biology, Kylee considered, “It was like, ‘Okay, well maybe this will be useful in math because there’s a hundred and ten examples here but I only really need to know two of them.’ Right?” The self-talk Kylee reports began as she thought about adding on to her set of strategies for learning. As another example, Danielle initiated a fifth small group session by requesting that the group meet again the following week. The session marked a shift both in the students’ learning together as identified in the characteristic of withness in conversations and in requiring less preparation on my part to provide the opportunity. There was a degree of spontaneity in the students’ initiating conversations about how they would improve their approaches to learning mathematics.

Regardless of the degree of advanced preparation for the conversational opportunities, the learning-based conversations were immersed in the intention of improving processes of learning mathematics. The intention, taken as the foundation for the conversations, was present for me as I formed prompts to pose to the learner-participants. As I inquired into how the students were improving in their learning processes for mathematics I would ask questions that would direct their attention toward learning, draw out their awareness of their learning, probe for the meaning of their explanations, and inquire into the processes themselves. These four guiding areas were helpful in framing questions both spontaneously and with deliberation and invited students to engage in an opportunity to explore their personal processes of learning

mathematics through conversation.

Presence

Another feature of opportunities for learning-based conversations is the individuals who are present in the conversation. *Presence* refers both to the members of a learning-based conversation and to the composition of members. As with the range that existed in preparing for conversations, there was a range in the membership of learning-based conversations. The students demonstrated a value for different perspectives on specific learning strategies from a variety of individuals, while not viewing the perspectives as prescriptions. This openness to considering different approaches of learning mathematics, yet maintaining responsibility to shape suggestions from others, meant that students were not looking for experts to tell them how to learn but were responsive to turning round ideas in conversation with others who were fellow inquirers. In this section, I explain possible members of learning-based conversations, explore self-talk as an individual conversational act, and explain the composition of groupings.

When I asked students about whom they had talked with in relation to their mathematical learning recently, their responses included teachers (Mrs. Finley, the *Learning Skills* teacher, and myself) and peers—at least, for those students who even saw themselves talking about learning. The students saw opportunities for conversations existing within the interactions I prompted through research processes. Only a few students gave examples of talking about learning strategies outside of class with friends. Nadia recollected that, "People ask me, 'How did you prepare for this?' And then I ask them, 'How did you prepare— how are you getting this ninety on this test?'" to find out that repetitive practice was a study approach for high achieving students. Parents did not come up very often in our interviews; however, Chelsea mentioned talking about learning with her parents and that her dad "tries to motivate me and tells me different ways" to study. Some students indicated conversing with themselves as they thought about how to improve their mathematical learning.

Just as Kylee's example of reported self-talk about cue cards at the stationery store, there were other examples of students who engaged in self-talk. Bakhtin's (1986) notion of the dialogic reality supports self-talk as a conversational space:

> However monological the utterance may be (for example, a scientific or philosophical treatise), however much it may concentrate on its own object, it cannot but be, in some measure, a response to what has already been said about the given topic, on the given issue, even though this responsiveness may not have assumed a clear-cut external expression. ... The utterance is filled with *dialogic overtones*, and they must be taken into account in order to understand fully the style of the utterance. After all, our thought itself—philosophical, scientific, and artistic—is born and shaped in the process of interaction and struggle with others' thought, and this cannot but be reflected in the forms that verbally express our thought as well. (p. 92)

An utterance, which for Bakhtin can be written or oral, may appear to be singular when an individual thinks or says it aloud, but it is still responsive to what has come before.

In many of the interviews and small group sessions, students described how they would state mathematical procedures (usually aloud) to learn from their homework. Grace explained that if she was not completing homework with her friends, "I even talk to myself" about the mathematical procedures. While self-talk was primarily focused on mathematical thinking,

Danielle described creating the idea of summary sheets when she was "sitting on the bus, and I was thinking ... how would I be able to separate my ideas and stuff, but then at the same time, I know why they go together in one lesson or something." Even when Elise interacted with a text (described below in the section "Mode"), she indicates self-talk in her recounting. In each of the cases, the way in which a student recounted the moment was in a conversational way, talking to herself or himself, just as someone would recount dialogue with another person. Rather than reflective thought, the opportunity to engage in self-talk focused on possibilities for improved learning processes and was conversational in nature as the student was turning round ideas about her or his own mathematical learning.

