INSIDE THE MATHEMATICS CLASSROOM

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In this paper we describe the behaviours, mathematical and affective, of a small group of grade 7 students assigned a common task: determining the feasibility of a new tuckshop. The activity set spanned eight 45 minute lessons. Data gathering involved videotaping each lesson, keeping field notes, monitoring students' reactions to the work done each day and their contribution to it. Measures of students' attitudes to themselves and to mathematics were also obtained. Different methods for reporting student engagement, generally and in mathematics, are compared.

INTRODUCTION

Official statements and procedures generated to direct the mathematics curriculum increasingly refer to students' attitudes. The National Statement on Mathematics for Australian Schools (Australian Education Council, 1990) is no exception:

> An important aim of mathematics education is to develop in students positive attitudes towards mathematics.... The notion of having a positive attitude towards mathematics encompasses both liking mathematics and feeling good about one's own capacity to deal with situations in which mathematics is involved (Australian Education Council, 1990, p. 31).

However, currently available versions of the National Mathematics Profiles, `intended to reflect the achievements of well-taught students whose mathematics curriculum has been based on the National Statement' (Australian Education Council, 1992, p. 1), do not reflect an explicit concern with students' attitudes. The Achievement Statements included in each of the six levels of the Profiles describe in behavioural terms what is expected of students. Students should `pose questions', `compare and sort', `copy, continue, and create' (Level 1 Achievement Statement). While attitudinal goals can be inferred by a sensitive reader they are not spelled out specifically. Difficulties associated with measuring student attitudes realistically in a classroom setting may, in part, explain this omission.

AFFECTIVE FACTORS AND MATHEMATICS EDUCATION

A careful reading of the recently published and impressive Handbook of Research on Mathematics Teaching and Learning (Grouws, 1992) reveals a growing concern among researchers about the role and measurement of affective factors in student learning of mathematics. For example, Schoenfeld's (1992) review of literature concerned with both cognitive and affective factors relevant to the learning of mathematics focuses on students' beliefs about mathematics (relevant to the `liking mathematics' referred to in the National Statement) rather than on their beliefs about themselves as learners of mathematics (i.e., `feeling good about one's own capacity to deal with situations in which mathematics is involved', mentioned in the same document). Moreover, Schoenfeld's dissatisfaction with the level of integration between the cognitive and affective domains in research on mathematics learning is clear:

> The arena of beliefs and affects needs concentrated attention. It is basically underconceptualized, and it stands in need of new methodologies and new explanatory frames. The older measurement tools and concepts found in the affective literature are simply inadequate; they are not at a level of mechanism and most often tell us that something happens without offering good suggestions as to how or why.... Despite some theoretical advances in recent years and increasing interest in the topic, we are still a long way from a unified perspective that allows for the meaningful integration of cognition and affect or, if such unification is not possible, from understanding why it is not (Schoenfeld, 1992, p. 364).

To assess whether or not a unified perspective is attainable it is necessary to go beyond self-report questionnaire measures, the most frequently used means of measuring attitudes towards, and beliefs about, mathematics.

In the one chapter in the Handbook specifically concerned with affect, McLeod (1992) also argues that the vast research literature on affective factors has had little impact on mathematics education.

> Although affect is a central concern of students and teachers, research on affect in mathematics education continues to reside on the periphery of the field. If research on learning and instruction is to maximize its impact on students and teachers, affective issues need to occupy a more central position in the minds of researchers (McLeod, 1992, p. 575).

Only those concerned about gender differences in mathematics learning, McLeod (1992) concluded, have more consistently attempted to incorporate affective factors in research on instruction, curriculum development and teacher education programs in mathematics.

AIMS OF OUR RESEARCH

A strong belief in sentiments such as those expressed by Schoenfeld and McLeod prompted the study reported in this paper. By relying on observable and readily inferred indicators of affective and cognitive behaviours, and not merely on self-report measures, we aimed to describe simultaneously students' cognitive and affective engagement in mathematical tasks encountered in a realistic classroom setting. Operationalising aspects of affective engagement was a crucial goal of this process. Thus devising a suitable method for categorising observed and inferred behaviours was also an important objective.

Affective variables included in models concerned with gender differences in mathematics learning served as a useful context for our work. Components of several relevant models are summarised in Table 1.

Table 1: Selected models of mathematics learning

Author(s)	Year	Relevant components in the model
Deaux & Major	1987	beliefs about the target, about self, social expectations, effect of context, response to actions selected
Eccles	1985	persistence, self-concept of ability, attitudes, expectations, attributions
Ethington	1992	self-concept, expectations for success, stereotyping of maths, difficulty of maths
Fennema & Peterson	1985	confidence, willingness to work independently, sex-role congruency, attributional style, engages in high level cognitive tasks
Leder	1990	confidence, attributional style, learned helplessness, mastery orientation, sex-role congruency
Reyes & Stanic	1988	societal influences, teacher attitudes, student attitudes

The variables highlighted in these models guided the choice of students' affective and cognitive behaviours to be described functionally. The observational scheme for social behaviours and information-processing components presented by Clements and Nastasi (1988) is similar to the approach we adopted for categorising these behaviours.

RESEARCH METHODOLOGY

While philosophical debate for (Howe, 1988) and against (Smith & Heshusius, 1986) the compatibility of combining quantitative and qualitative research paradigms continues, the mutual acceptance of complementary research paradigms has been recognised on the practical level by some researchers (Salomon, 1991).

