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### Professional development as discourse change: teaching mathematics to English learners

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## Professional development as discourse change: Teaching mathematics to English learners

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This study examines teacher learning from the perspective of cultural-historical activity theory, which emphasizes the creation of new environments and new artifacts. This study focuses on one elementary school teacher over the course of professional development sessions for equitable mathematics teaching. Within the professional development, the teacher created a student project that investigated linguistic diversity in the school community. Thematic analysis reveals that teacher discourse relating to teaching mathematics to English language learners (ELLs) changed after the implementation of the inquiry project. More specifically, the discourse shifted from focusing on ELLs' barriers and challenges to highlighting what ELLs can do. This shift was coupled with a change in the classroom mathematics learning environment.

Keywords: teacher learning; discourse; English language learners; cultural-historical activity theory; mathematics professional development

In a globalized society, an increasing number of people speak a first language that differs from the official language(s) of their country of residence. In many urban schools in English-dominant areas, there has been a significant increase in the

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population of English language learners (ELLs) who require focused educational supports to attain English proficiency. In classrooms that focus on teaching content like mathematics, history or science (as opposed to teaching language only), ELLs often have limited opportunities to interact in English and to develop academic languages (Harklau, 2002). Academic language is a specific genre of language used in the school domain and can be different from other genres of language, such as everyday conversational language proficiency (Cummins, 2000). It can take anywhere from 5 to 10 years or even longer for ELLs to reach the levels of academic language proficiency of “native” English speakers in content areas such as mathematics, sciences, and social sciences (Collier, 1995; Cummins, 2000; Thomas & Collier, 1997).

Previous research has identified some of the knowledge that is necessary to teach ELLs in mainstream content area classrooms (Gandara, Maxwell-Jolly, & Driscoll, 2005). Such knowledge includes, the ability to communicate effectively with students and to engage their families, teaching the mechanics of language, and building a sense of self-confidence in teaching ELLs. However, according to a teacher survey conducted in the United States, teachers in mainstream content area classrooms face difficulties in accessing professional development (PD) and resources for teaching ELLs (Gandara, et al., 2005). In this context, our research offers a case

of teacher learning based on an inquiry-based PD session focusing on teaching mathematics to ELLs.

### **Cultural-historical activity theory of learning**

In order to frame teacher learning, we take an approach based on cultural-historical activity theory (CHAT) that emphasizes the interactions between the learner and the social context (Cole, 1996). The CHAT perspective provides an alternative to a widespread perspective on learning that positions learning as an activity that happens essentially within an individual's mind. From the CHAT perspective, learning is embedded in social and historical contexts and conceptualized as the product of one's collaborative engagement in social and cultural activity.

One of the central concepts of CHAT is the notion of internalization, first proposed by Vygotsky (1981). With this concept, Vygotsky maintains that learning happens initially between people (externally or socially) and then moves onto the intrapsychological level. This perspective emphasizes the social origin of learning. As a counterpart to the process of internalization, Engeström (1987) introduced the concept of *externalization* in learning. Briefly, the concept of externalization highlights the creation of new cultural artifacts and the production of new societal activity systems. These two paired concepts – internalization and externalization – illustrate CHAT's assumption that “human development is based on active

transformations of existing environments and creation of new ones achieved through collaborative processes of producing and deploying tools” (Stetsenko, 2005, p. 72).

We employ the CHAT perspective on learning because we believe that teacher learning allows for the transformation of existing learning environments (for students) and creation of new artifacts (for teaching and learning). In addition, these external transformations are often reflected in teacher talk about their students, and about general processes of teaching and learning. From the CHAT perspective, discourse is considered to be a psychological tool and artifact and therefore we can examine it in the context of its production (Daniels, 2010). We use the term *discourse* with reference to the definition of Discourse (with a capital D) used by Gee (1990):

A Discourse is a socially accepted association among ways of using language, of thinking, feeling, believing, valuing, and of acting that can be used to identify oneself as a member of a socially meaningful group or social network, or to signal (that one is playing) a socially meaningful role (p.143).

By defining discourse in such a way, we can shift our focus from individuals who speak, to socially and historically defined Discourses appearing in classroom practices. Drawing on Gee’s argument, we focus on discursive practices seen in teacher’s talk about teaching to ELLs and in the classroom mathematics learning.

Because we limit our analysis to one small aspect of a broader Teacher Discourse, we use discourse with a small case “d” in this paper. Our use of the term discourse will

be reserved for that aspect of teacher discourse that is revealed in the way teachers describe the characteristics and pedagogical needs of their ELL students.

