Noticing Students' Conversations and Gestures During Group Problem-Solving in Mathematics

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Abstract This study investigates how attention to student conversation and gesturing can inform teacher decisions about intervention within group problem-solving in mathematics. A class of grade 5 students was videotaped during group problem-solving over the course of a school year with a purpose of examining how talk during these sessions was organized, and how changes in gesture and body language accompanied progress in the problem. It was observed that when students made progress in a problem their talk took on a cooperative, conversational structure. In addition, student gestures grew in size and became more animated as their confidence in their utterances increased. At the same time, students working cooperatively tended to echo each other's gestures and body positioning. Attending to these observed results will allow teachers to interpret how students interact in order to make more meaningful decisions about supporting group talk.

Keywords Noticing · Conversation · Gesture · Mathematics · Problem-solving

Alan Schoenfeld (2011) puts the case for noticing in the classroom succinctly when he writes "Noticing matters". A lot. (p. 223). It is less a case now, I believe, of justifying professional noticing as an area of research, and more a case of situating oneself within it. Schoenfeld (2011) goes on to ask, "Now what?" before pointing out that what a teacher sees in the classroom should shape what that teacher does. In particular, it should lead to changed practices. Also, importantly, that it is tied to the teacher's beliefs and orientations. In this research, my observations are tied to my beliefs, following Sfard (2008), that thinking is a form of communication, and that understanding, building on Wittgenstein (1957), is demonstrated as "going on conversationally" (Wells, 2014). The overt forms of this thinking, including conversational interaction, gesture, and body language, are then the noticeable clues that can help a teacher make decisions "in-the-moment". The intent of this research

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E.O. Schack et al. (eds.), *Teacher Noticing: Bridging and Broadening Perspectives, Contexts, and Frameworks*, Research in Mathematics Education,
DOI 10.1007/978-3-319-46753-5_11

is to suggest indicators that a teacher should try to notice in a classroom setting which relate to the understanding of a group of students. While recording and using the detailed tools of conversation and gesture analysis used in this research is impractical, there is evidence to suggest that there are indicators a teacher can notice in real time in order to help recognize developing understanding amongst students. I coin the term *teaching from the sidelines* to reflect the practice of actively noticing students, unobtrusively, while monitoring their progress. This requires that the teacher is looking for, and listening to, actions that unfold through group talk. These actions, general to group talk rather than particular to a problem, can then be used to support teaching. Specifically, this research addresses the question "What features of group talk, both as conversation and as gesture, should a teacher actively be able to notice?"

Literature Review

Mason (2002) pointed out "the mark of an expert is that they notice things a novice overlooks" (p. 1). This "expertise" comes partly with experience, but professional training plays an important role alongside this experience in helping to draw the teacher's attention to what to do with what they notice. The skill to be able to make pedagogical decisions in the midst of instruction is seen as crucial in the context of educational reforms (NCTM, 2000a, b). Many researchers in the field (e.g. van Es & Sherin, 2002; Corwin, Price, & Storeygard, 1996) promote the use of video to examine classroom activities in retrospect, and use their observations to point to improved practice. Other researchers, such as Fernández, Llinares, & Valls (2012), have researched prospective teachers' analysis of student artifacts via online interactions. This reflective activity is an effective way to develop one's noticing skills over time (van Es, 2004; Jacobs, Lamb, Philipp, Schappelle, & Burke, 2007), but does place an added burden on the already busy life of the working teacher. Coles (2013), who writes "We learn about things we do not know even exist by staying alert to the detail of what we see" (p. 58), illustrates a way this can be done as part of departmental meetings in a similar vein to the broader based video clubs of van Es and Sherin (2002). Developing and employing noticing skills in the heat of classroom activity is a much more challenging, but necessary, aspect in responding to Schoenfeld's "Now what?" question. Amador (2016), for example, reported that novice teachers lack in-depth interpretive analysis about student thinking, while Choppin (2011) found that teachers who attended closely to student thinking made better decisions regarding future assignments, leading to enhanced task complexity and student engagement. Informed task selection, and attending to students' strategies (e.g. Jacobs, Lamb, & Philipp, 2010), are important aspects of teaching, but "in-the-moment" decisions are also important in order to maintain the flow of classroom talk.

A feature of the reform-based classroom since the early 1990s has been a shift in practice away from procedural understanding and towards conceptual

understanding. A central focus of this shift has been promoting student talk in the classroom. Mathematical talk, which involves students' explanation of, and the defence of, ideas, is seen as a hallmark of effective teaching (e.g. Sfard, Forman, & Kieran, 2001), along with observing and listening carefully to students. Noticing what effective discourse sounds like, and how it can be used to enhance desirable outcomes, is more problematic. There are many forms of communication in the classroom, some of which can occur simultaneously. Within a whole-class discussion there may be several smaller exchanges taking place, while many students may not be engaged at all. Sfard, Nesher, Streefland, Cobb, and Mason (1998) conclude that the teacher plays a key role in the success of how classroom talk is managed, Sfard notes "There are many ways to turn classroom discussion or group work into a great supplier of learning opportunities; there are even more ways to turn them into a waste of time, or worse than that—into a barrier to learning" (p. 50). If this is the case, then it is important that a teacher is able to develop their noticing skills to be aware of what it is about classroom talk that indicates it is being productive and, as important, what indicates it is being unproductive. In addition, if the intent is to give the students space to think and generate their own solutions, the teacher needs to be away from the focus of the group but be aware of signs that indicate intervention is necessary.