Comparing quantitative and qualitative approaches to the same issue can provide complementary information (Evertson & Green, 1986; Firestone, 1987). Combining techniques from the two paradigms can occur disjunctively (i.e., an investigation of separate problems) or conjunctively (as multiple indicators of the same problem). In drawing different conclusions from distinct evidence, the former is considered easier to interpret (Howe, 1985). Conjunctive analysis has illustrated, for example, that when `two kinds of data checked one another,.. the confidence that could be placed in either alone' (Howe, 1985, p.16) was reduced.

Those writing on qualitative methods have also disagreed on techniques considered legitimate within the paradigm. Erickson (1986) argued against combining quantitative and qualitative techniques while Evertson and Green (1986) maintained that specific studies might call for their combination. As the field of mathematics education grew there was a parallel increase in the diversity of research methods adopted (Romberg, 1992). Problem-led approaches, previously not considered legitimate (Bishop, 1992) are now increasingly evident.

The research techniques used in this study were problem-driven. Observation methods, employing a descriptive system and videotaped records (Evertson & Green, 1986), were accompanied by self-report data which were analysed quantitatively. The latter findings have been reported elsewhere (Leder & Forgasz, 1991).

Specific details about the method adopted in this study are given later in the paper. Briefly, by relying on both self-report and behavioural data the approach employed reflects the complexity of the relationship between attitudes and actions postulated by Triandis (1971):

> What should be understood is this: attitudes involve what people think about, feel about, and how they would like to behave toward an attitude object. Behavior is not only determined by what people would like to do but also by what they think they should do, that is, social norms, and by what they have usually done, that is, habits, and by the expected consequences of the behavior (p. 14, emphasis in the original).

THE STUDY

The task and setting

The group task, set by the teacher as part of the regular mathematics program, involved a study of the feasibility of building a new tuckshop in the school. With anticipated growth in enrolments at particular year levels within the school and pressure already being felt on existing tuckshop facilities, an additional tuckshop serving students from selected grades was seen by those at the school as an option worth considering. To allow the students to put forward their views was consistent with the philosophy of the school.

The teacher organised the 28 students in the class into six small groups of four or five. All groups were required to investigate the feasibility of building the new tuckshop and had to prepare a report to support their case. The students were informed that their reports would be placed, via the school `parliament', before the school's administration.

The groups worked on the project for eight lessons, each of 45 minutes duration. Seven of these lessons were videotaped. One in the sequence was missed due to a timetable clash (a second class in the school was also being monitored by the researchers as part of this project).

The sample

The sample comprised one of the small groups. It consisted of five students: three females (C, Ch, and J) and two males (B and M). The teacher (DM) nominated the students for inclusion in the group targeted for closer study. All were described by him as being very good or excellent at mathematics.

Due to absences and attendance at special lessons such as music the target group did not have its full complement at all lessons. For example, at the beginning of the third lesson only two members of the group were present. The teacher sent a student from another group to join them temporarily. When a third member arrived the `intruder' was sent back to his own group.

Procedure

Data gathering involved videotaping each lesson, subsequently transcribing the tapes, keeping field notes, monitoring students' reactions to the work done each day and their contribution to it, and administering other instruments to provide self-report measures of students' attitudes and beliefs about mathematics and themselves as learners of mathematics. The data sources and their use are described below.

1. Lesson transcripts

This source was used to provide information at three levels: an overview of the lessons observed, a more detailed description of the behaviours and interactions of a group of five students during one lesson, and fine-grained analyses of two episodes within the same lesson. This sequence allowed for both low and high inference analyses.

Particularly for the interpretation of higher inference behaviours, the transcripts required considerable detail. Each speaker was identified, all dialogue was faithfully recorded and, when significant, tone of voice or non-verbals, including gestures or facial expressions, were also described.

The lesson overview data are summarised in Table 3. The other two data sets are reported in separate sections of the results section. Natural breaks in the action, necessarily not of uniform length, determined the units used to depict the students' behaviours in one complete lesson. Procedures adopted for the fine-grained analyses, i.e., clarification for the observational scheme adopted for categorising high inference cognitive and affective behaviours, are described in a later section.

2. Field notes and observational data

This information supplemented the lesson transcripts and provided a richer context for the higher inference analyses.

3. Students' perceptions of the lessons

The students' reactions to the lessons are summarised in Table 4. These data served as additional context for the fine-grained descriptions of students' affective and cognitive behaviours and further underpinned the higher inferences drawn.

4. Self-report measures

Information regarding the students' beliefs about themselves as learners of mathematics and of their attitudes to mathematics was also used to support the high inference analyses. Details of the instruments administered are given in Leder (1992). A brief profile of each student based on the self-report data is shown in the Appendix.

Operational definitions

The cognitive (cog) and affective (aff) behaviours we aimed to describe were each classified at two levels: lower (LI) and higher inference (HI). Students' own reports of their feelings following the lesson, recorded on `Today's Lesson' sheets and completed at the end of each lesson were classified as lower inference affective behaviours. (These data are summarised in Table 4.) Lower inference cognitive behaviours were those which were readily observable from the videotapes and corresponding verbal exchanges, and were often more closely associated with task engagement.

Task engagement also fell into two categories: central (C) (to the mathematical task at hand) and peripheral (P). Cognitive behaviours, including oral contributions to mathematical discussions, were categorised as high (HL) or low level (LL).

Table 2 lists behaviours observed, operational definitions used in this study, and examples derived from the transcripts. Examples of higher inference cognitive and affective behaviours are included.

