We really put our minds to it: Cognitive engagement in the mathematics classroom

Sue Helme and David Clarke
Faculty of Education, University of Melbourne

This paper reports the analysis of videotape and interview data from four year 8 mathematics lessons from the perspective of student cognitive engagement. The study attempted to contribute to our understanding of cognitive engagement by locating empirical evidence for its occurrence within the classroom. On the basis of the data we have examined, cognitive engagement can be consistently recognised by specific linguistic and behavioural indicators and appears to be promoted by particular aspects of the classroom situation, the task, and the individual.

Introduction

This paper comprises an analysis of videotape and interview data from four year 8 mathematics lessons from the perspective of student engagement. Our focus on the nature, role and significance of engagement stems from a consistent valuing of engagement within the literature on learning that has not been accompanied, in our view, by a satisfactory empirical demonstration of the role played by engagement in the learning process. The term "engagement" usually refers to the extent to which a student is involved with the content, or some aspect of the content of a learning activity, in a manner requiring deliberate and considered thought on the part of the student (Ainley, 1998). The "quality" or "level" of this involvement is generally believed to have a profound effect on learning outcomes, in that students who "really put their minds to it" are much more likely to learn successfully than students whose engagement with the subject matter is low.

Pintrich (1989) supported a "multivariate contextual model of student learning" and stressed the importance of "exploring the pattern of relationships among the various cognitive, metacognitive, and motivational components", particularly emphasising "the dynamic interplay between motivation and cognition" (Pintrich, 1989, p. 153). It is within this interplay that we suggest "engagement" is located. In his discussion of theories of self-regulated learning Zimmerman (1990) also stressed the interdependence of learning and motivation. Self-regulated learning can be identified with one aspect of engagement, in which the learner's engagement is a matter of personal inclination and volitional control. "High perceived control" was a postulated (and confirmed) correlate of student engagement in the work of Skinner, Wellborn and Connell (1990).

Ainley (1993) has associated student beliefs and goals with different "styles of engagement" and argued for a multidimensional character of student engagement. In Ainley's analysis, styles of engagement were linked to student achievement. Engagement itself was associated by Ainley with "students' general orientation to learning" and with "student construction of the task" with the proviso that any relationship between engagement and achievement may also be a function of features of the specific learning domain (Ainley, 1993, p. 404). These associations suggest possible indicators by which engagement might be recognised within classroom videotape and interview data such as that collected in this study.

Our research into engagement has focused on what we have called "cognitive engagement". In focussing our attention on cognition, we do not intend to ignore the motivational and metacognitive aspects of engagement. In fact, we would argue that the term "cognitive engagement" has been most appropriately employed in cases where there is evidence of significant metacognitive activity, as in the case of self-regulated learning. The term "cognitive engagement" appears to have sufficient currency in the literature for some authors to see no need to define the construct, either theoretically or operationally. For example, Pintrich and De Groot (1990) make repeated reference to cognitive

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For example, Pintrich and De Groot (1990) make repeated reference to cognitive engagement, in a paper dealing with motivation and self-regulated learning, without definition. Nolen (1995) similarly employs the construct in relation to self-efficacy, but without definition. Meece, Blumenfeld and Hoyle (1988) have also used the term "cognitive engagement" in associating different "goal orientations" with student engagement patterns, and identified cognitive engagement with "students' reported use of metacognitive and self-regulation strategies" (p. 515). We have avoided sole reliance on student self-reports of cognitive behaviour by seeking evidence of cognitive engagement from two main sources: videotapes of classroom activity and student interviews. From this evidence, we hope to construct a viable model of classroom learning in which student cognitive engagement is usefully situated.