It is important to notice how the stages of group conversation unfold, and to pay attention to both gesture and posture. In addition, I put forward ways the teacher can support classroom talk based on these observations. These results are part of a larger study (Wells, 2014) and more substantial arguments for these ideas can be found there.

Framework

Noticing

Goodwin (1994) investigated how members of a profession shaped events to focus their attention upon. Goodwin examined how professionals coded what they attended to into objects of knowledge, how they highlighted salient features, and how this led to what he referred to as "professional vision", an organized way of making sense of events in a particular social setting. Goodwin focussed the discursive practices of the profession and made an analogy to what Wittgenstein (1957, §7) called a language game—"a whole, consisting of language and the actions into which it is woven". Mason (2002) used "intentional noticing" in comparison to everyday noticing and "professional noticing" to refer to the action of watching someone else acting professionally. More recently, the term "professional noticing" has developed further in the work of Jacobs et al. (2010), as a progression through the interrelated phases of attending to student's strategies, interpreting their mathematical understandings, and deciding how to respond on the

basis of these understandings. These phases provide a framework to help analyse students' mathematical conceptions. More recently, researchers such as Thomas et al. (2015) use a broader description of attending to involve "noting aspects of a mathematical moment as a way to gather meaningful evidence (p. 296)". Important to this research, this broader description incorporates body language, changes in inflection, and other physical manifestations of learning.

Professional noticing in the classroom should not only include looking, but also listening. Students say a great deal more, and often in a way which is more demonstrative of their thinking, than what they are usually willing to write down. A thoughtful exchange of mathematical ideas can result in an artifact which belies the effort put into it. The transient nature of sound makes noticing more challenging in a busy classroom, so establishing what to pay attention to is important. While there is a growing body of research into noticing *what* students are saying (e.g. Fernández, Llinares, & Valls, 2013), in this research I was interested more in noticing *the way* they were saying it.

Conversation

Goodwin (1994) made reference to the work of Sacks, Schegloff, and Jefferson (1974) in developing Conversation Analysis. This stemmed from the observations of Sacks, who reportedly became interested in the organization of conversation through his work at a suicide counselling hotline (Pomerantz & Fehr, 1997). He wanted to know if the seriousness of the caller could be determined from the way they engaged in conversation. In effect, he was noticing significant moments in the talk, in this case the callers' mechanism of avoiding giving their name; the at-risk caller did not respond in an expected way. Sacks et al. (1974) recognized that verbal interaction has a social structure and organization where previously it had been thought that language was simply a medium to pass on information. In a similar manner, Scheflen (1964) reported that "Configurations of posture or body positioning indicate at a glance a great deal about what is going on in an interaction", and that "such behaviours occur in characteristic, standard configurations" (p. 316).

Turn-taking, where responses between interlocutors often occur in pairs and where there is an expectation of a certain response, is a characteristic of conversation. Significantly for this research, it was seen that turns appear in sequences so that a conversation has an introduction sequence followed by a core sequence and a closing sequence (Sacks et al., 1974). It was conceived that there is an institutionalized set of conventions that provide the framework for interactions in a particular context. Being able to notice key aspects of this framework in a classroom context—a special type of social situation—can be important to a teacher. Erikson (2011) has pointed out that students are adept at noticing what the teacher notices, and that the nature of classroom talk also reflects the atmosphere nurtured by the

teacher. It is important, then, that a teacher is able to notice the features of effective talk so that such talk can be supported and developed amongst the students.

Effective Group Talk

Deciding what constitutes effective group talk is a key question. What is happening during those interactions is equally important to consider. Goodwin (1994) made a link between conversation analysis and the ideas of Wittgenstein (1957), who suggested that meaning is generated in the context of conversation and not uniquely by the words uttered. Sacks et al. (1974) emphasized that there is no predetermined structure to a conversation, but nevertheless conversations exhibit an organization that can be analysed. Wittgenstein (1957) felt that understanding was present when a speaker was able to "go on" with an idea; I suggest that a conversation develops when the interlocutors are able to "go on" with their turns at talk.