We conceptualize the relationship between teacher discourse and the social organization of classroom learning as a dialectical process (please see Figure 1). Teacher discourse influences the social organization that teachers adapt in their classrooms (such as educational materials, student grouping, the use of ELLs' first languages, and the use of particular discourses), and these social organizations help teachers to become aware of and modify their discourses. Of course, many other aspects of schools and classrooms influence teacher discourse: curriculum documents, school-wide policies, textbooks, timetabling, and so on. In this paper, we focus primarily on teacher talk about their ELL students, how this talk is substantiated in classroom social organization, and how changes to classroom social organization helped teachers rethink their discourse about ELL students.

(Figure 1)

Figure 1 suggests two points of leverage for better supporting ELL's mathematics learning in the classroom. One point of leverage would be to try to change teacher discourse directly. The second point of leverage would be to change the social organization of the classroom in ways that support a change in discourse about ELL students' needs and capacities. This second point of leverage is in line with recent

research in mathematics teacher education that argues for the importance of *classroom-embedded professional development* (Franke, Carpenter, Levi, & Fennema, 2001; Kazemi & Franke, 2004; Musanti, Celedon-Pattichis, & Marshall, 2009; Steinberg, Empson, & Carpenter, 2004). Proponents of this type of PD have argued that teacher learning is facilitated by reflection on student work and student problem solving in the classroom (Franke et al., 2001). By creating opportunities for teachers to reflect on the role of language in students' mathematical problem solving, the classroom-embedded PD can support teacher learning of mathematics pedagogies that are sensitive to language minority students' needs (Musanti, et al., 2009).

### **Teacher discourse about ELL students**

Given our concern with using the social organization of the classroom to provide experiences that help teachers change their discourses about teaching ELLs, we will now summarize some of the research on a variety of such discourses. There are a handful of very common views about how language intersects with mathematics learning that have been delineated in the literature.

In discussing teacher discourse on ELLs' mathematics learning, Moschkovich (2007) discussed three views toward bilingual mathematics learners and how they use language for mathematics learning. The first view perceives mathematics vocabulary acquisition as the central issue for ELLs. The second view defines mathematics

learning as constructing multiple meanings for words. Because many ordinary words are used in a mathematically specific way, students have to acquire the specific meaning of the words in order to be competent as a mathematician. Moschkovich critiqued these two perspectives because the focus on vocabulary acquisition perpetuates a narrow conceptualization of mathematics and can hide students' competency in other important aspects of mathematics learning. Both perspectives risk maintaining deficit views of bilingual learners if they are used to emphasize obstacles which bilingual students face.

Vocabulary-focused or mathematics language-focused instruction has often been implemented by teachers with ELL students (Adler, 1999; Pappamihiel, 2007). For example, Adler (1999) illustrated a teaching dilemma between focusing on vocabulary and mathematics language and focusing on the mathematical problem, in a multilingual classroom. The teacher in Adler's study obscured mathematical problem solving by focusing too much on students' use of correct mathematics vocabulary and language. In order to overcome the drawbacks of these two perspectives, Moschkovich (2007) proposed the third perspective, which is based on sociocultural theories of learning. In this perspective, bilingual learners are conceptualized as students who participate in multiple language communities and therefore bring unique competences and resources to mathematics classrooms. Discourse practices such as

explaining, defining, conjecturing, using evidence, and so on, are seen as central to mathematics. Bilingual learners draw on all their available linguistic and meta-linguistic competence to participate in these practices.

Supporting ELLs' participation requires a shift of focus from vocabulary to student involvement in classroom practices. For example, a broad focus on the linguistic practices of mathematics allowed researchers to demonstrate ways in which Spanish English bilingual learners presented their knowledge of mathematics and everyday experiences in Spanish through group work, where Spanish language use was encouraged (Moschkovich, 2007). By highlighting bilingual learners' resources, including their first language, we can focus more on finding ways to use students' competencies to support further learning (rather than focusing only on what students cannot do, which typically does not lead to productive learning environments).

## **Method**

In this paper, we discuss a teacher PD effort in which we were involved as facilitators and researchers. This PD project, called the Radical Math Project, tried to connect teacher discourse with classroom social organization by working collaboratively to develop inquiry projects related to teachers' concerns about equitable teaching in their classrooms. One pair of teachers focused their inquiry project on more effective ways to teach the ELL students in their classrooms. In this

context, we examine the following research question: How does teacher discourse on teaching to ELLs change over the period of the PD sessions?

### ***Background of the study***

The study was conducted in a Canadian urban elementary school with a large concentration of students living in poverty. The school had a student population of approximately 450 students with representation of more than 30 different language groups; 23% of the students were born outside Canada, and for approximately 53% of the students, English was not the language spoken at home. Students' first languages varied and the major minority languages include Bengali, Cantonese, Farsi, Romanian, Russian, Spanish, Mandarin, Tamil, Urdu, and Vietnamese. School instruction took place primarily in English although students in upper elementary grades also took introductory French language classes.

