Students' Mathematics Culture

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An integral component of learning mathematics is to understand the social context in which the teaching and learning occurs. There is growing recognition that there is culture of the mathematics classroom (Boaler, 1993; Borba, 1992; Iben, 1989; Mousley & Clements, 1990) with many researchers attempting to delineate and define it. Taking into consideration Nickson's (1994) recognition that there is not a singular mathematics classroom culture since no two classrooms are alike, there are however aspects of mathematics classrooms shared across many sites and contexts. It is these similarities that can be said to be representative of the culture of mathematics classrooms, and as such become embodied to form a mathematics *habitus*. This paper explores the "underground culture" of the mathematics classroom. By this I refer to a culture which can be inferred from the behaviours of students as they go about their activities in the mathematics classroom.

Often the implicit values embedded in the culture of the mathematics classroom can be inferred from observations, and it is expected that students will come to learn and assimilate the culture of the classroom. But, as will be shown in this paper, in the process of displaying the behaviours synonymous with "good" learners", students develop elaborate strategies which are in opposition to the values of the classroom. These strategies can be seen to be a part of the student culture of the mathematics classroom.

Studies have shown that mathematics is most often seen as set of basic facts and procedures which have to be memorised (Southwell & Khamis, 1994); the use of text textbooks feature widely in the classroom and a there is focus on computational skills (Porter, Floden, Freeman, Schmidt & Schwille, J., 1988); transmissive models of learning where the teacher controls knowledge are common (Burton, 1994; (Clarke, 1984); mathematics is an individual activity (Clarke, 1984); students observe the teachers demonstrating mathematical conventions and then imitate the teachers' behaviour (Lave, Smith & Butler, 1989). Leder and Forgasz (1992) document a student's narrative on typical mathematics lessons. The student narrative reinforces Joyce and Weil's (1986) claim that teaching mathematics was based on Skinnerian models of learning where the teacher would explain a concept to a large group, set the students to practice the task on their own under the direction of the teacher while remaining seated in their desks. Factors such as these, represent a certain culture of mathematics classrooms, which is often different to other curriculum areas.

When we talk of "learning mathematics" what do we really mean? Are we concerned with just the content of the subject, or is there more for the students to learn if they are to be constructed as effective learners of mathematics? Bishop (1988a) has argued persuasively that the learning of school mathematics can be seen as a process of "mathematical enculturation" whereby students must come to learn the culture of mathematics even when that culture may be incongruent with that of the student. This work is further supported by the research which focuses on the social and cultural aspects of learning (Bishop, 1988a; Carraher, 1988; Carraher, Carraher, & Schliemann, 1985; Carraher, Carraher, & Schliemann, 1987; Saxe, 1988; Walkerdine, 1988) along with the work being conducted in situated cognition (Brown, Collins, & Duiguid, 1989; Lave, 1988; Lave, Murtaugh, & de la Rocha, 1984), suggest that there is more than just content *per se* that must be learnt when students are located within the mathematics classroom. There are certain discursive norms and rules (Voigt, 1985; Voigt, 1994; Zevenbergen, 1993) with which the student must comply, as well as social and cultural norms. These aspects of learning are often part of the hidden curriculum of mathematics in particular, and schools in general. If the student is to be seen as a successful participant in mathematical discourses, then it is essential that these hidden aspects of mathematics are also learnt. The very nature of mathematical discourses with their high level of particularised and idiosyncratic use of language, along with the associated levels of abstractness, means that it a complex and demanding process for students to learn. This is especially the case when many of these rules and routines are covert and unspoken, and actually embedded in the discourses themselves.

Wittgenstein (1953; 1967) developed the notion of "language games" to theorise the construction of certain forms of knowledge within a given culture. This knowledge becomes institutionalised in such a way that it becomes taken for granted so that it becomes a "form of life" for the community. Mathematics is one such form of knowledge. By taking such an approach, it is possible to examine the language games within the mathematics classroom in order to understand the processes through which students come to construct mathematical meaning. In this paper, I reappropriate the notion of "games" to theorise the student culture of the mathematics classroom. This view is synonymous with the constructivist writings, particularly those of the radical persuasion, where it is argued there can not be an assumed transference of meaning of one person to another, but rather, based on the prior experiences of the learner, different meanings will be constructed from any given event. In this paper, students construct their own versions of culture and while they are able to give external appearances of complying with the culture of the classroom, they have constructed a different set of meanings about participation in the classroom.

