EXPLORING COLLABORATIVE ONLINE PROBLEM SOLVING AS OPPORTUNITY FOR PRIMARY STUDENTS’ DEVELOPMENT OF POSITIVE MATHEMATICAL IDENTITY

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Abstract

Identity, as a “maths person” or not, develops as a result of a myriad of micro events. This paper uses positioning theory as a lens through which to view interaction between two year five students, within a computer supported environment, in the context of collaborative mathematical problem solving. Findings from analysis of the micro event show unexpected confidence from one student but also a power imbalance that ultimately impacted on levels of mathematics agency for both students. The lens of positioning theory drew attention to features of the interaction revealing aspects of each student’s identity, including mathematical identity, which might otherwise remain unnoticed.

We have all met someone who, as part of their identity, states, “I am not a maths person”. This identity has formed over time and through many micro experiences. Identity has been recognized as an important indicator of continued study in mathematics (Jorgenson, 2015). Mathematics identity, as well as one’s beliefs about mathematics, and what it means to be a successful learner of mathematics, are the components of “productive disposition” highlighted in the seminal book “Adding It Up” (Kilpatrick, Swafford & Findell, 2001, for the United States National Research Council). Those authors proposed that mathematical proficiency is composed of five interrelated strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. With this braid of strands in mind, mathematics educators strive to provide opportunities for students to not only construct knowledge but also to develop a positive relationship with mathematics. Such occasions may occur in different contexts for different students and so educators look for new possibilities, for example those opened up by information and communications technology (ICT). In Australia the national curriculum documents explicitly state that teachers are expected to make use of technology for learning and communicating mathematical ideas and concepts. For example, the Australian Curriculum (ACARA, 2014) promotes this theme in the following statement:

Students develop ICT capability when they investigate, create and communicate mathematical ideas and concepts using fast, automated, interactive and multimodal technologies. They employ their ICT capability to perform calculations, draw graphs, collect, manage, analyse and interpret data; share and exchange information and ideas and investigate and model concepts and relationships. (ACARA, 2014)

Mathematically able software, drill and practice tasks and games are readily available through the internet. An online environment can also provide opportunities to broaden students’ experience of both doing and also communicating mathematics, in particular through collaborative online problem solving. Digital technologies, now available across Australian classrooms, offer an alternative to the face-to-face classroom environment: one that is not only familiar to today’s students but also one where social dynamics may differ from the face-to-face setting. The use of digital technologies may thus offer new opportunities for developing each of the five strands of mathematical proficiency. Analysis of records of on-line interactions may provide teachers with further insight into the development of students’ mathematical identities. However, research on students’ communication when engaged in mathematical collaborative online problem solving, is limited, especially at the primary school level.

This paper reports on the use of positioning theory (van Langenhove & Harré, 1999) as a lens to
analyse student interactions in a computer supported collaborative space. Specifically this paper provides a detailed report of a trial of the application of this methodology in order to address the following questions:

Can positioning theory assist in the identification of perceptions of self and so track changes in students’ micro-identity as they interact with peers within a primary school level mathematical online collaborative learning environment? If so, what can we learn from these interactions?

This research adds to the work of Wood (2013) who used positioning theory to study a Year 4 student’s micro-identities as enacted across mathematics lessons. She noted that considering micro-identities “allowed for a more nuanced understanding of the complexities of learning moments creating the possibility of enhancing mathematical learning for all students” (p. 806).

Since the application of positioning theory requires fine detailed analysis, for this paper we have chosen to demonstrate the examination of the interactions of just two participants. The results of this study are not intended to be definitive but to indicate the potential value of using positioning theory to analyse interactions and storylines evident when primary school students participate in online collaborative problem solving.

Below we provide a brief background on CSCL environments and positioning theory. Next, the details of the context of the study are described. This is followed by results, discussion and then conclusions about the mathematical identity issues revealed by positioning theory and some implications for researching primary school mathematics within the context of a CSCL environment.

**Computer Supported Collaborative Learning**

CSCL takes place via the vehicle of technology (computers) typically linked via an intranet or the Internet. The collaborative learning referred to here is described by Dillenbourg (1999) as occurring when peers who are at more or less at the same level perform the same action, have a common goal, and work together.