### ***Context of professional development***

In this school, one of us (AUTHOR name) and another mathematics teacher educator (AUTHOR's collaborator name) facilitated a teacher PD program entitled "Radical Math," which was implemented to collaboratively develop ways to teach mathematics more equitably. Six teacher participants, four teacher candidates, one school administrator, one teacher-librarian, one mathematics coach at the district school board and one community support worker participated in the PD.

In Radical Math PD sessions, teachers developed inquiry questions relating to equitable teaching in their mathematics classrooms, designed a lesson/research plan to investigate those questions, implemented the lesson/research plan, reflected on this implementation, and presented their results. Monthly Radical Math PD sessions took place from October 2008 to May 2009. About halfway through the year, participants divided themselves into three subgroups, with each group focusing on a jointly developed inquiry question. Aside from monthly meetings, each inquiry group regularly gathered to plan research/lessons and to implement research/lessons. At the final meeting, participants gave presentations to one another about the questions they investigated and what they had learned.

***Data sources***

At the monthly Radical Math PD sessions, we collected agendas, teacher's work, fieldnotes, and meeting notes that summarized what had been discussed. The meeting notes were completed after the meetings and focused on what teachers said and the progress they made on the inquiry projects. These meeting notes were made publicly available to all PD participants so that everyone was kept informed of the group's progress. At the final meeting when participants presented their work, the entire session was video-recorded and then transcribed.

In this paper, we focus on one of the inquiry projects as a case study of discourse change through PD sessions. In investigating teacher discourse, we focus on the inquiry project designed by a Grade 4 classroom teacher, Ms. Mary Smith, and an English as a Second Language (ESL) teacher, Ms. Elena Marino, and a university researcher (AUTHOR name) (all names are pseudonyms). Their inquiry project focused on how to address linguistic diversity in their school during mathematics lessons. The teachers felt they were not reaching their ELLs and wanted to learn more about and improve their mathematics teaching for this population.

The data that we collected for this study of teacher discourse focuses primarily on the PD sessions themselves. We draw on the meeting notes, collections of artifacts from meetings (e.g., handouts that teachers filled in to record their progress on the projects), and the video of the presentation made at the end of the year. Some of this data focuses on the participants as a whole (e.g., results of a group brainstorming session), some focuses on this specific inquiry group (e.g., the group's report of their progress at the end of each meeting) and some focuses on Mary's classroom in particular. We focus on Mary more than Elena because Mary was a classroom teacher at the time of the study so we could collect fieldnotes in her classroom, and because Elena was not present at the final session of the PD, when the groups gave

their presentations. As a result, we have less data about Elena's discourse regarding classroom practices for ELLs.

The data from Mary's classroom were collected while Mary implemented a series of lessons related to the inquiry project. When Mary was implementing these lessons, we also worked with students, collected student work, and wrote fieldnotes (Emerson, Fretz, & Shaw, 1995). These fieldnotes focused on what students were doing and student talk about the mathematical work. Three classroom visits were conducted for two of Mary's math classes.

The data from Mary's classroom are considered primarily background material for this study of Mary's discourse change. From a CHAT perspective, we have argued that in order to change teacher discourse, we can begin by changing the social organization of the classroom. Thus, in this study, we rely on detailed information about the inquiry project itself to help us understand how and why Mary's discourse changed as it did.

The data we analyse for this paper were collected initially as an evaluation of the PD project. Thus the fieldnotes, meeting notes, and artifacts were not originally planned as part of a formal research project. However, we believe the process of change for the teachers involved in this inquiry project to be of general interest, and we therefore subjected the data to a more formal analysis for this paper. We

emphasize that this is a single case study and our analysis is limited to teacher talk during our PD meetings.

### ***Analysis***

In analysis, because of our interests in teacher's discourse on teaching for ELLs, we collected every episode when the PD participants discussed students' pedagogical needs, with particular emphasis on talk about ELLs and/or immigrant students. (In this particular school context, English was not the home language for the majority of immigrant students. Therefore, we included the episodes where teachers mentioned immigrant students.) We then analyzed this body of data and looked for themes about how teachers described their ELLs, and for the teachers' planned classroom activities and pedagogical strategies. Since our interest was in identifying change over time, we separated data into three time periods: 1) before the implementation of the inquiry project, 2) during implementation of the project, and 3) after completing the inquiry project.

