CHAPTER X

MULTIPLE LEARNING ENVIRONMENTS IN THE PHYSICS CLASSROOM

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Abstract

This study investigated the learning environment in a Year 12 physics class studying rotational motion to investigate how perceptions of that learning environment mediated learning. Data sources included observation and video recordings of each lesson for five weeks, transcriptions of classroom interactions, responses to a learning environment survey and interviews with the teacher and selected students. This study suggests that there are multiple learning environments experienced by students and that these environments are not always recognised by the teacher.

Introduction

After settling the class and expressing disappointment at the late arrivals, Mr Sparks (an experienced physics teacher) reminded his Year 12 students how a week ago they had compared hollow cylinders, solid cylinders and spheres rolling down an inclined plane. Mr Sparks noted on the blackboard, the observed order in which the objects reached the bottom of the inclined plane and asked, "Alright now my question is, Why? Those who did the maths competition yesterday, will have missed a formula that I presented without much explanation, and the formula was this: KE(rot)=ΩI 2. Instead of that formula's meaning, could we compare it with this: KE(lin)= Ωmv2 (both formulas on the blackboard). So what is it telling us?" Christina, the only student sitting in the front row, made a comment about rotational and kinetic energy and Mr Sparks followed with "If the body is rotating about an axis, it has rotational kinetic energy."

Mr Sparks then explained how, in comparison with linear motion, particles of a body were moving with different velocities in different directions in rotational motion, and how the correspondence in the formulas on the blackboard was between linear mass and moment of inertia, and linear velocity and angular velocity, at no stage attempting to put meaning to the term "moment of inertia." He then asked "How can we explain what happened in that experiment with this background knowledge?" Christina answered "Has something to do with the concentration of the mass being closer to the centre." "It is with the sphere, why should one beat the other?" Mr Sparks asked. Jon responded "One accelerates faster... the sphere." Christina then asked whether the actual area of contact was a factor, and Mr Sparks directed the question to the class. Christina responded further with "No, because the radius is the same, it would be for the two cylinders." Mr Sparks closed off this discussion with "So we can rule out area."

As the lesson developed, Christina continued to dominate the discussion in responding to Mr Sparks' questions. At one point, she finished an answer with a lengthy explanation,

> So if the moment of inertia is different for each one, the distribution of masses would be different, then that would affect the overall rotational kinetic energy, so, because if the sphere has greater rotational kinetic energy it will roll faster."

This answer was so complex that her classmates greeted it with laughter. Mr Sparks replied kindly, "Well you are wrong in the last statement but you are right in your line of thinking" and continued "Norm, Andy, you are evident by your silence, Allison, your silence is deafening."

After a brief comment from another student, Sean entered the discussion by providing Mr Sparks with the formula for dividing up the potential energy (mgh=ΩIw2+Ωmv2).

Mr Sparks proceeded with his focus on the mathematical aspects of the topic, developing and comparing Sean's formula for each of the rolled objects. He explained how substitution and rearranging would lead to the formula for the velocity of the objects on the inclined plane. There was little interaction during this derivation with students writing in their notebooks what was written on the blackboard work.

At the end of the lesson, the last for the day, Christina went to Mr Sparks with questions about word problems she could not do. Mr Sparks commented, "It is just nice, your comments Christina, I must say, look at some of these boys who are supposed to be bright, they are hopeless, aren't they?" Christina replied, "They probably know, they just don't voice their views." "They have gone to sleep, thanks Christina."

These excerpts from one physics lesson show how only a few students were prepared to ask or answer questions in this classroom and how one particular student, Christina, was persistent in asking and answering questions, even approaching Mr Sparks after the class. Mr Sparks largely focused on the mathematical aspects of the subject matter and made little attempt to ascertain if students followed or were developing an understanding of the concepts involved. The purpose of this study was to investigate the learning environment in this physics classroom as it was experienced by different individuals, how that environment assisted or constrained the learning of the participants, and the implications of the findings for improved learning.

Design and Methods

This study sought to investigate "the meanings and purposes attached by human actors to their activities" (Guba & Lincoln, 1994, p. 106). We therefore adopted an interpretive methodology (Erickson, 1986). Our interpretive framework was informed by social constructivist perspectives (Driver, Asoko, Mortimer, & Scott, 1994; Tobin, 1993) that recognise personal and social dimensions of learning. Trustworthiness, authenticity, and the benefits of the hermeneutic process were important considerations in designing the study and in analysing the data (Guba & Lincoln, 1989).

