Socio-constructivist and Socio-cultural Lenses on Collaborative Peer Talk in a Secondary Mathematics Classroom.

Julie-Ann Edwards

University of Southampton, School of Education

This paper uses socio-constructivist and socio-cultural lenses to examine transcripts of pupils' peer talk recorded while they were undertaking open-ended mathematical tasks in a naturalistic classroom setting. I discuss the two theoretical frames and then present episodes of peer talk from pupils between 12 and 14 years old which demonstrate how a socio-constructivist view of the zone of proximal development is enacted, and how a socio-cultural lens offers a window on social aspects of these established working groups which serve to provide the necessary support to enable all members of the group to access the mathematical knowledge being constructed.

Keywords: socio-constructivist, socio-cultural, collaborative, group work, socio-mathematical, norms, zone of proximal development

The socio-constructivist theoretical background

Vygotsky (1978) argued that the relationship between language and thought was a direct link, and that cognitive development was a social, communicative process. He interpreted individual utterances as having a role in both thought and language. Thus, a word implied both a generalisation of thought and a social interaction. He described the social construction of knowledge within a zone of proximal development (ZPD). In a classroom situation, the *actual* developmental level can be determined by traditional question-response-evaluation sequences and therefore *described*. The *potential* development, however, can only be *explained* rather than described because it is a process observed in relation to working with others.

Kinginger (2002) supports the use of Vygotsky's zone of proximal development in educational situations. She argues that Vygotsky's model of a process of cognition emergence has given direction to a more 'prospective' (rather than 'retrospective') educational emphasis, whereas more conservative discourses claim the same model as a "locus of transmission and reproduction of educational practices" (p241). Her argument for the advocacy of the ZPD is that it encourages collaboration and 'co-authoring' in learning. Such a model suits the research undertaken in this study, as in Kinginger's terms, this ZPD goes a long way towards supporting the 'prospective' educationist's implementation of social aspects of the construction of individual experience. Kinginger's interpretation of Vygotsky's model is of a "dialectic unity of learning-and-development" which includes the framework, the learning setting and the necessary resources, including those that are "dialogically constructed together". The outcome of viewing Vygotsky's model of learning as a dialogical process is that it allows a dynamic assessment of educational potential which includes mediating sources for its development rather than the more conservative static models of assessing potential. Learning in this context is seen as more than transference of new knowledge from inter-individual to intra-individual. It is seen also as societal change, in which "new forms of social activity are generated

through joint cooperative action". The ZPD is seen as "an interactive space that holds potential for multiple – and unpredictable – transformations of human identity, of the culture's toolkit, and/or of the activity setting" (p246).

While Vygotsky's model may be interpreted as relativist, Wegerif (1998) argues that Vygotsky, like Piaget, believed in "a single rationality and a single progressive path of development" (p83). This, Wegerif claims, is because the basis of Vygotsky's view of knowledge development came from a Marxist interpretation of the world – that individuals are products of their social and historical influences. Thus, a Vygotskian interpretation of the educational effects of learning in the ZPD is not related to post-modern notions of enculturation but as an upward movement on a predetermined ladder of knowledge. His understanding of mathematical concepts was that they "represent essential aspects of an objective world" (p86). Wegerif claims that both Piaget and Vygotsky shared monological views of reasoning in which the principle of identity is central. He challenges this notion of a monological view of reasoning arguing that there is evidence in dialogue that identity of every sort is constructed – that reasoning is dialogical. Consequently, it is dynamic and affected by its environment. Dialogical reasoning is not established through identity but instead through differences, particularly those between "participants in dialogue" (p79). It is generated through conflict and takes the form of constructive argumentation between discourse participants.