We drew on grounded theory (Glaser & Strauss, 1967) to generate codes, and went through several rounds of discussion and coding to identify the prevalent themes. The thematic coding was generated inductively by examining the above-mentioned data repeatedly. Each author examined the data separately and identified a thematic coding for an excerpt and both authors discussed the thematic coding until we came to

agreement. In the body of the paper, we will present some of the raw data as well as our major thematic codes. In this paper, we will present a detailed description of the inquiry project itself as the context of the research, and then present our analysis of discourse change for the PD group in general and for Mary in particular.

***The inquiry project focusing on student linguistic diversity***

In order to make sense of the change in teacher discourse over time, it is necessary to consider the PD activities that took place over the course of the year, as well as the classroom activities associated with the inquiry project on ELLs. In this section, we provide a detailed account of both of these contexts.

At an early Radical Math meeting, all participants (including Mary and Elena) brainstormed the key equity issues that they faced at the school. Because the school had a large population of newcomers to Canada and students whose first language was one other than English, teachers raised concerns about their ability to meet ELLs' learning needs, and told us that they lacked resources specific to teaching ELLs. In an attempt to make up for this lack of resources, we introduced research on ELLs and mathematics learning in the January PD session. We gave a brief report about recent publications on effective practices for mathematics teaching with ELLs (Janzen, 2008; Leonard, 2008), which was then discussed with the whole group. During this discussion, teachers started to talk about their observations of ELLs and mathematics

learning. Following this discussion, the groups began to plan their inquiry projects, and Mary and Elena selected ELLs as a primary focus.

The goal of Mary and Elena's inquiry project was to plan and teach a unit of data management that focused on linguistic diversity in Canada and in the school. At the time of planning, Mary was about to begin a unit on diversity in social studies, and the teachers decided to integrate the mathematics concepts with this unit. In one of the planning meetings, Mary stated that her hope was for students to reach an understanding of diversity as a resource for the country's growth. There were three main student activities during the language diversity unit:

- 1) Examining secondary data on linguistic diversity in Canada as well as the province and the city to which the school belonged
- 2) Conducting student surveys and collecting primary data on kinds of the languages spoken at the school
- 3) Organizing and summarizing primary data

Surveys were conducted by students but the survey question was designed by teachers.

The survey question generated by teachers was: what was the first language you learned to speak at home? Mary and Elena then decided to list some of the school's major languages on the survey sheet. Elena, who had been teaching ESL,

came up with the main minority languages at the school. On the survey sheet, teachers provided instructions for the students who would conduct the survey (please see the Appendix 1 for the survey sheet).

During the implementation of this unit, we collected fieldnotes focused on student engagement. We observed that students of minority language backgrounds were highly engaged and some of the students even stayed during recess to continue working. As seen in the following excerpts from AUTHOR name's fieldnotes taken on April 23 and May 1, 2009, students were willing to do mathematical tasks related to their languages.

When we were creating a bar graph, Ronna asked me, "Can I do Bengali? Please? I'd like to do my country. And David can do Vietnamese." I (the researcher) answered "Yes, of course." David said, "I can do Vietnamese. I love my country, it's my grandpa's and it's my father's."

We also noted that some students made personal connections with the numeric representations, thus revealing that the graphs and charts were mathematically meaningful to them. As seen in the following excerpt, students from a minority language background were able to understand numbers on the bar graph in the context of their everyday lives.

When David got "2" for Vietnamese from the Tally chart, he mumbled "I would be one. Who would be the second one? Maybe it's my cousin."

Another student, Fatima, who was also an English language learner, also demonstrated that she was interpreting the graphs in a real world context when she raised a question about the total number of some minority language speakers.

While making the chart, Fatima said, “Hindi is only one? I know at least three people.” Also, she commented “Vietnamese is only two?”

This also shows Fatima’s awareness of minority language speakers at the school. In contrast to Fatima, English speaking peers in her group barely commented on the number of minority language speakers or they did not have much knowledge about minority language speakers.

### **Results: Change in teacher discourse**

In this section, we report on teacher discourse on teaching for ELLs, separated into data gathered in three time periods: 1) before the planning and implementation of teachers’ inquiry projects, 2) during planning and implementation of teachers’ inquiry projects, and 3) after planning and implementation of teachers’ inquiry projects.

#### ***Teacher discourse prior to the planning and implementation of the inquiry project***

At the initial meeting of the PD (October 23, 2008), teachers and facilitators brainstormed results for the following topics: 1) what are your concerns and issues related to equity and mathematics? 2) how can we work towards equity in mathematics? 3) what would we need to do this work? Teachers wrote down their

ideas on post-it notes and we displayed and the collaboratively categorized the notes during the PD session.