Gadamer (1975) writes that "a characteristic of every true conversation is that each opens himself to the other person" (p. 347), while Davis (1996) makes a distinction between a "conversation" and a "discussion". A conversation is seen as an open-minded exchange of ideas, while a discussion consists of the articulation of pre-formed ideas. The implication is that the interlocutors in a conversation need to be willing to engage in the process; each party must be willing and able to interpret the others' utterances in a meaningful way. When examining students' talk, Sfard (2008) suggests that there should be signs of a change in their discourse about the mathematics as a basic indicator of growing understanding. When talk is reduced to discussion, as defined above, participants make statements they are unwilling to question or reluctant to change; there is little or no growth in their discourse. In this case, the interlocutors are unable to "go on" with their thinking and so to develop understanding. This is a finer grained view of conversation than is typically used but if we want classroom talk to be productive then, as Mason (Sfard, Nesher, Streefland, Cobb & Mason, 1998) points out, it needs to be within the confines of a "conjecturing atmosphere" rather than "unfocused or off-task interaction" (p. 48). Davis's (1996) distinction is really about narrowing down the term "conversation" to that part of talk which is interactive and effective. The conversation is seen as a "meeting of minds" (Davis, 1996, p. 42), and understanding as being "negotiated with others through communicative interaction" (p. 23).

Conversation implicature (Grice, 1975) is based on the belief that talk exchanges are characteristically cooperative efforts; that interlocutors generally want to make sense of what each other are saying in order to move the conversation forward. Grice (1975) outlined four maxims of cooperation, which are the hallmarks of conversation: quality, quantity, relevance, and manner. Essentially, this means only adding what you believe to be true to the group talk, and doing so in brief, unambiguous, and orderly contributions. Grice suggests that violating these maxims generally causes conversation to break down. Similarly, the Politeness Theory of

Brown and Levinson (1978) includes Goffman's (1972) notion of face, which is the social value a person effectively claims for him or herself. Face threatening acts are those that either undermine the social status of an individual (known as positive face) or a person's ability to act (negative face). Such acts inevitably cause some reaction from the person threatened and can be noticeable in terms of a lack of cooperation. I suggest that attending to these social aspects of conversation can be an important aspect of maintaining group talk.

Gesture

Further, classroom interaction requires that students listen to each other and an observable part of listening comes through bodily interactions. Gestures, and actions such as leaning-in and reaching out, are noticeable features. A shift towards an embodied view of human experience leads to a suggestion that understanding can also be exposed by subconscious gesturing. McNeil (1992, 2005) developed a continuum (later continua) ranging from the completely unintentional *gesticulation* to formalized sign languages such as American Sign Language (ASL). McNeil identified four types of gesticulation, namely *Iconic* gestures which represent an actual action or object; *metaphoric* gestures which represent an abstract idea; *diectic* gestures which point to or at something; and *beat* gestures which carry no meaning and are often timed with prosodic peaks in speech. Beat gestures can be associated with emphasis or an emotional state. McNeil later added the *performative* gesture, which enacts what it represents, such as a rolling ball indicated by rotation of the hand or arm.

In everyday talk, gestures have been considered to be an integral part of communication (e.g. Kendon, 2004; Sikveland & Ogden, 2012) and linked to speech in a semantic and temporal way, while body language plays a part in any group talk (Goffman, 1972). Goffman refers to expressive cues we use as part of the communication process, further researched by Vertegaal, van der Veer, and Vons (2000). Vertegaal et al. (2000) make a link between the amount of eye contact people give and receive to their degree of participation in group communications. In addition, Hastings (2006) describes how certain eye movements may be associated with particular kinds of thinking. Roth (2000) describes a conversation as gestures and talk, adding that gestures and words only take on specific meaning in their interaction. As such, Roth sees thinking as being shifted into the world before the listener rather than being confined "in the head" (p. 368). Radford, Edwards, and Arzarello (2009) support this position, noting that "Thinking does not occur solely in the head but also through a sophisticated semiotic coordination of speech, gestures, symbols and tools" (p. 111). Sfard (2009) observes that combining speech and gestures brings about "an obvious synergistic effect" (p. 193), adding that gestures are "crucial to the effectiveness of mathematical communication … to ensure that the interlocutors speak about the same mathematical object" (p. 197). In the realm of science education, Crowder and Newman (1993) have examined the

way gestures work in sense-making talk, observing that there is a change in the manner in which students gesture between describing models and figuring things out (running a model). Describing a model uses gestures timed with speech while running a model frequently exhibits gestures which precede related verbal content. Goldin-Meadow has researched extensively into the area of gesture-speech mismatch (e.g. Goldin-Meadow, 1999, 2015) as an indicator of developing understanding. Goldin-Meadow (1999) notes that "Children who produce a relatively large proportion of gesture–speech mismatches when explaining their (incorrect) solutions to a task are particularly likely to benefit from instruction in that task" (p. 424).

Echoing

A further interesting aspect of gesture has been referred to as "mimicry" (Kimbara, 2008; Holler & Wilkin, 2011), although I prefer the term *gesture echoing*, suggested by Pimm (2014), as giving a less intentional sense of the process. If a gesture or posture is being deliberately mimicked, then there may not be a genuine connection; if the gesture is subconsciously echoed, then the connection may better reflect a sense of shared understanding. Holler and Wilkin (2011) found such gestures "appear to facilitate the mutual understanding of the particular aspect that was being referred to" (p. 143).