Table 2: Observation scheme for high inference cognitive and affective behaviours

Behaviour	Operational definition	Examples
gender-role stereotyping i. (Aff, HI related to P) Specific example: mathematics as a male domain ii. (aff, HI related to C)	task engagement or verbal exchange indicative of gender-role stereotyping; in particular, relating to mathematics	i. B: Who's got the neatest writing here? M: Ch probably has J: Ch has B: (to Ch) Then you can write them all up ii. J: Well, what we're doing, all we're doing, they're (pointing to B) doing the graphs for me; I'm just colouring them in
confidence Two dimensions: i. personality indicator		

(aff, HI)

ii. in doing/learning mathematics

exhibits leadership, or certainty in ideas or course of action

DM: (to group) Now, have you decided if you've got enough information or do you think you might need some more?

J: We'll decide that, we'll get these graphs, we'll look at the information and then we'll decide. We're doing everything methodically.

DM: Have you worked out, um, what sort of strategy you're going to use in your report to get people to accept your recommendations?

J: We'll work it out when we get to it

DM: All right, you want to get that done first. All right.

B: Yep

contextual effects: peer/teacher influences

(aff, HI)

For example:

i. intolerant/ dismissive/ ignoring

(M about Ch: aff, HI)

ii. helpful/ considerate/

supportive/
reassuring

iii. peer
hierarchy

(M and Ch over
C: Aff, HI)

iv. affirmation/
positive feedback
verbal
exchanges or
other
indicators of
interpersonal
relationships
(eg. feelings/
emotions)

i.

Ch:	Do you want me to write the questions up the top, M?
M:	Pardon?
Ch:	Like, `how often', do you want me to write that across the top?
M:	Just write the, write the question.. (unclear). Just write the question
Ch:	What... (unclear)
M:	Just depends, whatever you want
Ch:	J!

ii.

M:	This isn't right, we've only got 30 people
B:	M, don't worry. Not many answered that, answered that...
M:	That's not many.

iii.
(all three girls are working on the sheets, the boys are just watching)

M:	(to C) No, let Ch write it in
C:	Yeah, sure (she hands over the sheet)

M: (to C) Here, give us the pen (she hand it back)

Ch: (to C) Right, here's another one (for colouring)

independent thinking

(J: cog, LL, HI, C)
(B: cog, HL, HI, C)

initiates or puts forward a logical and constructive suggestion/idea /question for solution or means to proceed in solution process

DM: If this current tuckshop (t/s) spends $2000 a week for both Middle School (MS) and Junior School (JS), what would the new JS t/s spend?

J: $1500 (DM shrugs indicating `maybe')

B: How many are there in MS?

task/work autonomy (self-directed)

(Ch and J: cog, LL, HI, P)

assuming control over the process of undertaking a task, including constructive solitary or co-operative work

Ch: Do you want me to help

colour them in?
J: OK, we'll have set colours for it...
Ch: OK
J: You can do the `yes' and `no's if you want
Ch: OK
J: And do you want them blue and red, or...
Ch: OK. Yeah, blue, blue for `yes' and uh, red for `no'
J: Yeah, so.. Where's some big..., who's got big textas? (she gets up to leave the table)

persistence

(cog, LL, HI, C)
continues with constructive work at task or with verbalised idea when encounters difficulty, rebuff or failure without coaxing or encouragement.

B: This isn't what we need
M: How about if you give everybody one survey..
B: This isn't what we need, M
M: ...so they can have a look at them (grabbing sheets from B)
C: Yes, it is (C takes a sheet from B). It's 10 out of 13 wanted a new t/s out of the teachers and 3 out of 13...
B: This isn't what we need. It's that profit stuff, (indistinguishable word) know how much people...
J: This'll help too. B, this'll help too, all right. So calm down

As already indicated, the results of our analyses are reported at different levels. The descriptions at the lower levels were informative per se and were also used to verify the higher inference interpretations of observed student behaviours.

RESULTS

1. Lesson overview - low inference

An overview of the lesson monitored is given in Table 3. The students present and a brief description of the work given is shown for each lesson. The data provide a useful context for more detailed descriptions of other events.

Table 3: Overview of lessons monitored.

Date	Who present	Main activities
Mon. 26/8	Ch, C, B, M Absent: J	- DM introduced task; class brainstormed ideas - Ch nominated as group co-ordinator - discussion re.: questions to include in survey; which classes to survey; who will conduct the survey
Tues. 27/8	Ch, M, C (came late), Ben (put in by DM - sent back to own group during lesson) Absent: J & B	- DM handed out survey sheets for class to complete - these comprised the Year 7 sample. Explained how survey had been compiled and completed by one Year 5 and one Year 6 class. - Much time wasted as group waited for a set of survey sheets to arrive for data to be extracted - Group devised own means for extracting and recording data
Wed. 28/8	J, C, B, M Absent: Ch	

- completed data extraction
- decided how data to be plotted on graphs
- responses from the three year levels combined
- began preparing graph sheets and plotting bar graphs

Thurs.
29/8
J, C, Ch, B, M
- girls coloured bar graphs, labelled graphs and axes
- boys carefully plotted graphs
- discussed further data needed and calculations required to further argument eg. teachers' views, projected additional monies spent by students, projected profits

Fri.
30/8

Lesson missed due to timetable clash. J. wrote summary - boys "arranged and argued over various mathematical results"; girls "began writing up our report".