For this analysis, we considered the post-it notes that mentioned ELLs and immigrant students. The full set of comments that were written on the notes, presented in the order in which we categorized them, is presented in Appendix 2. As seen in the table, ELLs were the group of students referred to most often during the brainstorming session. The prevailing discourse about ELLs' needs, and strategies for teaching ELLs, focused on the difficulty that teachers faced in teaching mathematics to ELLs. Teacher comments focused on the density and richness of the language in mathematics textbooks or word problems; this type of language was presented as a barrier for their ELLs. For example, one of the teachers wrote: "supporting ESL learners with math is a challenge when most resources have a high language/literacy base." Another participant wrote: "teaching math concepts through word problems has been difficult for some ELL students." Similarly, another participant pointed out that "the use of language in math for ESL/ELL students with reading challenges" was an equity issue. Thus, barriers and challenges associated with ELLs were highlighted.

There was no teacher utterance that highlighted linguistic resources or repertoires of practice that ELLs bring in to the classroom. Of course, these post-it notes were written in response to our prompt about the specific equity issues that

teachers faced, so it is unsurprising that they focused on the difficulties. However, in response to prompts about how to address these equity issues, teachers did not address the particular strengths of ELLs or how linguistic diversity could be leveraged towards equity.

As a consequence of this focus on language as a barrier for ELLs to learn mathematics, teachers were interested in finding methods of mathematics teaching that reduce language density or complexity. Teachers also wanted to learn more about “math language that is easy for all to understand.” Thus, at this point, equitable mathematics teaching for ELLs was represented as reducing or simplifying mathematical language, and the primary concern was to find resources that could help with this goal.

***During planning and implementing the project***

After the initial meeting, teachers used monthly meetings to plan their inquiry projects in their groups. They began to implement the classroom components of these projects in January 2009. A table in Appendix 3 contains the descriptions, from meeting notes and fieldnotes, of the progress of the inquiry project from the November meeting to the May meeting.

In the early stages of planning, vocabulary and word density was still of significant interest to Mary and Elena, and they planned to create mathematics

vocabulary posters to be used in conjunction with the language diversity activities.

As Mary and Elena planned the inquiry project on surveying linguistic diversity in the school, Mary's focus on mathematics vocabulary gradually disappeared from the PD discussions. Thus, we argue that Mary's discourse on teaching to ELLs was broadened over time to highlight other aspects of teaching mathematics beyond mathematics vocabulary. We will revisit this point when we discuss teacher discourse after the implementation of the inquiry project.

Another interesting point that came up during Mary and Elena's discussions concerned parent and student perspectives on language diversity. During planning of their inquiry-project, Mary and Elena discussed their view that the official school data was inaccurate. They believed that the percentage of ELLs was actually much higher than the school data showed. Elena argued that this was because many parents tried to hide the fact that they were using a home language other than English. From informal conversations with parents, she had learned that many parents did not believe that English language learners' first languages helped their subject-area learning. Elena also told us that some parents believed that they would be punished by the school if they did not use English at home. Thus, the inquiry project became an opportunity for the teachers to collect more accurate data, and to communicate to students that multiple languages were valued in the school.

This goal – to demonstrate the value of multiple languages – became the centrepiece of the inquiry project. This focus of the inquiry project represents a shift in teacher discourse, from considering languages other than English to be a barrier, to actually considering these languages as a strength (although admittedly, the teachers did not articulate these languages as a strength to support *mathematics* learning). This accompanied the shift from a focus on language as primarily vocabulary, to considering the connection between language and identity for students and parents.

***Teacher discourse after the inquiry project***

In Mary's final presentation, she did not discuss the challenges or barriers for her ELLs. Instead, she focused on what she learned about the linguistic demographics of the community and on the importance of making students' linguistic diversity visible (in a positive way) in mathematics teaching. Mary's presentation described her initial question and goal, successful experiences, and implications for designing future lessons. This presentation allowed us to examine Mary's discourse about ELLs and mathematics learning as she described the process of the inquiry project.

In the presentation, Mary described her initial question as being connected to the idea of diversity making the country (Canada) stronger. She focused on linguistic diversity in Canada and described how she connected the topic of diversity with mathematics lessons by examining language statistics and conducting a language

survey of the school. Mary's presentation focused on three main themes regarding teaching mathematics to ELLs: 1) learning more about students' community, 2) representing students' and parents' linguistic diversity, and 3) students' pride in their languages.