The primary focus of a mathematics lesson may be the learning of mathematical concepts, yet within the interactions that occur in the classroom, many other messages are being conveyed about the nature of mathematics. To be conversant and a competent participant in the mathematics classroom, students need to learn the unspoken component of the classroom culture, as well as the mathematical content of the lessons. These less overt messages are ones which the students will learn and use at different times and in different contexts, but are constitutive in their learning of mathematics. Within a classroom it can be seen that there are many facets of the culture which the students learn as they progress through their schooling. Much of the classroom culture is seen as valued so that students working on task, using the appropriate language of mathematics, actively participating in mathematical activities are likely to be seen as "good" students. Accordingly students learn that these attributes are important to display to the teachers. However, I demonstrate that students develop effective strategies for displaying appropriate behaviour while engaging in activities which are in opposition to the actual behaviours which are seen as valued.

Research method

The method for data collection was a critical ethnography conducted in three socially divergent schools. Seven teachers were involved in the study from either grade One/two or Five/six. The schools were in the state of Victoria so these classes were the second/third and sixth/seventh years of primary schooling. One class from each grade level from each of the three schools participated in the study. The teachers used a variety of pedagogies in their teaching of mathematics ranging from student-centred, small group learning to the more traditional teacher-directed pedagogy. The data was collected using the tools offered within the ethnographic method and further supplemented through the use of video cameras. All mathematics lessons were recorded. At least ten lessons from each classroom were observed and recorded. These were then transcribed and reviewed with observations of students behaviour noted alongside the transcripts.

The Games Students Play

It had been my original intention to use the transcripts to deconstruct the processes of meaning making within the constructivist approaches elucidated by Paul Cobb and co-researchers. However, the data that was collected was not amenable to such a process. The student interactions were nothing like those of the Purdue Project, but rather non-sensical and incoherent. Further to this, when the transcripts were examined, it appears that there is very little dialogue that could be considered as constitutive of mathematical meaning making. Such dialogue would most frequently occur when there was a teacher present. What was a surprising aspect of the data was that when the video tapes were reviewed, students could be seen to behaving mathematically and interacting with their peers in ways which could be construed as helping their peers to resolve their mathematics. This behaviour was subtle and easily missed in the more traditional methods of classroom observation. Even more interesting was the behaviour which could be observed would not have been accessible without a video camera. These behaviours were captured because the students were not aware that they were being observed. When students were engaged in the work phase[1] of a lesson this method of data collection captured the children behaving in ways which would seem antagonistic to the goals that the teachers had for the lessons. While the outcomes of the lesson would suggest to teachers and observers that the students had been actively participating in mathematically-oriented activities, the processes though which they were able to produce the desired outcomes could not be construed as mathematical, notwithstanding a very broad conceptualisation of creative problem solving!

Producing an answer

Perhaps one of the more predominant aspects of the mathematics classroom culture was the obsession with having an answer which would seem rational and satisfy the criteria of the teacher. This obsession has been noted by other researchers and can be observed when Clements and Ellerton (1990, p.1) cite the example from Reusser (1986)

> **There are 26 sheep and 10 goats on a ship. How old is the captain?*
>
> ** There are 125 sheep and 5 dogs on the ship. How old is the shepherd?*
>
> *With respect to the first of these problems, three quarters of the respondents gave a numerical answer, For the second, a fourth grade student stated that:*
>
> *125 + 5 = 130...that's too big, and 125 -5 = 120 is still too big ... 125/5 = 25. That works ...I think the shepherd is 25.*