The socio-cultural theoretical background

Much of the theoretical basis for a pedagogic approach using small group work in classrooms comes from the socio-cultural field. Collaborative group work (and research in this field), in which pupils work jointly on the same problem, is linked with ideas such as situated cognition, scaffolding, and the ZPD. As Coles (1995, p165) describes, "The social interactions developed in this kind of enquiry stimulate members of the group to think together; from a psychological point of view this pushes forward the level of thinking of each child and 'scaffolds' his or her cognitive processes". Although a Vygotskian view of learning encompasses a broad spectrum of contexts, it focuses on the individual outcome via an interpersonal process. Classroom studies with a socio-cultural framework (for example, Mercer and Fisher 1997, Wegerif 1998) have shifted this focus to an understanding of the process of learning within groups of individuals in specific social contexts. The focus here is on the interpersonal relations and their effect on intrapersonal learning within a group objective. These new units of analysis support a means of interacting which involves the whole self and a view of the interactions of a group as a means of cognitive development. Mercer (1995) proposes three necessities for this socio-cultural theory:

> A theory of the guided construction of knowledge in schools and other educational settings must do three closely related things. It must:
> - explain how language is used to create joint knowledge and understanding;
> - explain how people help other people to learn;
> - take account of the special nature and purpose of formal education. (p66)

This theory of the 'guided construction of knowledge' depends on two essential features – talk as social action, and the relationship between context and continuity. He contends that knowledge exists as a social entity, not just as an individual possession and that the essence of human knowledge is that it *is* shared. This gives recognition to how people construct knowledge together. "Individually and

collectively we use language to transform experience into knowledge and understanding. It provides us with both an individual and a social mode of thinking" (p67). This model of talk involves learners in working towards a joint understanding through argument as an active process, rather than a mere pooling of information.

Mercer asserts that if a theory such as the one he offers for the 'guided construction of knowledge' is to explain how talk is used to create knowledge and understanding, it must incorporate context and continuity. In this sense, context is taken to mean the broadest interpretation possible for context – beyond the physical setting into the interactions between participants which develop the context. His interpretation of continuity also goes beyond a linear continuous path to mean the fluidity of change and a dynamic interactive flow. "If context and continuity are not well established in a conversation, the thread of a developing joint understanding may be broken and misunderstandings are likely to arise" (p68).

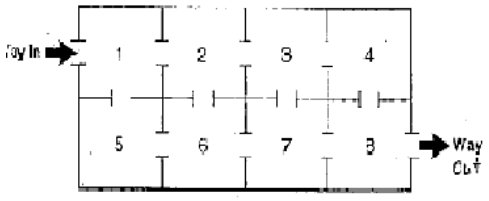
The study setting

The study was undertaken in an inner city secondary school (11-16 year olds) in the south of England in which 22% of the pupils were of ethnic minority origin. Pupils in this study experienced an emancipatory classroom. This involved pupils taking considerable responsibility for the direction and pace of the mathematics learning within the restrictions imposed externally. Open-ended mathematical activities were introduced as a whole class discussion with pupils and teacher making suggestions for possible routes for exploration. Most of the subsequent work was in small groups of two to six pupils, though the class was sometimes drawn together for a few minutes at various times in a lesson to enable a pupil to explain a discovery or for the teacher to raise a learning or organisational point that had arisen. Interaction between groups to share information or ideas was common. The teacher circulated amongst the groups, supporting directions of thinking, questioning directions of thinking, actively intervening to challenge directions of thinking, assisting decisions made towards solving a problem and responding to requests for help. Small group organisation was on a self-selection (usually friendship) basis. The management of small groups could be described as "low structure management" (Fawns and Sadler 1996); that is to say, there was no direct teaching of group skills for small group work. The construction of mathematical understanding as a joint endeavour and the self-selection of groups provided the impetus for pupils to develop 'norms' about necessary skills within groups.

Audio-data were collected from collaborative small groups comprising friends in naturalistic settings in mathematics classrooms during their normal activity of solving open-ended mathematical problems. These data were analysed using Mercer's (1995) model of three levels (*linguistic*, *psychological*, and *cultural*) to analyse peer discussion. The following extracts are analysed at the *psychological* level. This utilises an analysis of thought in action. It identifies to what extent reasoning is visible in the talk. It involves the communication structures between learners, the extent to which learners control the content and direction of the talk, and the 'ground rules' established for what constitutes valid talk within the group, what Cobb and Bauersfeld (1995) call 'sociomathematical norms'.