Regarding the first point about learning students' community, Mary found out that the provincial and national data did not often represent students' mother tongues but those minority languages were grouped into the category of "other." This finding surprised her and led her into taking actions to make all the language visible in her language survey lessons. For example, she discussed with students the changes in linguistic ecology in the city over time and she learned that her students were living in what she called linguistic "pockets" of the city. She described as follows:

My hope was for kids to see their languages on that list. So, that was kinda little bit of disappointment. We moved on. We talked about why it says "other." Even if your language is not represented, it is still important. And things change - languages on the list now would not have been on the list 20 years ago.

The discussions on the category of other and on changes in linguistic ecology were not planned initially. After examining the provincial and national data, Mary herself learned that minority languages in Canada were not represented in the data. This case is an example of how the teacher herself learned about student communities through conducting the inquiry project.

The second theme evident in Mary's presentation was her continued efforts to make students' and parents' languages visible. She said that she tried to represent all the students' languages in the language survey project. This effort may be a reaction to Elena's report that students and parents felt bad about using their first languages. Mary, for example, asked students' parents to write a word in their first languages and hung up that in her classroom. She said:

We had a sign we created inviting anybody who walked down our hallway to fill out our chart, and I went to the parent ESL class across the hall, and I just had them write "thank you" on here in different languages – the teachers of ESL made sure it was written in different languages.

Finally, in Mary's presentation, she highlighted the success of the language survey that students conducted in relation to fostering students' pride in their languages. Mary described:

It is very much a pride in their language and that was quite great. And it was interesting, students came back to my class, translating names of languages and not quite sure about all the languages.

Later in the presentation she emphasized this point again:

There was so much pride in the students in seeing their languages listed and talked about it and making sure that their language was on the chart. And pride in students speaking multi-languages which is really good that we could see that.

Mary further described that students' personal connection to languages led into students' high engagement in mathematics activities such as translating information from the Tally system into a bar graph.

These excerpts illustrate how much Mary appreciated “students’ pride” in their languages as the centre of mathematics learning. Recall that the teachers initially proposed an approach to reduce the language density from mathematics word problems or textbooks for her ELLs. In her final presentation, Mary’s discourse had shifted so that she argued that student pride in their languages can lead to ELLs’ high engagement in learning. Thus, Mary’s observation of student engagement in the language survey in her class supported her acknowledgement of student pride as an important contributor to mathematics learning.

## **Discussion**

In this paper, we have presented a case study of one teacher group’s trajectory in the Radical Math PD sessions through which teachers and researchers explored ways of making mathematics teaching more equitable for ELLs. Over the year, a focal teacher participant’s discourse changed from focusing on ELLs’ difficulties in learning mathematics (such as their limitation of vocabulary) to focusing on these students’ resources. This change was paralleled with changes in the social organizations of mathematics learning, which was implemented by the teacher in collaboration with others. Based on the CHAT perspective, we illustrated this change in teacher discourse and classroom learning environment as the externalization of learning – the creation of new contexts for learning in the classroom. While our study

offers a single case of teacher learning, this finding is important because there is still a dearth of research investigating the development of teacher discourse on student learning, especially in relation to a teacher's design of the learning environment (Campbell, Adams, & Davis, 2007).

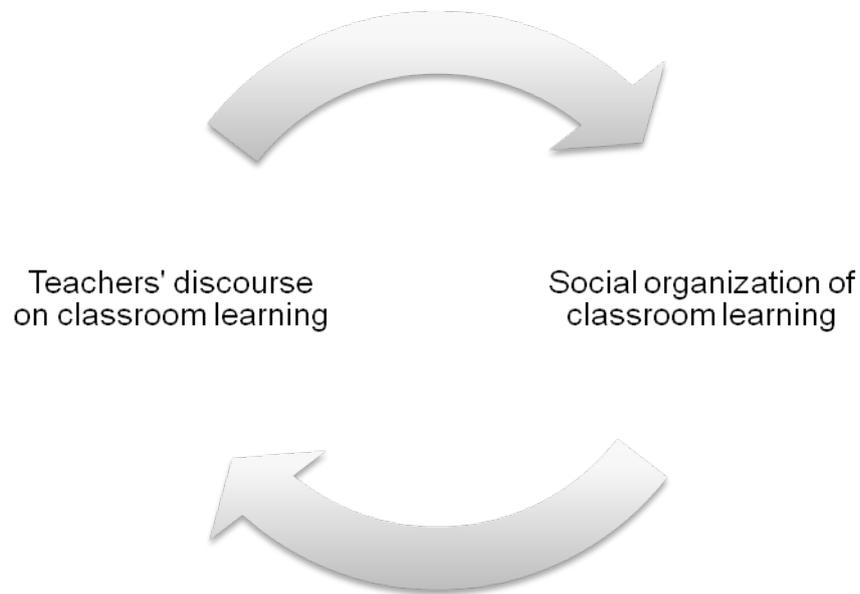
Our case study illustrates a process of teacher learning in which a teacher started to focus on what students *can* do rather than what they *cannot* do. In teaching ELLs/multilingual students, the dominant teaching approach highlights deficiencies of those students (such as their lack of vocabulary) rather than their resources or potentials (Gutiérrez & Orellana, 2006; Moschkovich, 2007). By highlighting what students can do, the teacher in our study facilitated ELLs' participation in mathematics activities.