Quite obviously, the student is more concerned with having a reasonable answer, so that the inherent mathematics of the problem is subsumed by the desire to have a "correct" answer. Early in their school careers, students learn that it is imperative to have some form of reply for the teacher should s/he be called upon to respond to some question. If there is no collusion between student and teacher in this interaction, the student is most likely to be constructed as deviant. The need to be able to produce some reasonable answer often subsumes the mathematising of the problem in order that some product is available. The most obvious example of this obsession is in copying a peer's work, where the child has not engaged in the process desired by the teacher, but is able to satisfy the requirements of the lesson with the production of some form of answer, response or product. Whether the student participates in such an activity because of a lack of understanding or laziness, is inconsequential. The point that I am developing is that the need for an answer subsumes the process of mathematically producing a response.

Such an example of this occurred in a lesson which was the culmination of a sequence of lessons where the (Grade 5) students had been developing knowledge and skills relevant to the properties and construction of 3D shapes. In this lesson, the teacher had asked the students to construct the net for a square pyramid. One boy remembered having seen a sketch plan of a net for this solid shape in a previous lesson. He then spent a considerable amount of time searching through his text book which he carefully kept hidden underneath the table top, thus making the turning of pages quite difficult. Eventually he found the plan, which he carefully transposed onto the grid paper. He successfully completed the construction of the pyramid and quite happily and readily shared his pattern with his peers who were able to complete their models as well. This group of students were able to produce a product which seemingly demonstrated that they knew how to construct a square pyramid, yet the process by which they arrived at their result effectively subsumed the mathematical content of the lesson to a marginal place.

The teacher in this classroom implemented what could be braodly referred to as a constructivist epistemology and would engage the students in active debates, justification, and clarification at the conclusion of the lesson. When he called on this student to explain how he had been able to construct his net, the student was able to justify his construction by proposing that he "made a square bottom, then put triangles on the sides that were all the same and then joined them up." Insofar as outside observers were concerned, this response would suggest that the boy undertook a valid process through which the shape could have been produced. Accordingly, it would be likely that the boy would be constructed as an effective learner of mathematics whereas in reality what could be said is that he has creative problem solving skills which enable him to produce an appropriate response.

The Work Ethic

Part of the classroom culture is that students must be kept busy. The dominant discourses with education explain the value of students being busy and "on task" as being necessary if academic learning is to occur. Alternatively, another dominant explanation is located within the discourses of behaviour management where keeping students busy and engaged in activity is necessary to maintain order and control in the classroom. Another explanation rests on the notion of enculturation a good work ethic so that students accept that being busy is productive and in this way are prepared for the workplace.

Students quickly learn that being caught "off task" runs the risk of negative consequences ranging from the wrath of the teacher, the imposition of extra work or even physical removal from the classroom. Students realise that most of these consequences are to be avoided and hence develop strategies for appearing to be "on task" during lessons. In the lower grades, students learn that when the teacher is out of ear shot they can talk about anything, but as s/he approaches, they quickly change their conversation back to the task. By the time they enter the upper the upper grades, more elaborate strategies have been developed.

In a Grade 5/6 the students had been set to task and as the teacher and I roamed the room checking students' work, and helping wherever necessary, it seemed as though all students were actively in a construction activity. However, when I reviewed the video tape, it was obvious that students had developed excellent skills for appearing "on task" while being able to avoid work. A group of boys (at the back of the classroom) were engaged in activity, but not associated with the task that had been set. Instead they cut their paper into assorted shapes totally unrelated to the set task and made paper spit balls for pens which they then shot at their peers. During all of these miscellaneous activities, one boy remained on task working through all of the questions which structured the activity. As the teacher roamed the room, the boys kept a very close on him. When he approached the boys, one of them raised his hand and asked for help since he could not understand what he was supposed to do. This strategy successfully diverted the teacher's attention away from the others in the group, while making it appear as if the boy was actually involved in the activity. When the teacher left the group, the boys continued with their non-mathematics activities. As the lesson drew to a close and the teacher warned the students that they only had a few minutes remaining, the boy who had been working throughout the lesson passed his results to the others.