Mon.
2/9
J, C, Ch, B, M
- DM discussed assessment of task
- girls worked on writing up report
- boys worked on mathematical calculations related to projected profits of new t/s etc.

Tues.
3/9
J (arrived late following music lesson), C, Ch, B, M.
- typed up report on computer
- DM suggested needed to show working for calculated figures - boys worked on this; they told girls how to integrate figures into report

Wed.
4/9
J, C, Ch, B

Absent: M
- J and Ch finished off presentation of

	report
-	C and B did work from blackboard set by DM

2. Students' reactions to the lessons - low inference

The results of the brief questionnaire administered at the end of each lesson to assess students feelings about and understanding of the work done are summarised in Table 4.

Table 4: Overview of students' reactions to the lessons

Student	Lesson	Feel about lesson	Point of lesson	Level of understanding
C	1	Neutral	Discussion, working in groups	Not sure, more talking would have helped
	2	Neutral	Discussion, find if tuckshop wanted	Knew what they were doing
	3	Neutral	Adding and making graphs	No difficulties
	4	Neutral	Working with figures	Understood because work was not hard
	6	Pleased	Write up report	

Understood - all
knew what was
required

7
Pleased
Writing
conclusions,
working with
figures
No difficulties.

8
Pleased
Find if new
tuckshop would
be profitable
Understood
because the work
was easy
Ch
1
Happy
Discussion,
working in a
group
Unsure. New
work, needed
more discussion

2
Neutral
Discussion,
working
together
Understood well
since knew what
was required

3
Absent

4
Pleased
Finishing off
work, working
together

Understood what
was needed

6
Pleased
Finishing
graphs, working
together
Knew what had to
be done

7
Pleased
Cooperating
Understood well

8
As above
As above
As above
J
1
Absent

2
Absent

3
Pleased
`seeing whether
we as a group
could
successfully
establish a
hypothesis
based on our
survey result'
Learnt to deduce
facts from
graphs. Easy to
understand

4
Frustrat-
ing
Sorting out

what was messed
up the previous
lesson
Learnt nothing,
but the work was
easy

6
Drew a
picture of
an angel
Writing up the
results
Easy to
understand

7
Pleased
Organising the
project
As above

8
Pleased
Finishing the
project:
`frantic but
fun'. Learnt
not to rush
work
Work was easy:
`doesn't require
much thought'
B
1
Neutral
Learnt to
listen
Not sure: `it
was a thing I
haven't done'

2
Absent

3
Pleased
graph work, how

to cooperate
Understood what
he was doing

4
Neutral
Graph work,
working with
figures
Not sure, more
figures would
have helped

6
Neutral
Working with
calculators,
cooperating
Not sure: `it
was difficult
but in the end
it got easier'

7
Pleased
Presentation
and cooperation
Unsure - nearly
finished

8
Pleased
Organisation
and cooperation
Understood now
they had
finished. `It
was a very good
project which
was difficult
M
1
Neutral
Discussion
about the
survey
Not sure
`because we
can't decide who
to survey

2
Neutral
Collating
results
Understood -
most people want
a new tuckshop

3
Pleased
Graphing the
results
Understood well

4
Enjoyed
Finishing
graphs, working
as a group
Understood well

6
Neutral
Figuring out
the results
Not sure:
`didn't know if
the results were
right

7
Enjoyed
Presentation
Learnt about
cooperation
Understood

8
Absent

Note: Lesson 5 was the missed lesson in the sequence
The data in Table 4 allow a number of conclusions to be drawn.

Students' responses revealed that understanding what was required did not necessarily add to the enjoyment of the lesson. However, students generally did not indicate a liking for the lesson unless they also felt comfortable with the work needing to be done.

Within the educational community, working collaboratively is considered to be an important benefit of group work.

Significantly, each student considered discussion and working cooperatively in a group important components of the lessons.

The different aims of the lesson identified by the students is intriguing. C, Ch, and J focussed more persistently on organising, writing up the work, and discussions; B and M included working with figures, with a calculator, graphing the results, and figuring out results as important aims of the lessons. That the girls, C, Ch, and J were generally more confident than the boys, B and M, that they had understood the work is also noteworthy. Subsequent analyses may clarify these apparent discrepancies. Looking in more detail at students' engagement during one lesson is the next step in this process.

3. A more detailed look at one lesson - low/medium inference

Description of lesson 4

To conform with space constraints, only excerpts from the beginning, middle and end of the lesson are presented.

[All present: B, C, CH, J, and M]

4.24 - 6.09

B, M, and J discuss method of plotting graphs. Some disagreement whether approach used previously is correct. J's view prevails.

Ch, who was absent the previous lesson, asks what is being done. J: `They (i.e. B and M) are doing the graphs for me'. Ch offers to help J colour in the graphs.

Tasks: B and M plot the graphs, J and Ch colour in the graphs, and decide on a colour code for the task.

Throughout there is some procedural discussion about access to colours and a ruler.

During this time B and M work on the graphs, J and Ch prepare to colour in the graphs. C does not seem not to have a clear task.

Conversation between B, J, and M (method for labelling axes); between J and Ch (colouring graphs and choice of colours) and (briefly) between B and M (method for doing the next item). The only reference to C is by M who asks if she has a ruler. N.B. completed sheet is handed to J.

6.10 - 7.25 separate conversations

1. B and M

Discuss method for drawing the graph. M still concerned that work done previously needs to be altered. B and M discuss the scale required on the graph.