Coles (2013) has observed that there is sameness in how talk unfolds in the classroom, year after year, even though each year the specific patterns of talk are different; there is "stability in those patterns across the years". Such an idea suggests an organization of talk that a professional might notice. Coupling this with thinking of understanding as a dynamic process, and incorporating the ideas outlined above, I suggest that it is "understanding as a state of action" that the professional classroom teacher can notice and support. In addition to paying attention to the mathematical content of the talk, I show that being more aware of typical organization of group talk (or lack thereof), and the manner in which students interact with their bodies, can help inform us about students' mutual understanding.

Methodology

The study was focused on two grade 5 classes over the period of their school year in a Canadian school. The school is located in a city east of Vancouver, BC, and consists of a wide range of cultural backgrounds typical of the area as a whole. Immigration to this region from many parts of the world is an ongoing process and produces a broad range of English language skills in the school. All the students in this study had a working knowledge of English, but some were clearly more fluent than others. Students were observed to converse freely outside of the classroom

about various social issues typical to grade 5. Such observations helped to gauge a student's general level of interaction with their peers. The school and classroom are considered to be "safe environments" in which to learn, meaning there were no obvious barriers to student participation. Classrooms are encouraged to be places where students examine their thinking and, as such, the activities captured were not presented in an atypical way to students. The classrooms were bright, with one wall being a bank of windows, and desks were arranged in groups of four. The room was colourful, with posters and student work adorning the walls. Lessons often spilled out into the corridor or common spaces around the school and students were comfortable being sent out to work in quiet places. The students in the study (n = 32) demonstrated a wide range of attitudes to their work, from showing a very motivated approach to indications of attention difficulties. No students, however, were designated as having learning disorders.

Video recordings of mathematics classes were carried out from September through to June on a weekly basis. In total, over 150 video recordings were made during this time, ranging in length from shorter clips to full-class (45-min) recordings. Recordings were also made of groups of students following the task completion, either when presenting to the class or when engaged in a full-class discussion. Each contact lesson was part of the classroom teacher's normal mathematics programme. With a few exceptions, the classroom teacher generally selected the lesson activities and taught the lesson. The intent of the research was to look for characteristics common to any mathematical classroom talk in a natural setting, rather than linked to a specific activity.

In order to capture talk and group dynamics, three cameras were used; one camera was placed close to the group to ensure clear sound recording, while the others were set back to the sides of the room to capture more of the students' gesturing. Cameras were placed on tripods, turned on at the start of the group talk, and then left to run so that adult presence was not intrusive. Additional field notes were made as the lesson progressed. The video clips were then downloaded and examined using the software *ExpressScribe* (NCH Software, Inc., n.d.), which allowed clips to be slowed down and played frame-by-frame for easier transcription and coding. While students were aware that they were being recorded, they quickly seemed to ignore the presence of the cameras.

In these classroom sessions, all material was relevant to the learning outcomes of the British Columbian grade 5 curriculum (Education, 2007), but were "problem-based" rather than instructional. The typical lesson format was of an introduction followed by group work. The groups were of two to four students, generally not selected by gender or perceived ability, but to give a variety of combinations.

Students were given time to read through the task and think about the problem without talking or writing anything down. The intent was to give the students the opportunity to think about the problem from the moment it was assigned. The students were then asked to discuss how they thought the problem should be solved and to think of more than one way to solve the problem. Occasionally, having students stand up to discuss the problem seemed to encourage more body language

and gestures than when they were seated. When the classroom teacher felt the students were ready, they were allowed to retrieve pen and paper to work on the problem, or to use white boards or manipulatives as appropriate. As the lesson drew to a close, the classroom teacher would generally bring the students together to discuss their findings.

Sorting the Data

Prior to making any transcription, a recording was viewed in its entirety with the intent of noticing any general features that immediately stood out. At the same time, recordings were initially classified into one of three broad categories: groups apparently making no progress, groups that seemed to be making progress before running out of time or ideas, and groups that seemed to have moved towards a solution they were satisfied with (not necessarily the same as expected by the teacher). Attention was paid to group dynamics, the quality of the question, and the mood of the class on that particular day (for example, events such as Halloween were detrimental to activities).

While a time-consuming process, transcribing the talk gave what Psathas and Anderson (1990) have called an "intimate familiarity with its details in the (real time) temporal flow of actual sequences" (p. 77). In addition to conversational markup, recordings were viewed a further time to look for gesturing and other salient features. Gesture markup was added to the transcript to indicate the temporal location of each gesture from its starting stage, through its stroke stage, and to its completion (McNeil, 1992). In order to break down the process further, focus was placed on the opening exchanges of the groups to see what was noticeably the same or different between groups that made progress and those that did not. From a broad base of these transcriptions, selections were narrowed down further in order to look for indicators that stood out across groups as they continued to work on the problem; this selection was done to isolate a few good examples of the general process, taken from each of the earlier groupings based on observed progress. The recordings were again reviewed in order to interpret what had been attended to on earlier viewings. Throughout, the focus was on recognizing features common to group talk in a variety of situations that a teacher would be able to attend to.