At the conclusion of the lesson the teacher asked students at random for their results. When he asked any of the boys in the group, they were able to provide him with correct responses. Insofar as the teacher was concerned, this group of boys had been involved in the lesson and appeared to have understood the mathematics of the task. While the boys were able to appear to be interested in the task and be "on task" during the lesson, their well rehearsed routine enabled them to avoid engaging in the mathematical content of the lesson. For the teacher who would be ascertaining how students were coping with the content and concepts, his evaluation of their knowledge would be based on his observations which were not continuous with the occurrences in the classroom.

Teacher as Controller

Another important aspect of the classroom culture is the relationships of power, in particular that of the teacher. S/he is able to control most aspects of the classroom environment. Part of this power is the teacher's capacity to determine what knowledge is desired and what will be seen as legitimate. Walkerdine (1982) argues that often incorrect responses are due to the student calling up the incorrect discourse. A common practice in the classroom is asking open-ended questions which have a number of interpretations. Many of the signifiers used in mathematics have a different meaning within another context, so that if students are asked to explain what is volume, it is quite conceivable that if they do not select the mathematical discourse, they are likely to discuss decibels and the noise that they can create from a stereo. Accordingly, it is important that students recognise the discourse that the teacher is working within. The teacher controls what discourse and is able to manipulate the discussion in order to achieve the appropriate discourse. Children in the infant grades quickly learn that the teacher often wants certain answers to questions but not others. Part of the classroom culture is that they have to learn is to provide the teacher with the answers that s/he wants. A common expression of this aspect of classroom life is "Guess what's in my head".

In the following lesson on shape, the teacher has drawn a nest on the chalk board with some eggs in it, although only the top half of the egg is shown. He has been focussing on the language of space in recent mathematics lessons. The day prior to this lesson the children had been studying the plovers which have been nesting in the school yard.

T	On my way to school...I was driving along
Cam	You saw a plover
T	Well, I just about did, but I saw the thing the thing that the plover lands in. The thing that the plover lands in on the ground.
Ben	A nest!
Cs	A nest
T	It was too, and anyway ... I sort of saw some shapes there that I
Tom	Oh no
Ben	No
Tom	Why do you always say that?
T	That I...who knows the name of the shape?
Mike	That's easybubs
T	It's not easybubs, some people don't know it. Alison, which one do you know?
Alis	Oval
T	Right I can see that, there's one that's really close to another shape...yes?
Sam	A semicircle
T	That's very good Sam

From this extract it is easy to see that a student assumed that they would be continuing the discussion on plovers using very little information on which to base his response. The teacher does not want to continue with this theme, and moves the discourse from plovers to his intended mathematical discourse (shape) by hinting at the nest. He later is more explicit and refers to "shape". This establishes the desired discourse and the lesson is then able to continue in a manner which the teacher has planned. While the teacher may have a clear idea of the objective of the lesson, part of the game for the students is to guess what the teacher has in mind.

Students learn that their responses are often not those sought by the teacher and that part of becoming an effective classroom participant is to work with the teacher and comply with the implicit rules of classroom dialogue. In particular, part of the classroom dialogue is to establish the discourse which the teacher wants. This means participating in the "guessing the discourse".

Becoming a Cultured Classroom Member

As students come to learn the implicit cultural values of the mathematics classroom, they learn strategies for working in ways which are congruent with the expectations of the school and teachers. While many of these strategies have external appearances of compliance with the goals of "good teaching", others are conterminous to the goals that the teacher may hold. Students learn quickly that there is a hidden agenda and that to be constructed as effective learners of mathematics means that they must comply with this agenda. As has been shown in the above examples, students have developed many elaborate practices for appearing to comply with teacher expectations and the classroom culture, but in actuality, resisting the values which are integral to the classroom culture. In conjunction with this compliance, the strategies which they develop make it very difficult for teachers to gain access to what students know about mathematics and the processes associated with mathematics. Teachers in this study were amazed to see the complexity of the strategies students developed in order to be seen as complying with the unspoken rules of classroom behaviour but were, in reality, avoiding engaging in any substantive mathematics.

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