Research analysing the contributions and roles taken by students in CSCL are limited and no significant research at the primary school level was identified in the relevant education literature. In studies undertaken in University settings researchers have shown differences in the volume of contributions that males and females make within CSCL environments. Prinsen, Volman, and Terwel (2007) who conducted a review study, inclusive of 13 articles, into gender-related differences within CSCL environments concluded that males tend to be more dominant and assertive within these environments, whilst females tend to take a more collaborative approach, build on each other’s ideas and generally agree more (2007, p. 406).

Gerry Stahl (2011), a pioneering researcher in the area of CSCL embedded mathematical problem solving at the upper secondary and tertiary level, argues that previous research into CSCL is not grounded in theories that explicitly investigate group interaction. He suggests that previous approaches to the study of CSCL have been grounded in theories that either focussed exclusively on individual roles or more broadly analyzed the role of the individual within the larger group. He argues, that in order to understand how the group constructs knowledge, we must examine and explore the interactions that occur between participants within the CSCL environment.

**Positioning Theory**

This study focuses on students’ interactions and is framed by positioning theory which Harré and van Langenhove (1999) describe as:

> the study of local moral orders as ever-shifting patterns of mutual and contestable rights and obligations of speaking and acting [where local moral orders are] the local system of rights, duties and obligations, within which both public and private intentional acts are done. (p. 1).

In a CSCL these local moral orders may relate to who starts the discussion, how long the posts should...
be, what writing style is accepted, how quickly replies should be posted; and so on. Researchers have identified participants’ positioning within CSCL environments as an under researched area (Dennen, 2011). Some research has been undertaken into the ways in which facilitators (or instructors) position themselves with respect to the students and, reciprocally, the ways in which students position the instructor within CSCL environments (Dennen, 2011). However greater understanding of student to student positioning in CSCL is required if we are to understand how working in such an environment may impact on students’ mathematical identity. Davies and Harré (1990, p. 57) provide a systematic approach which may be used to undertake an analysis of discourse informed by positioning theory. They reiterate that only through examining “utterances” relative to the range of story lines at play within a given context can these speech acts carry weight and meaning. Redman and Fawns (2010) give special consideration to the use of pronouns by participants. They note that changes in pronouns can highlight the active, moment by moment, positioning and repositioning of participants.

The Study

In this paper we used positioning theory as a lens through which to analyze one excerpt of student-to-student interaction in a primary school CSCL environment. Interaction was recorded in the transcript of students’ online discussion and viewed within the context of position, storyline and “speech” acts. The episode analysed took place during a ten week teaching intervention with 54 Grade 5 (10-12 year old) students in a lower to middle class suburban primary school. Over the ten weeks students worked collaboratively on 9 mathematical problems set from across the curriculum.

The CSCL environment was developed within the Edmodo online ‘social learning platform’ (Edmodo, 2014) because it supports teachers to set up ‘groups’ and allows various artefacts to be uploaded (Excel spreadsheets, Word Documents, images etc). Importantly, the participants had a little prior experience of this platform and, given the age and ICT inexperience of these students, the platform is relatively intuitive to negotiate.

Neither the class teacher nor the researcher (first author of this paper) contributed directly to the students’ online discussion. The decision, to not have an adult facilitator, was taken in order to avoid the communication between students being inhibited or heavily influenced by someone they perceived as an expert. However, the students were supported during weekly, face-to-face, whole group classroom sessions with the researcher. Since online discussion was a new experience for these students the researcher initially spent time discussing approaches to collaboration respectful of each member of their on-line group. Each week he reviewed the previous week’s solutions and discussed any challenges and successes that students’ perceived. Next he explained and read through the following week’s problem. The advice provided in the research reports of Davies and Harré (1990) and Redman and Fawns (2010) informed the approach taken for our analysis of student interactions in the CSCL. Unlike much of the dialogue recounted and interpreted within the literature that has informed it, interactions examined in this study occurred asynchronously between primary age children in an online environment. As a result discourse between students was less ‘naturalistic’ than typically occurs in the face-to-face environment. Students’ disjointed discussion required, at times, the use of contextual clues to infer participants’ meaning.