The study was conducted in a Year 12 physics class of 24 students in a large suburban high school (about 1400 students) in a metropolitan area of Australia. Physics is generally accepted as a difficult subject and is usually elected only by those students who have successfully completed science in Years 8-10. Three researchers visited the classroom each lesson over a six-week period. The data sources included field notes and analytic memoranda based of teaching and learning in the classroom; video recordings of classroom transactions; interviews with Mr Sparks and with selected students about their perceptions of teaching and learning and the learning environment; stimulated recall of selected lesson segments replayed to both the teacher and the selected students; and survey instruments to assess the learning environment in the classroom.

The perceptions of all students and the teacher were obtained using the actual and preferred versions of the Classroom Learning Environment Survey (CLES; Taylor, Dawson, & Fraser, 1995). This instrument is based on a constructivist position and contains the following scales: Learning About the World (relevance to prior understandings including everyday-life); Learning About Science (the nature of science); Learning to Speak Out (critical voice); Learning to Learn (negotiation of the curriculum); and Learning to Communicate (students' discussion of their ideas). After discussion with the teacher, preliminary observation in the classroom and analysis of the learning environment survey data, twelve students were initially selected for intensive study to span a range of views on the instruments administered and performance in the classroom.

Results

Table 1 reports the class, teacher and selected student mean scores and statistical information for each of the scales of the CLES dimensions. A one-way MANOVA with the five CLES scales as dependent variables and the version of the instrument (actual or preferred) as a repeated measures factor (Wilk's Lambda, $p<.01$) followed by univariate t -tests ($p<.01$) showed that there were statistically significant differences in the mean scores on the actual and preferred scales for three dimensions as shown in Table 1. Mean scores on the Learning to Speak Out

dimension (actual) had the largest standard deviation suggesting students perceptions of their critical voice in the classroom was more variable than for the other dimensions. Mr Sparks' perception of the actual environment was higher than the class mean scores on all dimensions except Learning to Speak Out. Teachers characteristically tend to view their class learning environment in more positive terms than students (Fraser, 1994).

Table 1
Means, Standard Deviation and Cronbach Alpha Internal Consistency Reliability Coefficients , and Statistical Significance of Differences Between the Means of the Actual and Preferred Versions of the CLES.

Scale "Learning...	Mr Sparks Actual	Mr Sparks Preferred	Class actual Mean	Class actual SD	Class actual Alpha	Class preferred Mean	Class preferred SD	Class preferred Alpha
About the World	4.1	4.3	3.42 **	0.58	.76	4.34 **	1.09	.96
About Science	3.7	3.5	3.18	0.48	.63	3.43	1.27	.92
To Speak out	3.2	4.0	3.52 **	1.03	.93	4.40 **	1.25	.95
To Learn	2.8	3.8	1.93	0.65	.85	3.54	1.42	.96
To Communicate	4.0	4.0	3.65 **	0.79	.91	4.12 **	1.40	.97

*p<.05, ** p<.01

Table 2
Mean Scale Scores for Selected Students on the Actual and Preferred Versions of the CLES.

	First	group	Second	group	Third	group	
Scale Learning...	Theon A P	Geoff A P	Karys A P	Carly A P	Belinda A P	Michael A P	Rachael A P
About the World	3.5 4.3	3.5 4.3	3.7 4.0	3.3 4.3	3.3 3.8	2.8 5.0	3.5 4.2
About Science	3.2 3.2	3.3 3.2	3.7 3.5	3.2 3.5	4.0 4.2	3.0 2.2	3.8 4.2
To speak out	4.2 4.2	3.8 3.8	2.5 3.2	4.2 4.5	2.2 4.0	2.0 5.0	1.3 4.0
To learn	1.3 1.7	2.5 3.0	1.5 3.8	1.5 3.5	1.0 3.7	1.2 4.7	1.0 3.8
To communicate	2.8 2.8	3.2 3.2	3.3 3.2	3.5 3.8	3.3 4.0	1.7 1.8	4.8 4.8

A - actual or experienced learning environment. P - preferred learning environment

In the following sections, we present the way Mr Sparks and selected students experienced the learning environment in this physics class. As a heuristic, we distinguished three types of students: those who largely perceived the environment in a way consistent with Mr Sparks, those who coped but wanted considerable change, and those who were struggling and wanted considerable change. Table 2 reports the means for each CLES dimension for representatives of each of these types of students.

Mr Sparks - the Teacher

Mr Sparks believed that the learning environment in his physics classroom was appreciated by and suitable for all of the students, that they were free to and would, express their critical voice and approach him with questions without embarrassment. He suggested,

> I am happy with my role in the classroom. If I thought I could improve my method of teaching I would certainly do that.... No other changes .... The feedback I get from any of them is nothing negative. As far as I am aware, they are happy with me as a teacher.