2. C and J continue to colour in graphs. J organises labelling of completed sheets. Discuss whether to use pencils or textas and whose pencils to use.

B and M work on labelling the axes and plotting the graph. J and Ch colour in the graph, exchange pencils. Some off task discussion between J and Ch to which C contributes.

The only `cross group' exchange occurs when M comments on J's pencil case.

7.26 - 8.56

DM joins group. B and M initially not involved. Again there is some discussion between them about labelling the axes. DM questions whether the group is presenting the information separately for each grade level. All except M contribute to the discussion. B agrees that on average all grade levels use the tuck shop to about the same extent. J seems to vacillate. Argues that year 6 went most frequently `cos' one kid went seven times a week or something'. DM's question about labelling the axes is noted but partly countered with J's `we just haven't got round to it yet'

Work distribution as before. DM's arrival and questions ultimately unites the two smaller groups and encourages C to join in. DM's questions: Can data be combined? Re labelling of axes - needs to be clear. Q1: J, C, B: on average yes, but see J's comment. Q2: shelved for the time being.

22.20 - 25.48

B tells Ch how to label the axes on one of the graphs he has drawn. Ch accepts his advice and asks him what colour she should use. B leaves the table to ask his classmate for the profit information he obtained. M declares that the graph he is currently plotting `is about the most important question of all'. He is unhappy about the way axes on another graph have been labelled. `The base of this is real messy but it's question 8.' There is further discussion between J, M, and Ch about the presentation. Ch, J, and C proceed with the clerical and colouring tasks. M calls out the points on the axes Ch is to write down. B returns without the information. He comments that they still need to get this.

During this time segment, there is little mathematical activity. M identifies a crucial question and decides how to label the axes, a task undertaken by Ch. When working, C and J are colouring in. J warns C to be careful about what she is doing. Presumably with an eye on the next task, B attempts to get the profit information. M and B do little, other than activities indicated.

35.49 - 40.18

When DM joins the group his help is enlisted by J to obtain the information on profits. DM tells them the most significant findings obtained. J, B, and M interact with DM. While J is vocal and engages a lot of DM's attention, her contributions are often a repetition of a comment made by DM or `prestructural' (`Well, I just know a lot of them'; `Why not? That's what politicians do.') Ch does not seem to be involved in this exchange. She asks M advice about the presentation format.

While highly visible in the exchange with DM, J's suggestions are prestructural2 rather than incisive. M and B attend to DM but do not interact with him verbally. B makes a (multistructural2) suggestion which seems to indicate that he is following DM's train of reasoning. From M's contribution it is difficult to assess what he is thinking. Ch continues with her writing task. C appears to listen to DM's explanations and questions some of the time but does not contribute to the conversation. DM leaves the group without making specific suggestions for the group to take up.

45.02 - 49.28

J and M have an off task conversation. Another student (outside the group) comments about the TV camera. This is the second such exchange. `Our' group seems oblivious of the camera and TV camera, though. J refers to the survey sheets and proclaims that students would come 2 to 5 times more. B challenges this but J insists that `we use the facts we want to' (p. 26). B is unhappy and uses his calculator to work out that `on the average, they come 1440 times more - everyone together' (p. 26). J wants to know how he worked this out. M also joins in the conversation. B shares his answer with DM who suggests another question they need to answer.

J, B, and M continue their discussion about mathematics. M's contribution is peripheral. J seems happy to guess and approximate without too much reference to the information in hand. B wants to be more precise and uses his calculator for a more accurate estimate. C and Ch are not part of this conversation.

END OF LESSON

Summary

Generally, the group `worked' well without prompting from the teacher and received minimal assistance from him. The teacher questioned the students' approach at different times during the lesson and thus gently ensured that they progressed. The girls engaged in more off task conversation than the boys, but the task they adopted or had been assigned made this possible. When they finished their job, B and M resented doing nothing and found new (relevant) work for themselves.

Given the division of labour, it is less surprising that the girls found the work easy, while the boys found it more challenging during at least some of the lessons. It is also interesting to note that for the majority of the time the girls and boys worked as two separate groups. Within each group there was considerable collaboration.

Despite being in the same group and thus notionally doing the same work, the five students were actually engaged in considerably different activities. C appeared to do very little during the lesson. Her suggestions and questions were largely ignored or rejected by the others. Ch worked diligently transcribing and labelling the material gathered and prepared by the others. J had a very high profile. She organised the others, spent a lot of her time colouring in, but also participated in discussions about mathematics with DM and B and M in particular. Her mathematical reasoning seemed at a low rather than a high cognitive level. M worked most of the lesson at mathematically relevant tasks. B likewise spent most of the lesson working on the graphs and organising the new material. Where possible, he used mathematical reasoning to challenge the suggestions of others and substantiate his own answers.

4. A more focused look at one lesson - medium/high inference

A detailed examination of two episodes from the lesson just depicted is presented next. The teacher was involved in one of these.

In this section the main focus was on the high inference affective behaviours of each individual student; high inference cognitive behaviours associated with the affective behaviours are also included. It should be noted that students sometimes manifested behaviours opposite to those operationally defined in Table 2; for example, lack of confidence. These are also described. (* - episode within event in which affective behaviour unit(s) were noted).

Event 1 - Time: 8.57 - 13.04

* B: (to J) With these (pointing to sheet), is it zero to 1 there, zero to.. is that two columns?