Many early studies of student engagement appear to have operationalised the construct in terms of time-on-task (for example, Peterson & Fennema, 1985; Hart, 1989), although the usefulness of this measure has been challenged over a significant period of time (for example, Peterson & Swing, 1982). We argue that cognitive engagement is qualitatively different from time-on-task or student participation. The fine-grained nature of our data collection has provided us with examples of occasions when a high level of student "percentage time-on-task" was not accompanied by a high level of student cognitive engagement, as we would define the construct. Ball (1990) employs the term "meaningful engagement", which suggests that more is intended than mere participation. However, in Ball's usage, meaningful engagement appears to be more closely related to what students do than to what they think. Similarly, Fullarton (1996) distinguished students' cognitive engagement, behavioural engagement, and emotional engagement, but did so in terms more aligned with "student involvement" than what we would term "student engagement."

This paper is primarily the report of an investigation of cognitive engagement. However, we assert that the behavioural and affective correlates of cognitive engagement need to be considered if the construct is to be meaningfully understood. Thus we have found it helpful to think of engagement in terms of three dimensions: cognition (what are students thinking?), behaviour (what are they doing?) and affect (what are they feeling?) (Baird, 1998). Once engagement and its relationship to classroom learning is better understood, we may then be able to use strategies to enhance engagement in the classroom, and possibly the consequent quality of student learning.

Operationalising engagement

We define cognitive engagement as the deliberate task-specific thinking that a student undertakes while participating in a classroom activity. But what forms does this thinking take? The purpose of this analysis was to identify instances of such activity using classroom videotape data as a primary source. We have focussed on linguistic indicators of cognition as our primary data source, such as questions, comments and explanations. The reflective comments students made in interview provided a second source of data.

There are many behavioural correlates of cognitive engagement. These include for example active participation, persistence, effort, and non-verbal indicators of attending such as eye contact, body orientation and certain gestures. Emotive responses such as expressions of enthusiasm or satisfaction can also be associated with cognitive engagement. Caution has to be taken however in making inferences solely on the basis of observed behaviour. For example, a student in a science class in the present study, who observed her behaviour in video-stimulated recall, spontaneously commented that her own behaviours could be easily misinterpreted by the teacher as lack of attention, when in fact she was giving serious consideration to what the teacher was saying.

Influences on cognitive engagement

Cognitive engagement operates within a complex web of influences, and the present study intends to take these into account. These influences can be broadly conceptualised as individual, task-related and classroom-related. Individual students bring to the learning situation many characteristics which influence their engagement, such as prior knowledge, cognitive and metacognitive skills, perceptions, expectations, interests, needs, values and goals. Self-regulated learners, for instance, (Zimmerman, 1990) actively seek out opportunities to learn and systematically use metacognitive, motivational and behavioural strategies to achieve desired learning outcomes. Within any classroom, a 'classroom culture' emerges creating conditions that either constrain or promote particular teaching and learning strategies and particular styles of interaction with the teacher and other students (Edwards & Mercer, 1987). Current analyses of data collected in the Classroom Learning Project suggest that teaching style and the nature of peer interactions have a powerful influence on student cognition and metacognition (Lerman,1998; Holton & Thomas, 1998; Baird, 1998). Classroom learning tasks and activities provide the vehicle for a student's cognitive engagement. Recent research into task characteristics such as complexity (Williams & Clarke, 1997), challenge (Csikszentmihalyi & Csikszentmihalyi, 1992), familiarity (Helme, 1994), intrinsic interest (Ainley, 1998), and personal meaningfulness (cf. Clarke, 1996) suggests a possible relationship between such characteristics and cognitive engagement.

Methodology

The current data base for the project consists of videotape records of 55 secondary maths and science lessons obtained using two cameras. One camera was directed at the teacher, while the other camera was focused on a group of about four students. The teacher was recorded through a radio microphone, and a single microphone was used to record the students. The two video images were mixed on-site to produce a composite picture in which the students occupy most of the screen with the teacher image superimposed in a corner of the screen. This combined image was recorded onto video-8 tape using a compact video recorder attached to a laptop computer. The researcher, seated at the rear of the classroom, was able to listen simultaneously to target students and the teacher and record field notes onto a word processing document. The field notes were "time-tagged" to corresponding events in the video record using *CVideo* software (Roschelle, 1992). The researcher was therefore able to document impressions of classroom episodes and learning events as well as to provide reference markers for the subsequent interviewing of students immediately after the lesson.