When students had opportunities to interact with others about their mathematical learning, the groupings of conversational members ranged from one-on-one to small groups of students. Mrs. Finley recounted several examples of conversations around learning strategies students had been working on during small groups or in response to interactive journal writing. As I described in the above section, spontaneous conversations were often one-on-one in class, as were the conversations in interactive writing and interviews I had with each of the students. While I coached students during individual conversations, the small group sessions contained dynamic conversation as the students suggested and considered different approaches to learning mathematics. Ashley and Danielle, who exhibited several examples during the small group sessions, took the opportunity to explore ideas like how to structure the summary sheets and how to connect mathematical ideas. Students did not mention whole-class conversations, and the didactic approach to the few whole-class elements I observed in the *Learning Skills* class did not open up opportunities for conversation. In a small group session for developing summary sheets, Ashley wished mathematics teachers would "do one entire mind map of the chapter on that big poster board with the class," as she imagined the possibility of a whole-class grouping as an opportunity for a learning-based conversation. This example expresses a common sentiment that students valued the opportunities to attend to their processes of learning with others who were oriented to listening.

Opportunities for learning-based conversations were composed of individuals who were inquiring into the ways in which students were learning mathematics and how they were improving their personal processes of learning mathematics. The conversations emerged from interactions among individuals with diverse approaches and ideas for learning. There was a genuine interest in coming to understand how the conversational partners were learning mathematics in order to engage in thoughtful turning round of ideas. In an interactive journal writing, Elise recognized her improvement in learning mathematics "by working with other students to gather ideas and collaborate ... by talking and studying with others, I have learned and created different ways to study." Collaborating, through learning-based conversations, with peers in small groups was viewed as one of the most important conversational opportunities by many of the students.

Mode

The *mode* through which the opportunity for conversation exists is another feature of learning-based conversational opportunities. This feature highlights the form in which the opportunity for conversation takes place, usually among two or more people. Primacy is given to words in marking a conversation, especially in opening up the opportunity for conversation. Words can be used in either an oral (speaking aloud) or written manner to prompt conversation, where the

words direct the focus on learning mathematics. Although other modes of conversation are not necessarily excluded, such as gestural communicative acts (Gordon Calvert, 2001) or students' actions, the turning round of ideas related to learning mathematics is difficult to ascertain in these fleeting actions. In this section, I describe how conversations began either through oral/aural means, in text-based practices, and the hybridity of the two modes. This feature is closely connected to form as a characteristic of ongoing conversations.

A conventional mode of beginning a conversation is the speaking and listening that occurs between two or more people, an oral/aural mode of conversation. Quite often explorations of the notion of conversation focus on the speaker's contribution, but there was also an active stance in listening that was demonstrated as the conversational participants came to understand processes for learning mathematics. The oral/aural mode of conversation occurred within the *Mathematics Learning Skills* class, in the small group session, and in the one-on-one interviews. Nadia's conversation with a friend about preparing for tests (described above) is an example of an oral/aural conversation that occurred outside of class.

Opportunities for learning-based conversations also occurred in a textual form during the interactive journal writing. There is strong support from the field of mathematics education that students engage in writing to learn (e.g., Borasi & Rose, 1989; Masingila & Prus-Wisniowska, 1996; McIntosh & Draper, 2001). As students were invited to consider in a focused manner their mathematical learning, the conversations in the interactive writing supported their learning to learn mathematics. Students would usually respond directly to the written prompt I provided and my reply was addressed to them and interacted with their ideas and themselves as learners. Consider the following example as a conversational exchange between Laurel and myself in the first two interactive writings (students labeled them as "journals").

> Journal #1: Laurel
>
> A1: Throughout the school year I have been focusing on completing all my assigned homework on a daily basis along with joining in on class discussions to further my learning and boost my confidence in the subject. Finally, asking for necessary help and helping others broadens my learning experience greatly.
> A2: Firstly I want to learn how to organize my busy life schedule around studying to find a happy medium, and secondly, different approaches to studying that may suit me better.
>
> *Laurel,*
> *It sounds like you have made a lot of progress already this year in your approach to learning math. You've identified many ways of supporting learning—homework, participation in discussions, asking and giving help. I wonder if we can work together on ways to get the most out of what you are already doing, instead of overloading your schedule. You mentioned that helping others benefits you. I wonder if you can incorporate explaining ideas into how you do your homework. This might only take a few extra minutes: after completing an assignment, look over it, and then in a few sentences explain what the important ideas are in the assignment. It gives you a chance to explain, and you make some unit review materials at the same time.*
> *Janelle*
>
> Journal #2: Laurel
>
> This week I am going to begin creating notes on what I complete in each of my homework