Results and Analysis

Analysis of the recordings made over the course of the school year indicated several moments, which, if noticed, can give a teacher clues as to developing shared understanding. By listening to and observing students in a group setting, the

classroom teacher can make a more informed choice about actions to support learning. In this section these observed key moments to attend to are first outlined, and then supported with evidence from the recordings.

Attending to the Opening of the Talk

This can be a time when there are many distractions for both the teacher and the students, but actively attending to how students open their talk can be fruitful. The results of this research indicate that taking a moment to settle the class to engage in a focused start to their group talk, and then actively listening from the sideline for certain features of the talk, can give important clues as to how the talk will progress. At this stage, it may not be a matter of what is said as the manner in which it is said, or left unsaid, that is important. The results indicated that if talk did not begin in a cooperative way, then the session did not develop mathematically; either the students were unable to develop a way to solve the problem, or there was no sense that the students had changed their discourse about the mathematics in the problem. Students who opened the session by establishing good grounds for a conversation, in the sense of creating a mutually supportive atmosphere, were more likely to engage in a mutually supportive exchange of ideas and move to the actual mathematics of the problem.

There was a clearly observable ritual nature to the opening talk that seemed to generate the conversational space needed to build understanding. When this ritual was violated, the group did not make progress beyond the introduction stage. In a typical opening start, one student would take on the role to read out the question to the others. If the question was lengthy, another student would take over when the first student paused. This seemed to be done without any predetermined agreement. Once finished reading the question, the cooperative readers were seen not to offer suggestions, but to pause to allow another to make the first contribution, even when (as was evident from ensuing turns at talk) the reader had already formed a clear idea of what to do. In each case where the student who read the question then made the first suggestion, the group failed to make progress and, significantly, no conversation was established. The following example illustrates such a violation, where italics indicate overlapping talk:

> *Simone*: Anna came across this puzzle, something times something equals six-hundred twelve.
>
> *Eric*: What might be *the missing numbers*
>
> *Simone*: *the missing numbers*. Well, so, how many solutions can you find, show all your thinking plus explanation. Well I first thought we could try doing six hundred twelve minus … well we know six times two umm equals twelve … so … twelve
>
> *Eric*: Wait, so six hundred twelve …

Simone has opened the talk by reading the question and pauses after the first line. Eric takes this as a clue to continue reading but is immediately overlapped by Simone, who finishes the question and then starts to make a suggestion. Eric's reaction to this is to aggressively interrupt and question Simone. This is rare at this stage and Eric's posture also changes; he sits back and lowers his eyebrows. From this point the exchange's turns are not cooperative and neither student supports the other's utterances. Although there are turns at talk they are more challenging in nature. The two students make no progress with the problem and eventually call the teacher over for help.

Interpreting the Opening Ritual

As an isolated case there may be a number of reasons for these two students not to work together well, but I stress this violation of the structure of the opening sequence, regardless of the individual case, could always be noticed to lead to a dysfunctional group. Violating the format of the opening sequence seems to be an affront to the face (Levinson, 1983) of the other students in the group and results in a backlash, which affects the group dynamic. The opening of the talk appears to tie in with the ideas of Grice (1975), outlined above, in terms of conversational maxims. The opening exchange sets the tone for any future talk about the problem. Without the dynamics of such a conversational space it does not seem that a shared understanding can develop. The interesting thing here is that results from this research indicated that a conversational tone is established very quickly, or not at all.

Opening politeness also extends to cases where students read the question quietly, as in the case of Alex and Nadia below:

Alex: okay, let me read the question … (15s delay)

Nadia: Well, I mean, ready?

Alex: okay.

Here, the words "okay" (in the first line) and "well" are used as markers to request a turn at talk. In this way, the talk seems to be established without a power struggle, as being a common working space. Once a communal conversational space is established, interrupts, overlaps, and completing another person's utterance are acceptable and common features of conversation.

Attending to the Manner in Which Students' Gestures Change During the Session

When students' gestures increased in size, this was observed to coincide with an improved vocalization of their thinking. Students demonstrating large gestures were, at the same time, able to "go on" with their ideas and make progress with the problem.

McNeil (1992) divides the space in front of the speaker in terms of a *centre* and *periphery*, where the centre region is the person's torso from waist to shoulder and away from the body. I refer to gestures, which move into the periphery area and beyond "big gestures". Such gestures seem to accompany confident utterances. Figure 1 (and again in Figure 6) illustrates how a student in this research uses large gestures, which fill the gesture space before her.

Student: *If you have like a pop can the bottom is like a little circle that sorta stands out that would be the perimeter*

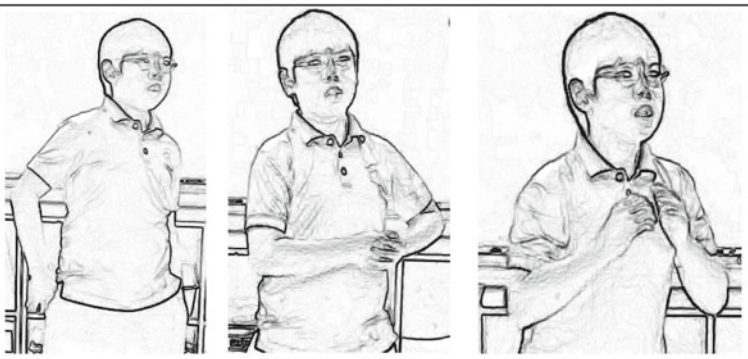
Her hands shape out the object in space and she points to its base. She then draws a large circle in the air with one hand while the other hand seems to hold the object in space.