The pair of students exemplified in this paper were a girl, Oleander and a boy, Zander (pseudonyms have been used). Oleander was from a home language background other than English and had been assessed by her teacher as ‘below level’ in mathematics. Zander had been assessed as ‘above the expected level’ in mathematics. While the teacher’s assessment was not explicitly revealed to the students, in class they were often set work in like ability groups. Oleander’s contribution to discussion varied between online and face-to-face interactions. Jazby & Symons (2015) reported that Oleander made fewer and shorter contributions in the face-to- face environment as compared to the online environment. Whilst, she contributed 39% of total posts at an average length of 20 words per post in the online environment, Oleander only provided 19% of contributions within face-to-face interactions, averaging 19 words per utterance.
Oleander and Zander were part of a heterogeneous group of four students, two of whom chose not to contribute to this particular discussion. In terms of their positioning Oleander and Zander would have expected the other two to at least read their posts. Researchers (Boaler, Wiliam, & Brown, 2000; Clarke & Clarke, 2008) report on a range of concerns about the long-standing tradition of streaming within western educational settings. These concerns include the tendency for teachers working with the lowest attaining mathematics class to deliver work of a tedious, rudimentary and non-challenging nature. In this study all students tackled the same problems. As a consequence a storyline influencing data analysis focused on the position of Oleander in the small heterogeneous group where the lesson content demanded higher order thinking and whether the online environment may elicit more productive discussion and provide illuminating insights into student identity.

Results and Analysis

In order to demonstrate the fine grained analysis required to apply positioning theory, one episode of dialogue between Oleander and Zander has been analysed (see below). This was typical of discussions that had occurred throughout the CSCL environment and offers an opportunity to explore the value of the positioning theory lens for analysis of students’ online mathematical discussion. The task that the students are working on is included below in Figure 1.

<table>
<thead>
<tr>
<th>Week 4 - How big is a dog?</th>
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<tbody>
<tr>
<td><strong>Problem</strong></td>
</tr>
<tr>
<td>What is the biggest breed of dog?</td>
</tr>
<tr>
<td><strong>Problem steps</strong></td>
</tr>
<tr>
<td>_ Research a variety of dogs using your netbook.</td>
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<tr>
<td>_ Decide what ‘biggest’ means. Provide a definition. Your group will have to decide whether they think 'biggest' means heaviest, tallest, longest etc</td>
</tr>
<tr>
<td>_ How do breeders measure this?</td>
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<tr>
<td>_ Create a graph in Excel representing the data you have found.</td>
</tr>
<tr>
<td>_ Horizontal axis (x axis) should be breed of dog and vertical axis (y axis) should be height/ weight/ length etc.</td>
</tr>
<tr>
<td>_ Upload the graph that you have made to this message board.</td>
</tr>
<tr>
<td>_ Which dog according to your definition is the 'biggest'?</td>
</tr>
<tr>
<td>_ Can you discuss any other facts that you can 'read' from the graph that your group has created?</td>
</tr>
<tr>
<td>_ Now think about another measurement you can use to define 'biggest'. E.g. If you defined 'biggest' as height of the dog last time, you might like to use weight this time.</td>
</tr>
<tr>
<td>_ Create a new graph.</td>
</tr>
</tbody>
</table>

Sequential utterances by the two students (Oleander and Zander) have been provided (verbatim) in italics. Analysis has been provided (where appropriate) below each utterance.

1. **Zander** In our group I think we should make the word "biggest" dog mean the "tallest" dog.

Zander chooses to initiate the discussion by appealing to the group through utilizing the pronoun ‘our’. In this way he seeks to empower all group members to take up this position. He reverts to the more assertive ‘I’ and shares his belief that ‘we’ (the group) should define the ‘biggest’ dog based on the variable of height. His sense of agency is strong and he positions himself as a leader.

2. **Oleander** Yea and it also could mean the weight in my opinion?