> assignments along with beginning to look back to the start of the year to begin review for [the course final examination]. By making quick notes on each section on key points hopefully it will help to spark my memory on specific topics.
>
> *Laurel,*
> *I remember noticing last week that you had begun a similar process with making quick notes for chemistry. Your self-discipline to start this early getting ready for [final examinations] is amazing! I wonder if, while making the math notes, you'll notice connections across units. These connections could help you remember topics in a more lasting way. How might you keep track of these connections you are making through your quick notes?*
> *Janelle*

It would have been difficult to invite students into learning-based conversations that gave them time to pause and offer a meaningful reflection on their approaches to learning mathematics. The process of interactive writing provided space for intimate conversations to occur between the students and me, a space that was safe for them to share their emergent thoughts about their learning, and a space where I could scaffold learning to learn in specific ways for each particular learner. The responsiveness available to me in my replies demonstrates conversational characteristics of being dynamic through listening.

On occasion, the interactive writing led to a conversation starting among the textual artifact, the student, and me. This interaction can be seen as a hybridity of modes where the opportunity for the learning-based conversation arises out of making sense collaboratively of a text. As an example, upon returning the first interactive journal writing, Kylee exclaimed that the suggestion in shaping her cue card strategies was helpful. Her engagement with the journal led to a conversation among the two of us and the text that foregrounded shaping an existing learning strategy of cue cards where she developed a stronger rationale for their use. While my intention was to be supportive through suggestions, uncertainty as a conversational characteristic was present as I could not anticipate how a student would understand and take up a suggestion.

There were other instances of the hybridity of modes when students and I were in conversation with each other and textual artifacts. Mainly, this opportunity arose in the small group sessions as I invited the group members to reflect on their record sheets and the process we had developed. At the end of a small group session, Vanessa, Teresa, and I compared the class notes with their transition record sheet. Teresa commented that, "if you look at notes and it doesn't really tell you, you can't really figure it out" whereas Vanessa explained that the record sheet was "less intimidating, when you see your own writing." The conversation among the individuals and several texts provided an opportunity to consider the qualities of a transition sheet—in particular, putting mathematical ideas in their own words—in order to improve the students' approach to learning through homework. Much of the students' work in the pure mathematics class was textually-based and dependent on words and abstract symbols, so opportunities for a hybridity of modes was important.

There are at least two special cases that occurred in learning-based conversations with respect to modality. The two cases are connected because the conversation went on as a student was thinking and not necessarily speaking aloud or recording on paper the conversation. It is impossible to know if these conversations were word-based because the students do not provide a detailed image of the conversations. One special case is when students engaged in internal self-talk, as described in the previous section. Another special case is when there was a conversation

between student and text. Elise, in our first interview, explained the process of shaping her summary sheet approach:

> I don't really talk about it. I just kind of look, and I'm like, "Oh, well, that could work," and then I kind of just had put it how it could work for me, because—I just noticed Danielle's just putting sticky notes. Like, I don't know how she's putting them on and, what kind of way she's doing it. But I know she used sticky notes and just put them on sheets. So I was like, "Oh, well, that's a good idea." So I just did it my way.

Rather than talking with Danielle, Elise observed Danielle's summary sheet and engaged in a conversational manner. While these two cases have an ephemeral quality, the impact of the internal conversations can be seen in the creating and/or presence of new processes of learning and in the way in which the students viewed themselves as mathematical learners.

Pace

The final feature of opportunities for learning-based conversations is the intensity of content and teaching. The *pace* feature refers to the rate at which students perceived the course content to be unfolding. Different from the ranges that exist within each of the above three features of opportunities for learning-based conversations, the provision of time to make choices about how to learn mathematics mattered to the students. In this section I describe the milieu of the *Learning Skills* class contrasted with mathematics class, portray the students' perspectives, and highlight students' choice as what is opened up in a less intense environment.