The videotape record was used in the interview to stimulate student recall of classroom events. The *CVideo* software enabled the researcher to locate within the field notes reference to actions of the student which seemed to be of significance either to the researcher or to the student. Having found a particular item in the word document, the software could be used to find very quickly the corresponding moment on the video record. This was then played back and discussed. Thus students were able to reconstruct their motivations, thoughts and actions, prompted by the video record of the classroom events. The audio record of the interview provided a third source of data. Interviews with teachers were conducted at a later time. Each teacher viewed the videotaped lesson and paused the tape whenever they wished to comment on events in the classroom which showed something important to them about teaching or learning. The audio record of the teacher's commentary thus provided a fourth source of data. Eight "integrated data sets" were generated from four mathematics and four science lessons. The four year eight mathematics classes (and associated teacher and student interview records) were analysed in this study for evidence of cognitive engagement. For more details of the origins, rationale and practicalities of data collection see Clarke (in press) and Clarke and Helme (1997).

Results and discussion

We identified a number of student behaviours in the videotaped lessons which we believe can be associated with cognitive engagement. These are listed in Table 1. The observed behaviours occurred in clusters which could be associated with distinct classroom situations. It is worth noting that the five situations in Table 1 can be divided into those situations in which the teacher is present and those in which the teacher is absent. The clustering of these behaviours and their consistent association with qualitatively different social situations provided retrospective support for their validity as indicators of the single phenomenon of cognitive engagement.

Table 1. *Indicators of cognitive engagement*

Classroom situation	Behaviour
Individuals working in parallel	Verbalising thinking; self-monitoring; concentration (resisting distractions and/or interruptions); gestures (interpreted as externalising thought processes); seeking information and feedback.
Collaborative small group activity	Questioning; completing peer utterances; exchanging ideas, directions, explanations, or information; justifying an argument; particular gestures.
Small group interactions with teacher	Answering teacher's questions; giving information; explaining procedures and reasoning; questions addressed to teacher; reflective self-questioning.
Whole class interactions with teacher	Asking and answering questions; making evaluative comments; contributing ideas; completing teacher utterances
Interactions between teacher and individual student	There were no episodes of sustained interaction in the data set currently available which could be subjected to analysis

From the interview records we were able to identify a number of additional possible indicators of cognitive engagement. These included student claims to have made a genuine attempt to learn something, resolve uncertainty or to have learned something in the lesson; student discussion, communication or recall of details of lesson content; and the claim to have been engaged during the lesson (e.g. "we really put or minds to it"). An example from two of the classroom situations listed above will be discussed in detail below. Numbers in brackets refer to line numbers in transcript excerpts. Unidentified students are referred to as S1, S2 and so on.

Individuals working in parallel

K and L were working alongside each other, trying to calculate how many blood cells they have lost in their lifetime up until today:

1. T: I want you to tell me how many blood cells to the *day* you have lost.
2. K: [to L] Does that mean how many up to now?
   [Overlapping talk between T and L for next three lines]
3. T: So you've got to multiply by the years, by the months—
4. L: And the months, and the days.
5. T: By the days. OK?
6. L: Well!
7. T: That's when you've finished that.
8. K: Seven hundred and thirty million a day, no, per year, times fourteen years. Shit.
9. S1: In your lifetime?
10. T: Yes, how many blood cells have you lost in a lifetime. If it's two million a day.
11. S2: I'm not dead yet. We've got to do so many months, so many days. Oh oh.
12. T: I'll go round and check the rest [T goes around room and checks work].
13. L: [counts on fingers, talks to self] May, June, July, August, September, October. That's six. And how many days have we had in October? [looks at diary] The nineteenth.
14. K: [working aloud] You times that by fourteen, equals one point oh two two to the power of ten. Oh yeah, I understand that. One oh two two. One, two, three,

four, five, six, seven, eight, nine, ten. Would that be right? [looks towards L] How many days in a month approximately?