J: (pointing to sheet) No, zero is that, that's 1, that's 2, that's 3, that's 4, and that's 5. You've got to put a little red mark - I thought M, weren't you supposed to be doing that?

M: (pointing to another graph sheet) I have

J: (to M) Rule them up in a black pen

M: I am

J: Good

J: confidence: personality indicator (aff, HI). J exhibits leadership in organising the others. Both B and M appear not to dispute her instructions with regard to these peripheral tasks.

* J: (to Ch, taking the sheet she has been working on)

Can I finish the numbers quickly on the other side...
Ch: Yeah
J: ...of that before I forget? Who's got my pen, by the way? (to B) You have.
B: Is that yours? (showing her a pen)
J: Can I quickly grab it?
B: (picking up a pencil) Can I use this, M?
J: Hang on, I'm finished now (she throws the pen across to B). (to Ch, as she hands back the sheet) Sorry.
Ch: That's all right.

J: contextual effect: peer hierarchy (aff, HI). J over Ch: J interrupts Ch's work, Ch submits. J over B: J commandeers pen from B, he submits. Unclear whether the number task J undertakes is central or peripheral.

* J: (to M) Make sure you rule it straight in black, not with Pacer as well
M: I will, I'm just marking it. I'm not...
J: Oh, good (looking across to Ch and grinning). Good (to Ch), making sure there.

J: contextual effect: peer hierarchy (aff, HI). J over M: directs him in how to undertake his task, he submits. She re-affirms her presumed superiority in her exchange with Ch.

* M: Ladies, give us it (the sheet on which results are recorded), there's no....

M: gender-role stereotyping (aff, HI). Use of the word `ladies' is generally viewed as no longer an appropriate way to address females, particularly such young girls. M's use may be interpreted as patronising; certainly he has met and learnt the usage of the word and appears to be using it in its unacceptable context.

*
M and J: gender-role stereotyping (aff, HI) - example contained in Table 2

* M: You see, what you do is, you write the question up here. You see...
J: (over M) But we'll help to write the rough copies and all that
M: Just write what the question was up above, up above it.
Ch: Mmm
M: Just write the question up there (points), 'cos if you don't know what it is, then...

J: Yeah. And I can write down what the axis , what the... and that stand for, if you want. I'll do them now if you want.

M and J: contextual effect: supportive (aff, HI). Having landed a submissive Ch with the task of chief scribe for the project (a peripheral task), both M and J seem to show support and sensitivity with perhaps a tinge of bad conscience. Task is peripheral.

* Ch: (to C) Will you go and sharpen this for us? (hands her a pencil after a vain attempt at sharpening it herself. C takes the pencil and moves off; she has done nothing but sit and watch or gone to sharpen a few pencils for the whole lesson to date)

Ch: contextual effect: peer hierarchy (aff, HI). Ch over C - may be related to her having submitted to others as chief scribe; exhibiting her limited level of influence. For C, at least, it is something to do. Task is very peripheral.

* J: Ch, you can write it
Ch: What?
J: What? (short pause) You can write it.
Ch: What?
J: ..stuffed up badly
Ch: What's wrong with that?
J: It's just that... you can write, you've got neater writing though

J: contextual effect: peer hierarchy (aff, HI). J over Ch - J's previous supportive overtones to Ch re. assisting now become questionable. Context relates to a peripheral task.

Summary of the affective behaviours during Event 1: no cognitive behaviours of HI were involved. The tasks associated with all the affective behaviours were peripheral.
J: confidence: personality indicator
4 contextual effects: 3 peer hierarchy (over M, over Ch twice, 1 supportive (of Ch)
gender-role stereotyping: assigning Ch as neatest writer
Ch: contextual effect: peer hierarchy (over C)
M: contextual effect: supportive (of Ch)
2 gender-role stereotyping: use of `ladies'; assigning Ch as having neatest writing
In all instances where peer hierarchical behaviours were concerned during Event 1, there was no evident direct protest. The hierarchy appeared accepted and known by all: J at the top, the two boys next (order not quite clear), Ch, and C at the bottom. J's confidence was clearly evident with respect to

peripheral tasks and their organisation.

M's use of `ladies' may not have been an intentional put-down. However, he must have picked up the use of this form of address from somewhere. J's stereotyping of Ch in the role of information recorder may also be a reflection of her experiences of womens' roles. It is well-documented in the science education literature that males more than females handle science equipment, perform experiments and participate in science-related activities (Kahle, 1988). M and J's future attitudes towards women's roles, particularly in mathematics and science, become questions of interest.

J was clearly the dominant person during this episode. C's minor, very peripheral role was noteworthy. B's lack of involvement would appear atypical of his general behaviour, yet may prove typical with respect to peripheral tasks.

Event 2 - Time: 35.49 - 40.18

* J: DM, is there a copy of the profits of the tuckshop? 'Cos we're going to have to find out whether they're going to make a profit with the new tuckshop

J: confidence (personality indicator: Aff, HI) - leadership, initiates discussion with DM by the question (but re. topic already discussed among group members). May be giving DM impression of HL thinking.

* DM: And they said they make, that they spend on their stock, each week, $2000
J: $2000 a week
M: (writing it down) I got it
DM: And they make $500 profit on it
M: So they make...
J: So they make $2500 roughly
M: (to DM) So they sell $2500 worth
DM: Yes
M: ...and they spend $2000
DM: Yes
J: Right, so...

M: contextual effect (DM): positive feedback accompanying independent thinking (cog, HL).