Student: *And the inside that is like closer to the can I guess is like the area*

The gestures she is using are large and take up the centre area in front of her while also moving into the periphery area in front and to the sides.

Figure 1. Larger gestures of confident student.

Typically, the recordings demonstrated that gestures get bigger as the person is able to "go on" with the talk. This is illustrated in Figure 2, in which the original image taken from the recordings has been modified to protect the identity of the student.



These recorded images illustrate how a student who starts off an explanation lacking in confidence is often stiff in posture and holds their hands/arms fixed, in this case by hooking them in his pockets. As his confidence grows he frees his hands and they gesture in a low space around his waist. As his confidence grows further, his gesturing rises higher and his body language is more dynamic.

Figure 2. Gestures growing in size.

Interpreting Observed Gesture Size

Figure 3 illustrates gestures that were recorded when the students were working in their groups. Evidence of large gesturing seems to be an indicator that the student is confident in what is being uttered as they corresponded with clear and confident utterances. This change in the size of gesturing supports research on gesture dynamics and interaction by Gerofsky (2008), and Winter (Winter, Perlman, and Matlock, 2013), who note that gesturing size depends on the ongoing discourse; and ties into findings by Crowder (1996), who found students used larger gestures but positioned themselves further away from their gestures when presenting other peoples' ideas.

Using the ideas from watching students presenting and working in groups monitored by the camera, an inference can be made that students who use dynamic gesturing are also confident about the ideas they are expressing. Seated gestures tend to be more confined but can still stretch outside of the centre into the peripheral area.

Figure 3. Seated Group work gesturing.

Attending to Students' Echoing

One recorded aspect of group interaction was posture echoing. The more conversational students were, the more they tended to echo each other's gestures and/or posture. Echoing, particularly that of posture, was a frequently observed feature and is illustrated in Figure 4. In the first panel the two girls lean closer and adopt similar poses as they become more involved in their conversation. The girl on the left makes increasingly large hand gestures during this time. Closing the conversational space was frequently observed when students were working on a shared understanding. Figure 4, panels 2 and 3, shows that the girls in the group adopt a similar posture during their interactive talk. The boy is excluded from the talk until he adopts the same posture. Several reasons for the boy being initially excluded from the group talk can be suggested, but I again stress that this is but an example of an effect frequently enough seen across many groups to suggest that it is an important indicator of inclusion, and so important to notice.

The three girls in this group adopt a common posture while speaking as seen in panel 2. The boy in the group can only gain the others' attention when he mimics their posture.

Figure 4. Posture echoing.

Figure 5 illustrates that when individuals withdraw from the group talk they uncouple their posture. In larger groups, posture echoing between elements of the group was seen to be a dynamic process, with individuals moving in and out of the collective posture.

Another example of posture echoing. The postures change but those students who are engaged seem to adopt a common stance. The student who uncouples from the group posture self gestures before rejoining the posture of the group (panel 3).

Figure 5. Changing posture echoing.

A second, less common, indicator or shared understanding was in gesture echoing. In this case the group members adopted a common gesture, which was then used to convey a shared meaning throughout the session. On occasions where I recorded more than one group working on the same problem, a striking feature was that the group used different common gestures to represent the same thing. This is illustrated in Figure 6.

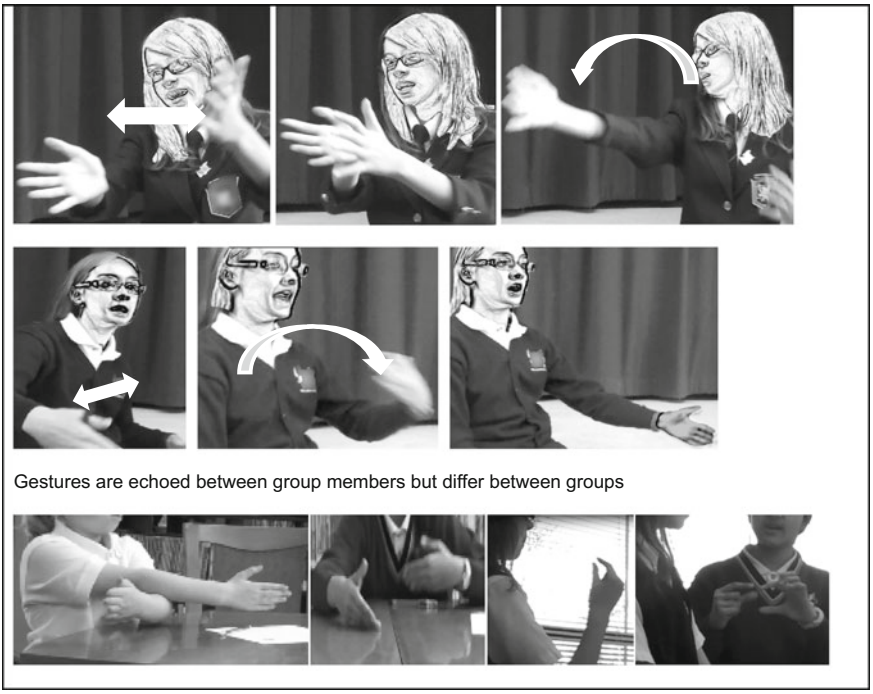


Figure 6. Gesture echoing.