15. L: [working aloud] Times nineteen. [looks towards K]
16. K: [to L] Would you do approximately thirty days for the month? It would be thirty point five days. No it'd be twenty-nine point nine days or something.
17. L: Hang on. [goes back to own work] Times, times [inaudible].
18. K: Would it be this? Do you reckon, L___? Um, L___, can I borrow your calculator? L___.
19. L: Yeah [inaudible, working aloud].
20. K: [talking as she works, L does not appear to be listening] That equals one point oh, oh, oh, no, one point oh two two to the power of ten, make it—
21. L: [to herself] That's wrong.
22. K: [to herself]—ten billion, two hundred and twenty million. [Looks toward L] Ten billion, two hundred and twenty million. Is that right? [no response, L is bent over work] Don't worry.
23. L: I hate you Mrs B___! [possible emotive response related to frustration of challenging task]

Indicators of cognitive engagement: L thought aloud as she worked (13, 15,17, 19), and her intense concentration was evidenced by her resistance to K's interruptions (17, 19). She actively used available resources to help her resolve uncertainty, such as repeating the teacher's instructions in order to clarify the task requirements (4), and referring to her diary to work out the number of days (13). She made use of gesture to externalise her thought processes (13), and showed evidence of self-monitoring (21). The emotive dimension of her engagement was apparent in line 23, in which she expressed a certain amount of frustration about the task. The quality of K's engagement was different from that of L. Apart from one instance of self-monitoring (8), she tended to rely on L for basic information (14), to clarify the task requirements (2), and to give her feedback about her ideas (16), and her progress with the task (18, 22).

L's interview record contained a number of insights into the influence of task factors on the quality of her cognitive engagement. It suggested that task novelty, context and personal meaning acted to heighten L's participation and cognitive engagement. However the link between cognitive engagement and successful learning has yet to be made in a convincing and empirically-grounded fashion. Although the data available to us cannot confirm that cognitive engagement facilitated learning in this particular situation, both the video record and the teacher's interview clearly indicate that L was a highly successful student. As evidence of this, the teacher considered the problem above to be quite challenging, "It's *quite a tricky task*", and her opinion of L's competence was confirmed by the fact that she addressed L personally when she initially set the task. Pending further analysis, we suggest that L's consistently high cognitive engagement contributed significantly to her success and to the quality of learning suggested by the teacher's description of L as *"like a little mini teacher in the room"*.

Collaborative small group activity

F and M had a set of graphs from which to select the one that best fitted the v-t graph of a ball thrown into the air. They had also been asked to do a sketch of the graph. It was an extremely challenging task, because of the risk of confusing the trajectory of the ball with the graph of its velocity (which in their final selection the girls appear to have done).

1. M: [To F] Ready, what do we do with the ball thrown into the air?
2. F: This [points to material on table].
3. M: Which one?
4. F: I reckon [selects an alternative by tapping her page with pencil].
5. M: Uh uh, I don't reckon. It would go up—it wouldn't go up fast, and it would come down real fast, so.
6. F: But it doesn't come down real fast.

7. M: It does [nods head].
8. F: [shakes head]
9. M: It comes down faster than it goes up.
10. F: No. What happens, is it goes really fast [with pencil traces what appears to be trajectory of ball thrown into air] and then it slows down once it gets to the top, and comes — it comes up and then slows down [repeats first gesture], and stops when it turns around. And then it comes up again [pencil moving up] it goes down quite fast and then it slows down when it gets to the bottom [sketching second half of parabola] because it has to—
11. M: [looking at book] Yep, this one. Because it doesn't, but it doesn't, that's like it goes up and then [speaking slowly] kind of moves real [speaking slowly, gesture with hand], you can see how it. But that one just kind of goes like that.
12. F: But it doesn't go Oo-op [moves pencil upwards from desk in straight diagonal line] slow down suddenly, it sort of gradually slows. [another student briefly interrupts about another matter] I reckon—
13. M: D.
14. F: D. 'Cause it doesn't really just go uomp [moves ruler up from desk in steep curve with a jerk] and then slow down straightaway [moves ruler slowly in arc] and then—
15. M: All right, do D. [makes side comment about pen]
16. F: Then we have to draw it.