My observations of the *Learning Skills* class revealed a class with a relaxed and flexible milieu. As I had informal conversations with Mrs. Finley, I came to see that she fostered an environment where students did not feel pressured by a fast pace but had time to engage in learning mathematics. The students in the class were left to be independent in deciding what courses they would address and how they would go about learning the content they selected. While students acknowledged that they did not always use the class time in productive ways, as Robyn admitted, "Sometimes I do nothing," they also valued the opportunity to learn "how to do my homework and how to ask questions and how to kind of feed off each other" as Jocelyn explained. Ashley commented that, "In [math] class it's limited because you have to move on and it's a very fast paced environment. Here [in *Learning Skills* class] you can sit down and slowly work though everything." In this way, the students juxtaposed the relaxed environment of *Learning Skills* with the speed at which their mathematics class moved, both within a class as teachers rapidly explained and from class-to-class as there was a new topic each day. When Shane explained that, "Sometimes I just think about how I learn" during our first interview, it was in the context of having time that this thinking occurred. The slower rhythm of the *Learning Skills* class provided opportunities for students to learn, both mathematics and learning processes.

Within the relaxed pace of the *Mathematics Learning Skills* class there were opportunities for conversations about learning. The small group sessions, while a research process, became a part of the students' experience of the course. Ashley identified "the [small] groups that we're doing, it's mostly concentrated there" for where conversations about learning to learn mathematics occurred for her. Near the end of a small group session, Chelsea pointed out that, "I feel like when I write a summary sheet, I actually can think about what I'm writing" because

she was “doing it step-by step slowly.” The development of summary sheets, as a new learning strategy for Chelsea, occurred within the conversational context of the small groups. The complexity of the opportunity in the small group is highlighted because there was time for the development of a new learning strategy along with reflective conversation within a relational space. The conversational characteristic of listening occurred within the sense of withness that was occasioned by time to listen and be together.

The different intensity, explained by the students as a change in pace, provided opportunities for students to choose to engage in learning to learn mathematics through conversations. When I joined the class just over half way through the course, the students pointed to conversational opportunities in their first journal. Chelsea identified “ask the people around me ... ask teachers about what they think is a productive way to study and understand math” and Danielle agreed that the course would be “a way for me to ask how to remember a concept or how I should look at certain topics” in relation to their goals of improving learning processes. Even the journal as a form of conversation was a characteristic that allowed the suspension of time. Because the students had already experienced the structure of the course, their choices for ways to improve their learning processes by prompting learning-based conversation was situated within the pace of the *Learning Skills* course. When I offered, students chose to accept invitations to engage in conversations about their mathematical learning. Objections could be raised to developing a different pace in a mathematics class—a relaxing of the relentlessness that students in the research project valued—yet at the same time the notion of pace could be shifted toward opening up small moments over time for students to inquire into and shape their processes of learning mathematics.

Discussion: Integrating the Features into a Model

Considering the features of opportunities for learning-based conversations does not portray the complexity of the opportunities as there is a singularity of view in examining each feature individually. In order to understand the complexity of the students’ opportunities to be in conversation with each other and their teachers about their learning processes, attention needs to be given to how the features interact. In the reintegration of data and developing connections across categories, Charmaz (2006) suggests that “diagrams can offer concrete images of our ideas. The advantage of diagrams is that they provide a visual representation of categories and their relationships” (p. 116). With the benefit of drawing together the descriptions of each of the features of learning-based conversational opportunities, the diagram below is meant as a provocation for further thinking rather than a focal point. I offer a diagram that integrates the four features and suggest how these ideas could be taken up to provide opportunities for students to have conversations that shape learning processes in high school mathematics.

A *Model of Providing Opportunities for Learning-based Conversations*, depicted in Figure 1, represents the four categories of analysis and their interaction as it informs ways in which the students had opportunities to talk about their learning strategies and thereby refine their learning of high school mathematics. The four rectangles in the diagram represent spaces for each of the features for students’ opportunities to be in conversation about their learning. In some ways, the rectangles are “containers” for each feature, where variety across a feature is contained within the representation. Rather than prescribing a metaphor like a continuum, the rectangle opens up a chance for the observer to interpret the features and its representation. Preparation, presence, and mode are represented by the interior rectangles. The overlapping

placement of these three rectangles is deliberate, to depict how each of the features contributed to moments for learning-based conversations. Pace, as the as the fourth feature, situates the other three features in a particular moment that is characterized by a relaxed intensity as described above. The various features of learning-based conversations are equally valuable and needed.

The four rectangles in the diagram, altogether, figuratively represent moments highlighting the complexity of students' opportunities to be in conversation about their learning. In fact, each of the conversational moments could be placed within the space created by the diagram. In this way, providing opportunities for students to be in conversation about their approaches to learning mathematics needs to attend to all of these dimensions. At different times, the students in the study remarked on the importance of individual features of conversational opportunities and demonstrated through their growth as learners the difference made through having a variety of conversational opportunities.