In our analysis of teacher discourse, we focused on what teachers said, and what they did not say. We therefore noticed that in Mary's final presentation, when she discussed how students had engaged in the mathematical project, she did not remark on their mathematical knowledge or accomplishments. This was despite the fact that during our classroom visits, we observed students' engagement in mathematics work, such as collecting and organizing primary data and displaying the data with charts and graphs. As we discussed in relation to classroom embedded PD, a teacher's reflection on students' mathematical work and problem solving is

considered to be an important source for furthering a teacher's understanding of students' mathematics learning (e.g., Franke et al., 2001). This study suggests that perhaps examining student engagement and identity is an alternative pathway to changing teacher discourse; however, further research is needed to gather whether Mary's change in discourse could sustain better learning opportunities for the ELLs in her classroom.

This case study raises other questions on the sustainability of this and similar PD projects. While we worked with the teachers for a full year, and worked to develop teacher community, ultimately we could not continue the work for a second year because the teachers had too many PD commitments already. However, they still reflect fondly on their work with us and have since presented their projects at several teacher-oriented conferences. Thus, this case study highlights the importance of longitudinal examination of teacher professional development.

Figure 1. The relationship between teachers' discourse and social organization of learning



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**Appendix 1. Language Survey Sheet**

Room number [ ]

What was the first language you learned to speak at home?

- English
- French
- Urdu
- Tamil
- Bengali
- Romanian
- Farsi
- Other languages

Tell students that they should only raise their hand when they hear the name of the language they first learned to speak. If they do not hear the language then have them tell you the language. Write the language on the line that says other languages (try your best at spelling). Be sure to thank the teacher and the class for letting you come in and taking the survey.

## Appendix 2. Teacher Discourse at the Initial Meeting

1. What are your concerns/issues related to equity and mathematics?
<p>a. Resources:</p> <ul style="list-style-type: none"> <li>○ Smart Board use</li> <li>○ Which resources should we be using (e.g., Jump, Math Makes Sense, Software) and how and when?</li> <li>○ Enough resources to reach learners at all stages</li> <li>○ Available manipulatives in the classroom or central location</li> </ul> <p>b. Language, and ELL students</p> <ul style="list-style-type: none"> <li>○ Supporting ESL learners with math when most resources have a high language/literacy base</li> <li>○ The use of language in math – ESL/ELL students with reading challenges</li> <li>○ Teaching math concepts through word problems has been difficult for some ELL students</li> </ul> <p>c. Gender:</p> <ul style="list-style-type: none"> <li>○ Girls say “I’m not good at math”</li> </ul> <p>d. Computation <i>and</i> Reasoning:</p> <ul style="list-style-type: none"> <li>○ Make students critical thinkers and have them be accountable for their learning</li> <li>○ Moving from computation to applying math concepts (especially for some of my students who recently immigrated)</li> <li>○ Making jump from competent computation skills to putting it all together, higher level thinking</li> <li>○ How do we teach students both ‘math facts’ and higher order problem solving?</li> <li>○ Math is still seen as a set of skills instead of a kind of literacy for life (higher level thinking, critical analysis of world)</li> </ul> <p>e. Differentiation</p> <ul style="list-style-type: none"> <li>○ How do I address the range of ability within one grade level in math?</li> <li>○ Helping student with large gaps in school as math builds</li> <li>○ How do we best meet the <u>varying</u> needs in our class? (i.e., differentiate)</li> <li>○ Try and have all students have the same basic foundation in math</li> </ul> <p>f. Talking and writing</p> <ul style="list-style-type: none"> <li>○ Students still have difficulty talking and writing in math</li> </ul> <p>g. Relevant, real-world math</p> <ul style="list-style-type: none"> <li>○ Applying concepts to real world problems, situations, projects</li> <li>○ Math questions that relate to our kids’ lives</li> <li>○ Kids who are mathematically competent outside of school but can’t show it in school</li> <li>○ How do we make math instruction both relevant and rigorous?</li> <li>○ Teaching through “real-life” problems</li> </ul> <p>h. Other</p> <ul style="list-style-type: none"> <li>○ Math is a gatekeeper – especially algebra</li> <li>○ Teachers sometimes have math anxiety</li> <li>○ Assessment and evaluation</li> </ul>
2. How can we work towards equity in mathematics?