Indicators of cognitive engagement: F and M employed various resources to help them with the task. Both students used gestures to create a 'slow motion' version of the path of the ball and to help them work out how the velocity changed during its flight (10, 11, 12, 14). Gesture here seems also to have enabled them to create a 'shared representation' (Clarke, 1996) which they could both 'see' and modify until they reached agreement. M used her voice to enhance this process: as she described the changes in the ball's velocity, her speech slowed down and speeded up accordingly (11). The episode was primarily characterised by a "negotiative event" (Clarke and Helme, 1997), in which the students initially disagreed and used argument and explanation to eventually reach consensus (4-15). There is evidence of monitoring of task requirements in line 16, in which F reminded M that they had to draw the graph.

The data available to us does not enable us to demonstrate a connection between cognitive engagement and learning outcomes. We would argue though that the challenging nature of the task pushed these students to make full and creative use of their cognitive resources to help them make progress on what was for them a very very difficult problem.

We really put our minds to it: The case of H

H participated actively in a group discussion, prompted by the task: "Name some rates that affect your life". Her contribution of child maintenance rates was clearly about something quite personally meaningful.

I: So can you tell me what made it, what was good about it, what worked for you?
H Uh, I think, um, it was just that we all really put in together, we really put our minds to it, thought about it.

H's statement strongly suggests that cognitive engagement is intrinsically satisfying and motivating. This was the only occasion in over 100 interviews relating to 55 lessons in which any student made a spontaneous positive claim about their engagement. Both the classroom dialogue and the above interview excerpt suggested significant cognitive engagement on the part of Student H. Our conjecture is that it was the novelty of the task and its connectedness with H's personal experience that promoted the high level of cognitive engagement. The following interview excerpt appears to support this interpretation.

H: 'Cause we hadn't done anything like that before, in maths.
I: Uh huh.
H In maths, yeah.
I: Uh huh, so what at home do you know, what was that, what were you thinking about then?
H: Well, water rates, 'cause I remember my brother did an assignment on that, um, child maintenance rates because um, my father has to pay them for my brother and I, um.
I Right.
H: All, all the rates that we pay, bank rates, home loans, we just bought a new home and stuff like that. So yeah.

Conclusions

Cognitive engagement is valued by the education community and widely held to facilitate learning. Most studies which have investigated this link tend to rely on measures of cognitive engagement such as time-on-task and student self-reports. The former are unsatisfactory because of their superficiality and limited construct validity. The latter are limited by an individual's ability to accurately recall their actions and reconstruct their thought processes and motivations. The present study attempted to contribute to our understanding of cognitive engagement by locating empirical evidence for its occurrence within the classroom, and by exploring the relationship between forms of cognitive engagement and different classroom situations and activities.

On the basis of the data we have examined, we are prepared to assert that cognitive engagement, as we have defined it, is observable in classroom situations and can be consistently recognised by specific linguistic and behavioural indicators. In this paper we examined cognitive engagement in two distinct classroom situations, individuals working in parallel and collaborative small group activity, and observed that different patterns of cognitive engagement appeared to characterise each type of activity. Preliminary analysis of teacher-student interactions suggests significant differences in the patterns of cognitive engagement from those reported here. We have also found evidence to support the view that task characteristics influence cognitive engagement, as do individual-task interactive factors such as the personal meaning which the task holds for the student. The emotive aspects of engagement were also evident in our data. It appears to us that some students possess particular skills which act to support their cognitive engagement. These skills may be metacognitive in character. This issue will be the subject of further investigation.

References

Ainley, M. (1993). Styles of engagement with learning: Multidimensional assessment of their relationship with strategy use and school achievement. *Journal of Educational Psychology, 85* (3), 395-405.

Ainley, M. (1998). Interest in learning and classroom interaction. Paper presented to a meeting of the Classroom Learning Project, University of Melbourne, February 12-13, 1998.