The mapping of the conversational moments is what creates the space in which the students in this study were talking about their learning and shaping their learning strategies through conversation. The diagram illustrates how each of the conversational moments contain part of each of the four features, to lesser or greater degrees. Returning to Dey's (2010) discussion of categories as those which "lack clear boundaries defined by an unambiguous set of criteria; categories are fuzzy and category membership is a matter of degree" (p. 170). In this way, the diagram captures the overlapping of features present in each of the conversations had by students. For example, the small group sessions students participated in began with developing a learning process like identifying and representing big ideas from a homework assignment. For the end of the session, I had *prepared* prompts asking students to compare the small group experience with how they saw themselves as mathematical learners. The conversation existed in a *hybrid* space, verbally among the group of students as they *participated* and in interaction with the texts they created. The conversational opportunity to reflect on a learning process included variations in several of the features explicated.

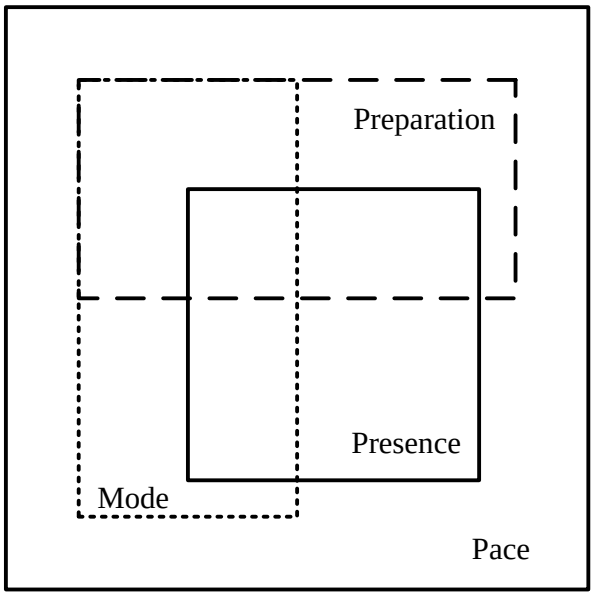

Figure 1. Model of Providing Opportunities for Learning-based Conversations

The development and integration of the four features of opportunities for learning-based conversations represents the interpretive work of elements the students valued as they talked about how they were improving in learning mathematics. Charmaz (2006) emphasizes the entire process of engaging in grounded theory as "creating abstract interpretive understandings of the data" (p. 9) and acknowledges that "theory emphasizes *understanding* rather than explanation" (p. 126). Constructing each of the four features of conversational opportunities allowed for a growing awareness of the nuances of integral elements in providing opportunities for learning-based conversations. Drawing on Skemp's (1976) notion of relational understanding, integrating the four features to notice their interconnectedness occasioned a moment of understanding that students benefited from multiple conversations, over time, and of a variety of kinds—but that each of the features needed to be present to some extent in the conversational opportunity for it to invite authentic engagement by the students to talk about and shape their mathematical learning processes.

More than providing an understanding of the particular opportunities for learning-based conversations, the *Model of Providing Opportunities for Learning-based Conversations* can be offered up for other mathematics educators and teachers to use. Kieren (1997) explicates that "'theories for' ... provide [the teacher] with insights that she can use in observing and listening differently to the mathematical actions and languaging of her student" (p. 32) in order to shape pedagogical and learning practices. For teachers who already encourage students to talk about their learning, the diagram and accompanying descriptions of the features for conversational opportunities could be used as a way to understand how students engage in learning-based conversations.

For teachers who want to incorporate learning-based conversations, the diagram could support a starting place to consider how to balance multiple features and various kinds of conversational opportunities. In fact, for the students in the study the opportunities for many different kinds of conversations were important in their shaping of personal processes of learning mathematics. Although the context of the study was a *Learning Skills* class, there are small moments available to high school mathematics teachers to invite students into learning-based conversations. For instance, 20 minutes could be set aside bi-weekly for students to alternate writing a journal about a successful learning approach and discussing in small groups an idea for how to make connections among mathematical concepts.

For researchers, further research could substantiate the categories with examples from multiple contexts. An important extension to this work is to explore how to engage students in earlier grades in learning-based conversations in order to describe and theorize about how conversational opportunities could be adapted for younger children. I invite further study in this direction in order to empower students to succeed in learning mathematics in earlier grades as they develop and refine approaches to learning mathematics through learning-based conversations.

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