Interpreting Echoing

If students are engaged in conversational talk, which will typically be accompanied by gestures, a shared understanding is being developed. This is in keeping with the idea of "exploratory talk" (Mercer, 1996), in which talk is mutually supportive when seeking to address the task in hand. If a student is constantly out of sync with his or her group, then some form of teacher intervention is necessary. When students uncouple from the group posture, this stemmed from either a loss of shared understanding and giving up, or from questioning the shared understanding and temporarily standing back in order to clarify thinking. In the former case the student's contribution to the group talk diminished; in the latter case the student typically made small self-gestures as indicators of their continued engagement.

They were then often able to re-engage with the group and make productive contributions to the group talk. Noticing this can be an important indicator to the teacher as to the level of shared understanding of the student concerned.

Attending to Developing Talk

Paying attention to the organization of the talk, as well as gesture and posture, brought out further features that were noticed. Groups that maintained a cooperative conversational space were able to progress deeper into the problem. This talk featured comments that were supported by others or were justified to the group. When fragmented talk within the group occurred it was generally an indicator of a breakdown in shared understanding. This fragmented talk is illustrated by the excerpt in Figure 7. The three boys, Aaron, Bashir, and Chan, are working on an area problem in which a field changes dimensions. Aaron is mistaking area with perimeter but continues with this despite the protest of Chan and the confusion voiced by Bashir.

The = symbol is used to indicate conjoined utterances; italic are overlaps		
24	A:	err you have to do ten times twenty first ((to Bashir))
25	B:	(Softly) then I .. then just=
26	A:	=ten times twenty is (drawing out the word 'is' like a prompt)
27	C:	two hundred (interrupting Aaron and Bashir's exchange)
28	A:	two hundred and then *two hundred* plus fifty eq*uals*
29	C:	*two hundred* *NO* (overlapping Aaron's prompt)
30	A	two hundred umm fifty minus two hundred equals fifty
31	C:	I guess that works
32	B:	You missed=
33	A:	=No this one's right ((points to Bashir's work)) but you just have to (*pause*) so this one's two hundred, right ? then you subtract yeah you can do it this way too, two hundred=
34	B:	=What?
35	C:	Just write the answer to the question (sighs)
36	A:	so it depends if you reduce by fifty the area=
37	B:	=why's it two hundred fifty? (Softly spoken)
38	A:	okay (pause) that's *when* you *then*
39	C:	*Aaron … Aaron …* why are you doing it all by yourself now? It's like its copying (soft laugh)

Figure 7. Fragmented talk typical of a discussion rather than conversation.

Interpreting the Developing Talk

In Aaron's discussion, in which ideas are being transmitted rather than worked on collaboratively, there is no connection being made for Bashir. Even when Bashir tries to add his thoughts, Aaron ignores them and continues (lines 25 and 32). Aaron also speaks over Chan's overlays without recognition (line 28). Chan's use of the word "guess" in line 31 indicates that he remains unconvinced by Aaron's help for Bashir, and perhaps even for himself. Chan interrupts Aaron more forcefully (line 34). Perhaps sensing that Aaron is still not helping, Chan interrupts Aaron's gesture space over Bashir's work by placing his hand into the gap between Aaron and Bashir, and suggests that Bashir "just write the answer" (line 35). Bashir tries again to ask for help (line 37), but Aaron continues to simply "talk". Finally, Chan stops the talk, asking more pointedly why Aaron is working by himself. Chan says what Bashir is doing is no more than copying from Aaron. Interestingly, this comment is made without a physical gesture. Chan has shown that he has been quite demonstrative throughout the session so the lack of any physical gesture here may be significant, perhaps dismissive or disengaging.

This inability to create a conversational space was typically seen when groups became unable to make further progress in the problem. By noticing when students are conversationally engaged, when their postures are echoed, and looking for signs of gesture echoing, the classroom teacher has indicators upon which they can act. In cases where a group was in a conversational mode, the arrival of the classroom teacher was seen to be detrimental to progress and it took some time for the group to re-establish their sense of shared understanding after the teacher had left. It is therefore as important that a teacher knows when *not* to intervene as much as when to do so.