Rather than studying fewer concepts in more depth for the limited time he perceived he had to cover the current syllabus, Mr Sparks wanted more class time as he felt a need to cover the topics to be encountered by the students in university physics, otherwise students could say "We are struggling because we did not have a good foundation." This is an indication that tertiary preparation was an

important referent for his actions which was also evident in his stated goals for the classroom which included providing a sound body of knowledge on which to build tertiary study. To achieve those goals, he saw himself directing and controlling the course as "very much a provider of information....the authority in the area, disseminating the knowledge."

His CLES scores (Table 1) suggested that he would have liked to have more opportunity to negotiate the curriculum with students and increase the extent to which students felt they could exercise their critical voice. However, he stated that negotiation of the curriculum was simply not the way the class functioned and there was no time for that approach. On the other hand, he was basically satisfied that students were free to exercise their critical voice:

> they are certainly free to complain, I have few complaints. But I would also think that from their view they don't really have a lot that they would want to complain about... . I would be surprised if they felt that I was unapproachable, put it like that.

The major constraint for change and a referent for much of the enacted curriculum, was time to cover the externally prescribed syllabus. When we pointed out that students felt a lack of feedback on their progress, Mr Sparks argued that it could be overdone, and anyway, "... they will write a couple of articles where they will get feedback, the text has a lot of problems to be solved and I ask at the beginning of the lesson if there are any questions on the current problems." After one lesson sequence, we interviewed students and found that they had not grasped the essential concepts of those lessons. He maintained the lessons were successful, but that he would not really know students' understanding until the examination, again using lack of time as a referent ("I find I can't find out individually from everyone, simply because of lack of time.")

Mr Sparks acknowledged that he did not facilitate students' interactions about their own understandings and commented "I don't have that skill." On the other hand, he considered his extensive use of demonstrations made up for this lack of interaction. Thus, although he realised in the course of this investigation that a considerable number of students did not have very positive experiences in this learning environment, Mr Sparks showed little inclination to change. Rather, he had a number of referents that supported his current model of teaching. As the data presented in the following sections indicate, some students (first group) perceive the learning environment in similar terms to Mr Sparks and do well, while others want significant change in areas that Mr Sparks cannot conceive of being changed.

The First Student Group

The first group of students, exemplified by Sean and Jon, were achieving at a "high achievement" level in physics examinations. They were generally happy with the learning environment they were experiencing and expressed a preference for only comparatively small changes to the degree of relevance and negotiation of the learning experiences. For example, Sean commented on the learning environment:

> Well, joyous, we are usually happy to learn and all that. Generally, we appreciate it, so it is reasonably good. There is nothing in particular I would like to change. I think it is pretty good and we generally get the work done, I am pretty happy with it.

Students from this group acknowledged that Mr Sparks did try to include everyday applications in his teaching, and that while they were basically happy with that, some further increase would be welcome as indicated in their CLES scores. Both students indicated that they could speak out in the classroom to question the teacher, "I mean it is OK to ask, but it is not often questioned. It is alright at the moment." This was reflected in their CLES scores which indicated that the learning environment they were experiencing was also their preferred environment.

These students acknowledged that there was generally little discussion with the teacher on curriculum matters as that was all pre-planned by the physics teachers for the semester (there were two physics classes). Further, the control of the teacher was ceded without question and the desirability of having many students having interaction on classroom transactions was questioned.

> If you have heaps of people saying how much they would like to do, you are going to get all those different views so I think it pretty much has to be set down. Mr Sparks and the other teacher know what is best so I think it would be fine at the moment. (Sean)

The transmissive approach with the teacher as the major knowledge source and controlling the learning environment was not conducive to class discussion of ideas between students. Sean conceded that "Mr Sparks runs all the lessons" and that there were "no deliberate strategies to get us to talk to each other about what we are thinking, but it is fine the way it is." Further, taking time to discuss ideas with other students was seen as cutting down class instruction time and as there was a lot of pressure to cover all the work, "if you have to step back and talk to someone and explain, you might get caught up and get behind (Sean)."

Overall, students in this group were succeeding in the current learning environment and were satisfied it was providing the learning support they needed. There was a high degree of congruence with that perceived by the teacher and even in the discourse used to justify why it was satisfactory. They agreed that "It would definitely help our knowledge if we helped others, but there is not much opportunity to explain what we are thinking (Sean)."