Two lenses on peer talk

The first extract is from a Year 8 group (12-13 year olds), discussing the problem of deciding a route through a series of rooms containing 'bags of gold' according to the number of the room. Hence, for the 2 x 4 grid which follows,



a route which omits room 2 will maximise the number of bags of gold collected. In the following extract, the group are discussing a 3 x 3 grid.

E This goes across … it goes one, two, three, four …
M It goes one, two, three, four,
E …five, six …
M seven, eight, nine …
J And I've noticed with this one, yeah …
E and it goes one, two, three, six, five, four …
J …you can do *all* of them …
E …seven, eight, nine
J …you can do *all* of them on this one
E all of what?
? [inaudible comment]
[Pause for 3 seconds]
M Maybe it's the way … maybe it's the way you set it out, though
E You can, actually, you can either go like that …
J …like that to reach every single one …
E …or you can go in … well, maybe not …
M If you go *down* like that, one, two, three, you won't be able to do the pink pen
E You would, would you …
J Yes, you would
K You could, yeah
J You could, with any of it, its just one, one more that you can do anything with

Using a socio-constructivist lens, we can see that J asserts in lines 5 and 7 that all bags of gold can be collected in a 3 x 3 grid, again in line 9, again in line 15, and finally in line 21. E, M and K eventually realise what J is asserting through counter-challenging M's challenges. This might be seen as evidence of learning taking place in Vygotsky's ZPD. Through a socio-cultural lens, the pupils are continuing each others' sentences, evidence that the group has established a cohesive and trusting community where the 'ground rules' require repeated repetition and confirmation of colleagues' ideas and opinions. Members of the group are talking aloud, to place their thoughts in the public domain (lines 13, 16 and 18), allowing the rest of the group access to these thoughts. J allows the rest of the group time to arrive at her level of understanding of the problem, through 'talking themselves into it'. This offers evidence of the mutual development of shared understandings of the situation.

The second extract is from a Year 9 group (13-14 year olds) who are exploring two sequences of numbers which have a logarithmic relationship. This task is an introduction to this mathematical knowledge.

R [giggles] I still don't understand
M Right, you know the log of the graph here … have you done C yet?
R Huh?
M Have you done C?

L This graph
R Yeah
L We're going to do the same but with the log numbers
R OK … you'll have logs of the C numbers at the bottom and logs of the values of the C numbers at the top. Then, what?
L Then it should be easy to see the relationship between the two
R And where you are going to put the places for each one, like
M It'll give you almost a straight line up to there
R Yeah, like … nought point three against whatever that one is
M Yeah
R OK
J How can that show the relationship?
L Cos it will be a straighter line
J Yeah, so if it's a straight line, you've got, um, C numbers … the log of C numbers here and its got the rank log, … number … this log
L The log value of the C numbers
J The log value of the C numbers … Oh right, I get it, …yeah
L It's a bit simpler
J Yeah, I know
[Pause as all work independently for 8 seconds]
J Yeah, I get it
M I know what it shows now
J You do eight times eight times eight times eight
L Pardon?
J Eight times eight times eight times eight
L Four times yeah?
J Yeah, OK yeah, … so … log … [whispers some numbers] … equals … four …right?
L Ummm? Yeah
J Oh, I'm so brilliant … OK, I can do this as well

Using a socio-constructivist lens, the way in which M and L support R and J's learning could be said to be acting in their ZPD. The quality of their explanations to aid R and J's understanding support Webb's (1991) findings about the level of mathematical learning in groups being directly proportional to the quality of explanations given by members of the group to each other. Both R's responses in lines 13, 18 and 19, and J's responses in lines 27, 29 31, 32 and 34 indicate a high level of understanding of the explanations given.