Attending to the Shifts in Group Talk

The significance of the development stage of group talk is that it illustrates how the conversation can move from general talk about the problem to then incorporate the mathematics. The extension stage occurs when the students continue their conversation beyond the immediate requirements of the problem, for which they are content to have found a solution in the development stage. Figure 8 is an excerpt showing three students moving into the extension stage. They have found a solution for a problem involving ferrying cars and trucks across a local river on a boat with 42 "spaces". Each student shows clear signs of engaging in conversation as their turns at talk support and extend those of their interlocutors. Their talk is inclusive (e.g. line 14) while at the same time includes justification (line 18). Line 19 shows how this continued.

11	C:	and then that'll be thirty… and then three times the cars
12	M:	Yeah (pause)
13	C:	Okay (pause)
14	M:	Oh, no (pause), I was just thinking about like if you know that six time six equals thirty-six then if you added ten, then you would have forty-six and not forty-two (pause) so that wouldn't work (pause) Sally can you explain it?
15	S:	Yeah (drawn out). So like (pause) ah so there's forty-two vehicles and there's ten umm six trucks then you can't do it at the same time so you could put the umm trucks at two times across the river (pause) and then (pause) umm (pause)
16	M:	then the cars too like three plus *twelve* is
17	C:	*No we all*
18	S:	*no* two times six two times six equals twelve (pause) and then umm three times ten equals thirty (pause) and then add and you get forty-two, so yeah ..
19	M:	I'm trying to think of like other possible ways that you could do this

Figure 8. Moving to the extension stage of the problem.

Interpreting Shifts in Group Talk

These stage transitions can be important indicators of the students' progress and something a teacher should actively try to notice. In this transition there was a change in the talk indicated by the students posing or responding to "what if" style questions. This is an example of the conjecturing atmosphere referred to by Mason (Sfard, Nesher, Streefland, Cobb & Mason, 1998) as necessary for deeper learning to occur. Many groups stopped when they felt they had fulfilled the requirements of the question and needed further prompting to think more deeply about what they had found. Noticing when students shifted between stages, and intervening to prompt further enquiry, was seen to prevent group talk degenerating and becoming unproductive.

Conclusions and Reflections: Teaching from the Sidelines

Noticing is about being aware of details the casual observer looks past, as Mason (2002) pointed out. The results from this research suggest that there are such details a teacher can attend to in real time in order to help promote productive talk in the classroom. Such productive talk may be seen as an indication of developing mutual understanding amongst students. The third aspect of professional noticing involves deciding on effective tactic drawn from the interpretation of the classroom events (Jacobs et al., 2010). The concept of *teaching from the sidelines* is that the teacher stands far enough away from a group so as to minimize his/her influence on that group. At the same time, the teacher can be aware of the progress of the group by watching and listening to the group members.

Results from this research highlighted how it was possible to stand back from any group in the room and yet tune into the group talk unobtrusively. While a teacher may develop and enhance their noticing skills through experience, being more aware of key points to notice in group talk will develop these skills further. This research draws attention to the gestures and postures of the students as they interact with one another, something that previously may have been done sub-consciously and unresponsively. It is possible to recognize, for example, when students are engaged in mutual activity from their posture and/or gesture echoing. An unproductive group—one that may be helped by intervention—is apparent by a lack of such echoing. An individual who is not engaged in a larger group is similarly noticeable. The confidence a student has in their utterances is often indicated by the nature and size of their gesturing. The absence of gesturing, or when gesturing is small or a mismatch to talk, can be a noticeable sign of a lack of confidence in an utterance and as such be a good time to offer support.

By listening carefully to how groups begin to solve a problem, a teacher may choose to intervene quickly if the student who reads the problem violates the polite turn-taking aspect that characterizes the introductory stage of the group talk. Similarly, flouting any of Grice's (1975) maxims of quality, quantity, relevance, or manner can stall the functioning of the group. Working with students who routinely flout these maxims might be considered as a way to better integrate them into the class. It may be the case that students are expected to know how to function in a group setting, and while this is a skill many have developed, there is work that can be done to improve this. Conversation may be a skill teachers need to teach, for example, and foster in their classrooms if they are to have success in non-traditional ways of teaching. This, I suggest, is where professional noticing can be of great importance, for students cannot learn these skills unless teachers can intervene at the appropriate time to support them.

Students who are functioning cooperatively in a group are best left alone as the casual "dropping in" of a teacher may break the pattern of conversation and disrupt the understanding process. Conversely, it is important that a group be monitored so that they remain on-task and develop a mathematical understanding that meets the intended outcome of the problem (or extends beyond it or beside it in a productive manner). Learning how to listen to and notice productive indicators of success/failure can be an important habit of mind for teachers to develop. If talk is seen to be "central to the meaning making process and thus central to learning" (Mortimer & Scott, 2003, p. 72) then it is important that classroom teachers are able to manage this talk. This should also mean that the teacher notices important features of successful talk.

The results of this research suggest features of group talk which can be attended to and subsequently allow for in-the-moment interpretations and decisions about how best to support the group talk. Such features may not be noticed by casual observation, or if attention is paid to the content of the lesson alone. By carefully noticing the organization of group talk, and paying attention to student posture and gesture, there is much more that the teacher can learn about students' shared understanding.

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