Baird, J.R. (1998). From ignorance to understanding: Thinking, feeling and acting. Paper presented to a meeting of the Classroom Learning Project, University of Melbourne, February 12-13, 1998.

Ball, D.L. (1990). With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. Craft paper 90-3, National Center for Research on Teacher Education, Michigan State University.

Clarke, D.J. (1996). Refraction and Reflection: Modelling the Classroom Negotiation of Meaning. *RefLecT* 2(1), 46 - 51.

Clarke, D.J. & Helme, S. (1997). The resolution of uncertainty in mathematics classrooms. In F. Biddulf and K. Carr (Eds.) *People in Mathematics Education.* Waikato, NZ: MERGA, 116-123.

Clarke, D.J. (in press). Studying the classroom negotiation of meaning: Complementary accounts methodology. To be published in 1998 as a chapter in A. Teppo (Ed.) Qualitative research methods in mathematics education. As part of the Monograph Series of the Journal for Research in Mathematics Education. Reston, VA: NCTM

Csikszentmihalyi, M. & Csikszentmihalyi, I. S. (Eds.) (1992). *Optimal experience: Psychological studies of flow in consciousness.* New York: Cambridge U. P.

Edwards, D. & Mercer, N. (1987) *Common Knowledge: The Development of Understanding in the Classroom.* London: Methuen.

Fullarton, S. (1996). Transition to secondary school: A help or hindrance to engagement in mathematics? Paper presented at the 1996 joint conference of the Australian Association for Research in Education and the Educational Research Association of Singapore, Singapore, November 25th to 29th, 1996.

Hart, L.E. (1989). Classroom processes, sex of student, and confidence in learning mathematics. *Journal for Research in Mathematics Education, 20* (3), 242-260.

Helme, S. (1994). *Mathematics embedded in context: The role of context in task perceptions, performance and the solution methods of adult women students.* Unpublished Master of Education Thesis, Australian Catholic University.

Holton, D. & Thomas, G. (1998). Mathematical interactions and their influence on learning. Paper presented to a meeting of the Classroom Learning Project, University of Melbourne, February 12-13, 1998.

Lerman, S. (1998). Accounting for accounts of learning mathematics: Reading videos and transcripts. Paper presented to a meeting of the Classroom Learning Project, University of Melbourne, February 12-13, 1998.

Meece, J.L., Blumenfeld, P.C. & Hoyle, R. (1988). Students' goal orientations and cognitive engagement in classroom activities. *Journal of Educational Psychology, 80*(4), 514-523.

Nolen, S.B. (1995). Effects of a visible author in statistical texts. *Journal of Educational Psychology, 87*(1), 47-65.

Peterson, P.L. & Fenema, E. (1985). Efective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics. *American Educational research Journal, 22* (3), 309-335.

Peterson, P.L. & Swing, S.R. (1982). Beyond time on task: Students' reports of their thought processes during classroom instruction. *The Elementary School Journal, 82*(5), 481-491.

Pintrich, P.R. (1989). The dynamic interplay of student motivation and cognition in the college classroom. In M.C. Maehr & C. Ames (Eds.) *Advances in motivation and achievement, Volume 6: Motivation enhancing environments.* Greenwich, Connecticut: JAI Press Inc.

Pintrich, P.R. & De Groot, E.V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33-40.

Roschelle, J. (1992). *C-Video.* Software package. San Francisco: Knowledge Revolution.

Skinner, E.A., Wellborn, J.G. & Connell, J.P. (1990). What it takes to do well in school and whether I've got it: A process model of perceived control and children's engagement and achievement in school. *Journal of Educational Psychology, 82*(1), 22-32.

Williams, G. & Clarke, D.J. (1997). Mathematical task complexity and task selection. In D. Clarke, P. Clarkson, D. Gronn, M. Horne, L Lowe, M. Mackinlay & A. McDonough (Eds.). *Mathematics: Imagine the Possibilities.* Brunswick, Vic: MAV.

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist, 25*(1), 3-17.