The Second Student Group

A second group of students, exemplified here by Christina and Karen, were not satisfied with the current learning environment and preferred different environment as indicated in Table 2. Christina was achieving a grade of "sound achievement" in physics examinations. She acknowledged that physics was difficult for her and the subject she least enjoyed. Karen was receiving a "high achievement." Each acknowledged that Mr Sparks did present applications but that they would like more. For Karen many of the applications were not relevant, "When I do (come in) contact with applications, it helps me to understand, but I don't always come in contact with the stuff we learn in physics," a comment reflected in her mean score preference for that dimension (Table 2).

As was the case for Sean and Jon, Christina and Karen acknowledged that it was OK to express their critical voice if they wished to. However, they too used the discourse of Mr Sparks in indicating that there was little opportunity, "Because you are following a set course outline and syllabus, you do not have much say." They believed they had very little interaction with the teacher in negotiating their curriculum which was similar to the class view as expressed by the class mean score on that dimension. Like Sean and Jon, and using the same discourse, they considered that the teacher did not have time for such interaction because of the need to cover the set syllabus. Nevertheless, they expressed a preference for considerably increased discussion with the teacher on such issues. For example, in relation to negotiating assessment, Karen noted, "We only get assessed four times a year, you cannot tell where you are or if you need to improve. So you really don't know how you are going until you do the test." This contrasts with the position on feedback expressed by Mr Sparks. Karen also expressed concern at the way problems were introduced in class and wanted more voice in this and support for working through them which contrasted with Mr Sparks' view that he should be able to place more responsibility on the students in working problems.

While Christina expressed satisfaction, Karen would have preferred more discussion as evident in their mean scores on the preferred version of the Learning to Communicate dimension. They each valued discussion with their colleagues and the teacher in agreeing that, "When you explain your ideas to someone else, I think you are going to get a better understanding." Both Christina and Karen felt no hesitation in asking questions and communicating with Mr Sparks, and took it into their own hands to clarify their understandings. Christina was observed in the class to be particularly persistent in her interactions with the teacher both during and after class. She noted, "I think I can adjust if there is something I do not know. Yes, I do ask a lot of questions and that is good. I am very persistent because I know in my mind what I want to work out." This was also noticed by other students. For example, Rhonda remarked that:

> Christina is one of those people who can say anything ... Mr Sparks will say she is wrong and she will just go on working. Whereas if anyone else is wrong they will get embarrassed ... and (just) try to work it out at home.

Karen also saw it as her responsibility to ask questions and to find answers if she did not understand. She took responsibility for her own learning in seeking help from her classmates both during and outside of class (which was evident in field observations) and in the library.

Christina and Karen were coping although they would have liked to see substantial changes to the learning environment. They have taken the responsibility on themselves to ask questions and discuss with others until they have their answers and this has allowed these two girls to adapt to a classroom where formal opportunities for discussion amongst students are not promoted or prominent. As Karen remarked and Christina agreed,

> The people at the top are going to cope no matter what, the people at the bottom are going to need more discussion and we are going to cope with more discussion so everyone benefits with more explanation and discussion.

The Third Student Group

This group of students--exemplified by Rhonda, Norm and Brenda--had lost confidence in their ability to understand physics and felt that they were unable to adapt their learning to reach understanding. Rhonda and Norm were receiving grades of "sound achievement" and Brenda a failing grade ("low achievement"). Their scores on the learning environment survey showed that all three would have liked major changes to the environment in terms of their perceived critical voice and negotiation of the curriculum with the teacher.

All three students reported communication difficulties with Mr Sparks, which meant they were unable to express their concern with the learning environment or to seek help from him for their learning difficulties. Brenda said that she could not ask for help without embarrassment. Rhonda considered that Mr Sparks did not understand that students worked at different paces so that, when she was behind in her work, she did not ask Mr Sparks, "because he makes you feel embarrassed and like you are just stupid." All three students expressed concern with the pace of the work and the learning support they were being given. Brenda explained:

> I don't feel comfortable at all, I get left behind a lot....if he could just take the time not to rush through it like he does, you know, explain this is why you know this... He will stop and the next lesson we will start on something else, but I hadn't got the last thing yet.

They considered that more interaction, working through problems and explanation of their difficulties rather than leaving it to themselves to find their errors would assist their learning. This would require more feedback on progress which was central to a concern expressed by Rhonda. She noted that in other subjects, much of the homework was handed in and corrected by the teacher which gave her an indication of her progress. In physics, Mr Sparks had said "Do the homework, but I don't care if you do or you don't basically," and he didn't check it.