A socio-cultural lens shows us that this level of understanding is partially borne out of the equal mathematical status each of these group members share and as an outcome of the established (unwritten) 'rules' about ways of working together mathematically. Both R and J are unconcerned that, in this particular situation, they appear to be the weaker learners. Their confident questioning of M and L and their talking aloud to clarify their thinking and place their thoughts (whether they be right or wrong) in the public domain indicate that they are secure within the working practices of this group. This supports evidence from classroom studies of very much younger children who establish socio-mathematical norms when working together in groups. Although J does not enter this discussion until line 16, it is with a clearly directed question, demonstrating an understanding of the conversation which has ensued. She has been 'tied into' the reasoning because, as Wittgenstein (cited by Ernest 1998) argues, the knowledge is made public through the various types of talk – talking aloud, direct questioning, explaining, repetition of others. What is particularly interesting, in this extract of talk, is that the longer established friendship pairings of M and R, and J and L, appear to have given way to the learning needs of individuals in this group. All participants are actively engaged with the necessary thinking to move the group forward.

Discussion

The analyses provided here offer evidence of some of the affordances of group work in secondary mathematics classrooms and examples of how the dynamics and interactions of groups support the construction of a continuous (or shared) thinking space to support their mutual mathematical understanding. The socio-constructivist theoretical lens enables us to focus on transference of new knowledge from inter-individual to intra-individual through the ZPD. The socio-cultural lens allows us to examine Kinginger's "dialectic unity of learning-and-development" and explore the structures within the group via the use of language.

Here, in the 'threads of talk' linked together by repetitions or continuation of each other's sentences, we see evidence of what Mercer declared was essential for developing joint understanding - strongly established context and continuity. This is also evident in the way each of these groups have an established set of 'rules' or sociomathematical norms – a way of engaging with each other as equals, despite an apparent inequality of understanding in a given learning situation.

Such attention to learning theories in relation to classroom practice should be seen as an important focus, not only for teachers and researchers, but also for policy makers. The recent trends to 'roll out' yet another pedagogical practice, without due attention to the learning theories which support these, inevitably leads to the current situation in which teachers are expected to implement the changing whims of policy makers, currently a shift from the 'back-to-basics' to a focus on processes and skills. A focus on learning theories, rather than competing pedagogies, would go far to support teachers' practices in secondary mathematics classrooms and allow them some autonomy to develop a pedagogy appropriate to their individual situations.

References

Cobb, P. and H. Bauersfeld. 1995. *The Emergence of Mathematical Meaning: interaction in classroom cultures*. Mahwah, NJ: Lawrence Erlbaum.

Coles, M. 1995. Critical Thinking, Talk and a Community of Enquiry in the Primary School. *Language and Education* 9: 161-177.

Ernest, P. 1998. The Culture of the Mathematics Classroom and the Relationships between Personal and Public Knowledge: an epistemological perspective. In *The Culture of the Mathematics Classroom*, edited by F. Seegar, J. Voight and U. Waschescio. Cambridge: Cambridge University Press.

Fawns, R. and J. Sadler. 1996. Managing Student Learning in Classrooms: reframing classroom research. *Research in Science Education* 26(2): 205-219.

Kinginger, C. 2002. Defining the Zone of Proximal Development in US Foreign Language Education. *Applied Linguistics* 23(2): 240-261.

Mercer, N. 1995. *The Guided Construction of Knowledge: talk amongst teachers and learners*. Clevedon: Multilingual Matters.

Mercer, N. and E. Fisher. 1997. The Importance of Talk. In *Computers and Talk in the Primary Classroom*, edited by R. Wegerif and P. Scrimshaw. Clevedon: Multilingual Matters.

Vygotsky, L. 1978. *Mind in Society: the development of higher mental processes*. Cambridge, MA: Harvard University Press.

Webb, N. 1991. Task-related Verbal Interaction and Mathematics Learning in Small Groups. *Journal for Research in Mathematics Education* 22: 366-389.

Wegerif , R. 1998. Two Images of Reason in Educational Theory. *School Field* 9(3-4): 77-105.

Yackel, E. and P. Cobb. 1996. Sociomathematical Norms, Argumentation, and Autonomy in Mathematics. *Journal for Research in Mathematics Education* 27: 458-477.