* B: Does that include electricity as well?
DM: No, no, that doesn't include their costs for labour...
C: What does it cost?
DM: ...and it doesn't include their costs for electricity, and it doesn't include their costs for equipment
B: I would have thought they'd lose money
DM: What they do, no, they don't lose money and they

don't make money, they break even. OK?

B: independent thinking (cog, HL)

C: contextual effect (teacher): ignored (aff, HI) by DM accompanying question which reflects independent thinking (cog, HL). C reacts by tuning out.

* DM: Well, how do they make the profit? How is the profit made?
J: (M begins to speak simultaneously but stops) By people buying things and people said they'd buy...
DM: And, by buying things at a cost greater than what they pay for it, right?
J: Mmm
DM: Now, how do you increase your profit? You either increase the cost, increase your price or...
B: or increase the number of people that come in
DM: (nodding) or increase the number of people, good, increase the number of buyers in the...

B: contextual effect (DM): affirmation (aff, HI) for B accompanying independent thinking (cog, HL, HI)

*
M: contextual effect: M dismissive of Ch (aff, HI) - example contained in Table 2

* Ch and M hold conversation parallel with group talking to DM. Ch is working on the graph sheets; it would appear she is not paying attention to the other conversation at all. M, on the other hand, is partially attending to both.
C: I'll write question 2 up the top?
M: Yes
C: \`Question 2' or just \`Q2'?
M: (inaudible response - he shrugs his shoulders probably indicating that he doesn't care which)

M: contextual effect: dismissive of Ch (aff, HI).

Ch: lack of work autonomy - seeking direction from M but exhibits task persistence (cog, LL, LI, P); not distracted by the ongoing discussion others are having with DM.

Summary of affective behaviours with accompanying cognitive behaviours (if occurred) for Event 2.
M: 3 contextual effects: positive feedback from DM accompanying independent thinking, 2 dismissive of Ch
B: contextual effect: affirmation following independent

thinking
J: confidence: personality indicator (leadership)
C: contextual effect: ignored by DM following independent thinking - reacted by tuning out

During Event 2, both M and B had their mathematical contributions affirmed by DM. This may have served to maintain or boost their confidence in themselves as learners of mathematics. Conversely, neither J nor C received feedback from DM. J's manifested self-confidence may be higher than C's, which may explain J's continued persistence in the discussion and C's loss of interest. Ch, meanwhile, persevered with her peripheral task and displayed a lack of task autonomy; M showed little tolerance for either.

DISCUSSION

An important aim of the study was to attempt an integrated description of students' cognitive and affective behaviours in a mathematics classroom setting. Two sets of research in particular shaped the innovative observation scheme for high inference cognitive and affective behaviours which was devised. These were models of mathematics learning previously found useful for examining gender differences because of their inclusion of affective variables and work such as that of Clements and Nastasi (1988) who supported their operational definitions explicitly with transcript excerpts.

The high inference analyses were preceded by an outline of the sequence of lessons observed and detailed descriptions of the content of one lesson. These, together with information about the students' perceptions of the lessons and their attitudes and beliefs about themselves and mathematics, provided an awareness of the context in which the episodes described occurred. The different sets of data were informative in their own right and were essential prerequisites for the integrated analyses. The discussion below illustrates that the methodology adopted provided a `unified perspective' of the students' cognitive and affective behaviours.

Cognitive activities

1. Tasks undertaken and mathematical contributions

As the sequence of lessons progressed, task demarcation became more evident. The two boys took on the more mathematical tasks, while two of the girls, J and Ch were generally more concerned with the written report and issues of presentation. J was also often involved in mathematical discussions particularly when DM was present. C's overall contribution was minimal and restricted to very peripheral tasks.

During the monitored lesson, the boys were occupied with tasks central to the mathematical requirements of the project for most of the period. On the other hand, the girls' were engaged in more peripheral activities and, at times, their conversation was off-task and more social. J participated in some mathematical discussions but did not actively engage in the conduct of a mathematical task. With the exception of C, the students' post-lesson (lesson 4) comments were fairly representative of the levels of their mathematical and task involvement. C's remarks were perhaps indicative of her focus of interest as a passive observer rather than an active participant.

2. Individuals' levels of cognitive involvement

Over the duration of the project, three of the five students were very involved in mathematical tasks and discussions: M, B and J. M and B spent most of their time actively engaged in mathematical activities both at high and low cognitive levels. They plotted graphs, used calculators, consulted, and co-operated autonomously. J's cognitive involvement was mainly in discussing mathematical issues related to directions for further action, particularly in DM's presence. Her contributions were not always constructive and the cognitive level of many of her comments was questionable, mathematical reasoning often not accompanying her remarks or assertions.

Ch exhibited persistence and work autonomy but not in the mathematical aspects of the project; she appeared very-single minded about completing the tasks she had been assigned. C's limited participation in activities appeared to be mediated by her relative status amongst group members and with DM. Her cognitive involvement may not have been as limited as observation alone would indicate. From her few oral contributions and her post-lesson comments, she did appear to gain from the experience. Her input, however, would not seem to have been valued or to have made any impact on the progress or outcomes of the project.

Affective behaviours

Stereotyping: The major tasks undertaken by the boys and the girls in the group seemed to conform to a pattern of gender-role stereotyping. Support for the acceptance of stereotyping could be inferred from comments made by M and J.