Interestingly, major changes of the same magnitude were not preferred for the extent to which students discussed ideas with each other. Although Rhonda's CLES scores suggested that she was experiencing a high degree of discussion with students about her ideas, she interpreted that largely in the context of discussion outside the classroom ("I guess we don't really get to talk to many people in the class. But as soon as we walk out we turn to someone like Christina and ask them to explain it. It would be good to talk to other people in little groups"). Further, students in this group felt that physics was not relevant. For example, Norm considered the physics he was studying as a large "waste of time," as it was not relevant to his interests or the things he saw in the world (see also Table 1). However, students from this group suggested that if physics was more relevant, this would help them in learning the subject.

Discussion

Early research on learning environments assumed that there was one common learning environment in a classroom and that variation in scores on learning environment instruments was considered as error variance. As reported in earlier studies (Fraser, 1994), this study also supports the view that there were multiple learning environments experienced by the students in this classroom. Only some of those environments were seen to be supportive of student learning by the students. While this study identified three such perceptions, there may well be many more that interact in different ways to facilitate or constrain learning. Importantly, the multiplicity of learning

environments present and the constraints these environments placed on the student learning was not recognised by the teacher. We described the congruence of the goals, beliefs and behaviours of Mr Sparks and the first group of students. This congruence may have tended to reinforce his satisfaction with his classroom approach and reduce any impetus for change from his perspective. We observed that Sean and Christina answered many of the questions the teacher posed, often being the only respondents. The influence of these interactions may have had the effect of producing a frame of mind that was comforting to Mr Sparks, particularly when he had such little interaction to gauge the dissatisfaction evident in the minds of some other of his students. This was exacerbated by some students being too embarrassed to voice their discontent and their inability to learn effectively in that environment.

Further, the different perceptions of the learning environment identified here, are continually evolving as a result of the dialectical interaction of the views and practices of students and teacher and the social forces associated with the class in the wider educational system. As evident in this classrrom, included in such social forces are power relations which are often taken for granted by the participants (Gilbert & Low, 1994).

There were indications that students from groups two and three wished changes that are congruent with a social constructivist perspective of learning. Students wanted more interactions and shared decision making in matters of learning. In such a classroom, the teacher would be assisting the students to make their re-presentations of their knowledge explicit, at the beginning of the unit and throughout its development, to themselves and to the teacher. This would assist the teacher to diagnose the learning difficulties of the students and take facilitative action. An important feature of such a classroom would be an environment of trust and openness that would enable all students, whether having difficulties or not, to make their knowledge explicit and to test its viability in discussion with the teacher and other students. Such an environment would be one where it was expected that students would consider the evidence of their knowledge claims and those of others in deriving a consensus view (Tobin & McRobbie, in press). A further important feature would be for the teacher to model and socialise the students through a process of cultural apprenticeship into the distinctive discursive practices of this domain (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Most students in this study expressed a concern for more relevance to their life world in their studies (Tables 1). Yet, from the researchers' perspective, Mr Sparks did employ a large range of demonstrations and references to applications of the physics being studied. As one student remarked, however, some of the applications were too complicated for them to follow. Perhaps more discussion to develop an understanding of the applications would also make the relevance of the physics studied more apparent to the world of the student. Such a learning environment would have the potential to satisfy the learning needs of all students, even though that environment may still be perceived in different ways by the participants and be constantly evolving.

Can Mr Sparks accommodate the changes that students have asked for? While Mr Sparks was unstinting in his willingness to help the students, his claim that he made up for the lack of student interaction in other ways was not borne out by this study. Changing the behaviors of teachers need to take into account their beliefs, their goals and the contexts in which they perceive themselves. Further, it requires not only a personal commitment to change, but also an image of alternate behaviours that the teacher believes can be effectively implemented in that context (McRobbie & Tobin, 1995). Mr Sparks expressed personal limitations and a lack of confidence to employ the kind of strategies that would seem to be being asked for by the students in the second and third groups, strategies recognised by all students as helping their learning. In addition, his current approach was one strongly influenced by the need to prepare students for tertiary studies and the constraint of a shortage of time to cover the externally imposed syllabus. These constraints are not unique to this classroom or teacher. Other studies have also identified cultural myths such as these which are strong referents for teacher behaviors (Britzman, 1991, p. 7;Tobin & McRobbie, 1996) and justification for continuing in traditional models of classroom instruction. That is, both actor-oriented and structure-oriented forces (Galtung, 1980) are seen as contributing to students' and teachers' perceptions of the learning environment and are thus phenomena that need to be considered if change is to be brought about in classrooms.

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