Oleander suggests an alternate (but equally valid) option when she states that ‘it’ could be defined by
using weight as a variable. Her statement indicates that she understands the problem and she positions herself as a group member willing to contribute to moving the problem forward. Whilst, a micro identity of mathematical confidence is displayed here, a general sense of resignation that her view will not be accepted is apparent. This is evidenced through her use of the words ‘in my opinion’. This takes away from her agency, as it acknowledges that her offering is open to debate. This is compounded by her choice to attach a question mark to her statement. A sense of mathematical confidence and an awareness of a lack of agency are simultaneously displayed.

3. Zander

These are some breeds of dogs that are very tall.
The world’s tallest dog is Giant George. He is registered as a Blue Great Dane. He is 109.2cm tall. [details of 9 more breeds].
These are some breeds of dogs that are very tall. ...

Zander chooses to ignore Oleander’s contribution and re-affirms his stance that the variable the group will use to describe ‘biggest’ will be height. By removing any pronouns he maintains his position. Zander does not seem to have felt challenged. Perhaps despite Oleander’s contrary viewpoint he does not feel a need to reposition himself. Zander continues to position himself as ‘leader’ and therefore ‘decision maker’ within the group.

4. Oleander

I’m thinking of doing the last one? What would you prefer?

Again Oleander’s repetitive use of question marks to frame her suggestions indicates a possible lack of confidence. In addition, she positions herself as a group member committed to consultation and collaboration. Whilst, she had made her determination she is open to change. This is reinforced by her choice of asking Zander what he would prefer to do. Here whilst her potential motivation is to engage in ‘collaboration’ she positions Zander as the authority and ‘decision maker’ and implies that she will be amenable to his judgments.

5. Zander

Me too.

6. Zander

Going back to the tallest dog, you can not make 2 opinions. You can only make 1. And I believe that it should be the tallest with our group. Unless when you’re doing the last bit of the work. Then you can do another opinion.

Zander chooses to refocus the discussion on his stance that biggest should mean tallest. The use of the pronoun ‘you’ repeatedly and insistently reiterates that the group must come to a consensus about what ‘biggest’ should mean and that the group should agree with his viewpoint. His use of the words ‘I believe’ is powerful and shows that he is operating on the faith or belief of others within the group. He is hopeful that other group members will be faithful and follow him. He continually positions himself as the authority and leader within the group, and resultanty positions Oleander as having less to offer. By explaining that ‘you can only make 1 (opinion) he positions himself as a person of greater authority within the group.

Zander’s chooses to soften his stance by suggesting that Oleander’s opinion may be of value in the last part of the work. Having positioned himself as leader within the group, he allows Oleander to employ her suggestion once the bulk of the work has been completed.

7. Zander

I think the tallest dog in our case is the Blue Great Dane, or the other two options could be the Anatolian Shepherd, or the English Mastiff.

8. Oleander

Okay then we would just do the tallest. Mine [be]cause it could be said. In 2 ways and for our group it could be tallest

Oleander chooses to accept Zander’s directions. Her statement of ‘we would just do the tallest’, shows that she understands that the group does need to come to a consensus on the issue and that she is unwilling to debate the matter further. She would be positioning herself as defeated, if not for her final statement showing she knows that her original idea of using weight as the variable to indicate biggest is still valid but to save further argument is happy for the matter to be resolved.

The two participants’ positions in the local moral order, of members of the ‘top’ mathematics stream and member of the ‘bottom’ mathematics stream in addition to their genders may influence the storylines. The two storylines frame and inform us about interactions between Zander and Oleander. The two storylines shown to be impacting on the power and identity of participants are related to their positions in the local moral order. These storylines inform us about interactions between Zander and Oleander.

It is evident from the above analysis that Zander chooses to take an assertive and dominant position within the online space. The following exchange exemplifies this:
Zander: You cannot make 2 opinions. You can only make 1. And I believe that it should be the tallest

Additionally, we see evidence of Oleander choosing to take up the position of a collaborative group member, open to other students’ ideas and committed to finding agreement. This is represented as she negotiates:

Oleander: I'm thinking of doing the last one? What would you prefer?... Okay then we would just do the tallest.

It is notable that during the physical classroom discussions, a clear learning focus was on how to approach collaboration within the online space. By week 4 of the study, when the interaction above took place, collaborative guidelines had been discussed in detail. It is evident from the dialogue that Oleander has internalized these expectations and Zander either does not need to do so or does not see this as a part of the intended learning outcome.