Group hierarchy: A clear pattern of peer hierarchy was evident to which all members of the group appeared to adhere. Ch was initially nominated as group co-ordinator; J was absent on the day. When J returned (lesson 3), Ch was absent. J took control and, even when Ch returned the next lesson, retained it throughout the entire project. J's dominance of the monitored lesson was clear. In the two episodes she took the lead in the exchange with DM. and demonstrated, without being challenged, her assumed leadership role in directing others in what to do. The peer hierarchy, a factor dependent on the group's composition, exercised a controlling influence on the directions of the project, and in the behaviour of and language used by group members.

The teacher: The monitored lesson showed that DM had interacted differently with group members. DM's style did not seem to inhibit the students from expressing their opinions. While J lead and dominated the exchanges with DM, B and M were also very involved. DM initiated one exchange with Ch which was taken over by B and J. C was not spoken to at all by DM. The closely examined episode involving DM revealed that both B and M received positive feedback for their contributions to the discussion. This was not the case for J. C's one comment was ignored and Ch was not involved.

IMPLICATIONS

There appeared to be greater consistency in beliefs and observed behaviour for the boys than for the girls. For example, M demonstrated his concern for both mathematical accuracy and neat presentation, and persistence at challenging tasks. B expressed his enjoyment of the group activity, was prepared to work hard and tried to make sense of the solutions. On the other hand, there was little evidence that Ch discussed, persisted at or tried to find new ways to solve mathematical problems. Similarly, J's involvement in mathematical activity did not go beyond discussion. When she argued for data selectivity, her behaviour seemed to belie her expressed concern for accuracy. The effects of the peer group on C's lack of involvement may explain why her behaviour did not match her beliefs about working co-operatively in problem-solving.

The tasks in which the students were engaged might partially account for the belief-behaviour mismatch for the girls. However, there was no indication that they were dissatisfied with the predominantly non-mathematical role which they undertook. They also reported that they had found the project relatively easy while the boys recognised the challenge of the task. Active participation in its mathematical aspects would have contributed to the boys' views.

Differences in task engagement and the more subtle differences in students' experiences during demanding mathematical assignments may, longer term, influence learning outcomes.

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APPENDIX
STUDENT PROFILES

A short profile of each student in the target group follows. The vignettes have been compiled using data obtained from self-report measures of students' beliefs about mathematics and attitudes towards themselves as learners of mathematics. Only information collected prior to the group work task being undertaken is reported here. The teacher also provided achievement levels for each student.

C:
C wrote that she liked maths; her reasons were fairly pragmatic. She noted the importance of maths for a good future, its usefulness in everyday life and that logic can be learnt from maths. She rated herself as very good at maths (4), considered that her classmates would recognise this level of achievement and believed her teacher would rate her similarly - he did.

C indicated that she liked talking about mathematics but was unsure about small groups talking to the whole class about maths. However, she liked to work in small groups to discuss maths problems. She indicated that she felt pleased when it was easy to get correct answers to maths problems, when she worked hard to solve problems and when students helped each other work things out.

Ch:
Ch likes maths because it is a challenge and is regarded as very important for entry into the real world. She believed she was excellent at maths (5) and that her classmates and her teacher would concur with this view - he did.

Ch indicated that she likes talking about maths to a friend and both talking about maths and discussing problems in small groups. Ch indicated that she felt pleased when she got correct answers and didn't make any mistakes, liked knowing more than others, was happy when she had worked hard and solved problems including finding new ways to do them, enjoyed problems which made her think, enjoyed lessons when everyone understood and when there was co-operation in working things out. She believed success came from trying to understand not just getting correct answers, being interested in learning, working together and being persistent at hard problems.

J:
J wrote that she liked maths because it was challenging, interesting and fairly simple. She believed maths helped her concentrate, taught her to be logical and would be helpful in later life. She believed she was excellent at maths (5) and that both her classmates and her teacher would concur with

this view - he did.
J indicated that she liked talking about maths to a friend. In small groups she liked talking about maths and discussing maths problems. J felt pleased about getting correct answers to problems and not making any mistakes. She said she enjoyed problems which made her think hard, liked working hard to solve problems and finding new ways to solve them; she liked it when the solutions made sense. She also said she enjoys lessons when everyone understands the work and when students work together. She believed success came from helping each other to understand and through persistence with hard questions.

B:
B wrote that he likes maths because it was interesting, always different and never boring. He considered himself excellent at maths (5) but believed both his classmates and his teacher would only consider him average (3). His teacher regarded him as excellent (5).

B indicated that he didn't like talking about maths generally but was unsure about talking to a friend about maths. He felt that he did like working in small groups to discuss maths problems. B indicated that he liked working hard and solving maths problems particularly when the solution made sense. He said he felt good when he didn't make any mistakes. He considered that students who were interested in learning will succeed and that they needed to try to understand and not just get correct answers.

M:
M wrote that he liked maths because it was a challenge "to get it right". He also indicated that he recognised that if he did well at maths it would be "easier to find a good job". He considered himself excellent at maths (5), that his classmates would concur with him but that his teacher would only consider him very good (4). He was right in that his teacher did rate him as very good (4).

M indicated that he enjoyed talking about maths and discussing maths problems in small groups. He said he liked maths problems which made him think and was pleased when maths problems he solved made sense and when he found new ways of solving problems. He also indicated that he liked being the only one who could answer a question, and enjoyed maths lessons when everyone understood and when students could help each other. He believed students would succeed if they were interested in learning, if they tried to understand not just get right answers, if they were persistent with hard problems, worked hard and set their work out neatly.