- |  |
|--|
| <ul style="list-style-type: none"><li>a. Curriculum<ul style="list-style-type: none"><li>○ Structure our lessons around deep problems (but also drill)</li><li>○ Limit language in questions</li><li>○ Allow students more time to master math concepts before evaluating them</li><li>○ Social justice issues are engaging – can we use those as a lens?</li></ul></li><li>b. Assessment, eliminating bias, internal work?<ul style="list-style-type: none"><li>○ What constitutes ‘Level 4’?</li><li>○ Aligning instruction and assessment</li><li>○ Implement Smart Board technology in our math program for all grades and students</li><li>○ Identifying then working towards eliminating (replacing) normative thinking by staff towards students</li></ul></li><li>c. Lesson study, co-teaching, on the ground<ul style="list-style-type: none"><li>○ Understanding of how math is learned</li><li>○ Job-embedded professional learning, focusing on co-teaching</li><li>○ Inter-relate math with other subject areas</li><li>○ Start thinking of teaching as ‘coaching’, so we can learn alongside students – reduce the fear of teaching math</li><li>○ Develop and/or try out innovative math ideas</li><li>○ Are teachers interested in co-teaching?</li><li>○ Time to plan in grade groups</li><li>○ Building capacity in teachers to create complex and relevant questions that drive inquiry and promote multiple approaches to problem-solving</li></ul></li><li>d. Parents/community<ul style="list-style-type: none"><li>○ Get parental involvement and community involvement</li><li>○ Awareness of what/how kids live</li><li>○ “best” trained teachers to teach math</li></ul></li></ul> |
| 3. What would we need to do this work?   |

- a. Resources
  - Time
  - PD for integrating math with other subjects
  - Time to do action research
  - Money
  - Math resources for ESL/ELL
  - Give students the things they need to be successful problem-solvers
  - Resources specific to math and social justice
  - Appropriate materials available
  - Manipulatives
  - In-service for teachers
  - Resources to address all learning styles
  - All students need to have access to resources/manipulatives
- b. Specific PD
  - Smart Board
  - Ron Lancaster, Smart Board session/demo
  - Capacity/Volume
- c. Assessment
  - Diverse kinds of assessments
  - Plan from assessment in very dynamic responsive way
  - To collaborate
  - Support from admin in this subject area
  - Tension between teaching for deep understanding and report cards
- d. Other
  - Math language that is easy for all to understand
  - Explanations to parents about how/what math is
  - Understanding of how math is taught in other countries

## Appendix 3. Progress of Mary and Elena's Inquiry Project

Timeline	Project summary
November 20, 2008	The group talked about lessons that start from students' interests and that are relevant and responsive to their needs (e.g., doing a lesson on volume or area that focuses on a social justice issue like overcrowding). This discussion led participants to wonder more about the school community. Chris, a teacher participant, pulled up some statistics: there are approximately 450 students in the school and there are 30 different languages. 67% of the parents were born in other countries. 38% speak English at home.
December 11, 2008	<p>Mary proposed a question: How can I integrate math in my Critical Pathway relating to diversity in the provinces and regions of Canada? Why is it important?</p> <p>Mary and Elena decided:</p> <ul style="list-style-type: none"> <li>• Implementation will involve using Statistics Canada data to help with language data.</li> <li>• To have students investigate language use in the school and to graph results for parent night. Mary added that she would like to create math vocabulary posters in many languages so that words like 'less than', more than', etc. can be translated for and by students.</li> <li>• Resources needed: picture books on provinces, social studies texts, language data, immigration data.</li> </ul>
January 29, 2009	<p>In small group, Elena and Mary searched data on immigration and languages from websites such as Statistics Canada.</p> <p>In their small group, Elena and Mary talked about how students' parents tended to hide their home languages. The official school data stated that the school had 46 % of the students with English as a first language. Mary looked at the number and raised a question – the percentage seemed to be lower than expected. Elena explained that this was because parents hid the fact that students' home language was other than English.</p>
March, 2009	The group implemented a series of lessons involving graphing and comparing language diversity in Canada, in Toronto, and in the classroom.
April, 2009	<p>The group displayed students' graphs of languages spoken in Toronto, Ontario and Canada.</p> <p>Mary brought up the issue that the Stats Can information grouped many languages into one group: "other"</p> <p>Mary implemented the language survey project. She made sure that there was no 'other' category. All languages were represented.</p>
May, 2009	Mary posted a large graph in the hallway outside of her room for Open House – parents/families filled in languages spoken at home. Students acted as ambassadors.