A significant observation representative of the stark differences in the positioning of the two participants is that Oleander regularly phrases her ideas as questions to be decided upon i.e. for consideration, whilst Zander never chooses to frame his ideas using this approach.

A consequence of the students positioning themselves in this way is their resultant positioning of each other. That is, a result of Zander positioning himself, as a dominant authority/ leader is that Oleander is positioned as having reduced agency and therefore is disempowered. Oleander consistently repositions herself as a collaborative group member, open to ideas and working towards agreement. However, this results in Zander assuming a position of power that is relational, (Redman & Fawns, 2010, p. 176) and acting on this, indicates a degree of agency within the group, based on perhaps, the local moral order in the classroom and the local conventions of social practice. Zander identifies himself as a leader, and signals this to others.

Conclusions and Implications

The aim of this small-scale study was to determine whether positioning theory might help to investigate students’ micro-identity, as demonstrated in collaborative online mathematical problem solving.

The dialogue makes apparent that in this instance, Oleander’s problem solving and reasoning is of a similar level to that of Zander’s. However, the identified storylines signal that her contributions are being dismissed. Students are commonly put into like ability groups according to their mathematical procedural ability and fluency. These areas of mathematics are more easily assessed regularly. This study reveals that despite the ‘below level’ macro identity assigned by her teacher Oleander saw herself as having a valuable contribution to make to the problem solving. Her willingness to express her views to the ‘above expected level student’ in this online environment is all the more interesting because in face-to-face group interviews, conducted by the researcher, Oleander was reluctant to take part (Jazby & Symons, 2015).

The value of Positioning Theory here is that it helps us to recognize that we establish our micro-identities relationally, influenced by the local moral order. That is, through our interactions with others. Zander chooses to assert his micro-identity as leader and mathematically confident. Throughout the episode we see a struggle, between the students as to whether his attempt at claiming this mantle will be legitimised. Whether, or not he is successful with his goal impacts on Oleander’s micro-identity. If he succeeds, to an extent, her identity, as being capable of providing valuable mathematical ideas and contributions is negatively impacted. Whilst, if Oleander’s views were recognised and acted on then her identity in this instance, of being a valuable ‘mathematical’ contributor would be realised.

Complicating matters further is Oleander’s desire to conform to the micro-identity of ‘collaborative group member’ promoted by the researcher in their class sessions on appropriate on-line behaviour. In this instance a desire to assume the micro-identity of collaborator seems to be in tension with her acquisition of a micro-identity associated with valued and accepted contributor of mathematical ideas and thinking.

In this paper we have viewed one episode contributing to the development of the micro-identities of two students. It may be of interest in the future to view the unfolding narrative in discourse beyond
this episode. This may allow insight into the changing nature of student mathematical micro-identities’.

The focus on analysis of pronoun use also appears to be worthy of further consideration. Whilst this focus illuminated aspects of the positioning of Oleander and Zander, in the context of working in the online environment, it was possible to gain further insights through closely examining punctuation. For example, student use of question marks could at times indicate a lack of certainty or confidence. Whilst, they were not used in dialogue in this study, analysis of emoticons may also be helpful for analysis of positioning within the online environment.

Previous studies, with older students, suggest that girls are more collaborative than boys in a CSCL. This was the case with Oleander but her tentative approach and willingness to give way to Zander is also consistent with micro-identities resulting from their teacher assigned classroom grouping. Research also shows the negative impact on perceptions (the identity of oneself and others) that ability grouping can produce. Asynchronous on-line work allows a student both time to think and the option to mask any insecurities.

The interactions in CSCL environments not only provide students with new opportunities to express their identity but also provide researchers and teachers with a record that may reveal strengths, weaknesses or levels of confidence not evident in the usual classroom. Oleander’s contribution to this micro event provides an example revealing a moment of positive mathematical identity not apparent in the classroom. Through utilizing the lens of positioning theory within the CSCL environment we may be able to detect and respond to storylines impacting on students’ mathematical identity that would otherwise remain untold.

References


http://www.curriculum.edu.au/leader/is_time_up_for_ability_grouping,22535.html?issueID=11280


