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Student Beliefs About Learning Physics

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STUDENT BELIEFS ABOUT LEARNING PHYSICS

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INTRODUCTION

When students enter the physics classroom they bring with them preconceptions about physics; physics content, methods, and skills; But of equal importance are the preconceptions they have about college; the attitudes, social climate, and other factors that allow the student to feel that he or she belongs at the college, and the preconceptions about learning, teaching, and the skills that are associated with being a successful student.

The importance of understanding what is in the mind of the student when he or she observes what the teacher says and does was posited by Ausubel, Novak, & Hanesian (1986),

> "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly."

The implications of this statement have frequently been examined from the point of view of the preconceptions about physics content that students hold. Previous work (Dickie, 1988) has shown that Québec students hold similar preconceptions about physics content to those held by American students, as reported by Halloun and Hestenes(1985); physics preconceptions have been reviewed by McDermott(1984), while a more general review encompassing mathematics, science and programming is that of Confrey(1990). The implications of these preconceptions for the teaching of physics have been discussed by a number of authors(Menstre & Touger, 1989; Hake, 1987; Champagne, Gunstone, & Klopfer, 1985), and recently Hammer(1989, 1991) has considered the effects of students' beliefs about learning and about the nature of physics on their learning, while Ramsden(1991) has examined the ways in which students learn in natural educational settings and how they see themselves adapting to learning in higher education (Martin, Ramsden, & Bowden, 1989), and Posner and Strike (1989) have been concerned with the influence of the student's conceptual ecology on learning. Tobias (1990) has pointed out that the mismatch between the styles of the teacher and the learner contribute to the drop out of students from science and Dickie and Farrell (1991) have explored the "impedence mismatch" between high school and college.

The effects of the transition from high school to CEGEP have been investigated from the student perspective by the "Easing the Transition" project, (Cornell et al 1990) in which students were interviewed first during their final year of high school to determine their preconceptions of CEGEP and then again during their first semester at CEGEP, when they were asked to recount their impressions and recollections of their CEGEP experience. The study chose to look at the high school and at the college from the student point of view rather than looking down on the issues with the preconceptions of the teacher, or with the professors' definitions of the problems that must be fixed. The project sought to discover what student perceptions, and what institutional policies and practices function as obstacles to student success in the first year of CEGEP.

In the present work the focus of the Easing the Transition study has been narrowed by concentrating on students studying physics at CEGEP, and extended by following those students who chose to study science or engineering at university. In addition the study sought to determine the student view of the learning task in physics and to compare that view with that of the professor, as explored by Donald (1989).

RESEARCH QUESTIONS

The project, which is on-going, seeks to answer two broad questions;

What student perceptions and attitudes influence their learning in physics?
What do students consider is the learning task in physics?

The motivation for the work is the hope that increased understanding of student beliefs about the teaching/learning processes, together with acceptance of students' preconceptions about physics content, can lead to better understanding of how these beliefs influence academic performance in physics, and so allow this performance to be improved.

METHODOLOGY

In the spring semester of 1990 interviews were conducted with 7 students who were in their final semester at John Abbott College and who were taking the final CEGEP physics course. These students were planning to follow science or engineering courses at university. Three of the students were re-interviewed in the fall semester of 1990 after they had entered McGill to study engineering. A second cohort of four students was interviewed in 1991 while in their final semester at John Abbott and again in their first term at McGill. In the spring semesters of 1990 and 1991, volunteers were sought in the honours physics mechanics course at McGill; in all eleven students were interviewed.

The interviews were open ended in the ethnographic tradition (Hammersley & Atkinson, 1983; Mishler, 1986) and began with a general question such as, "could you describe that physics course for me?" or, "what was interesting for you at College?" The responses guided subsequent questions and probes, allowing the students to take the lead as they replied in a narrative style. These interviews provided rich data about the students' perceptions, strategies and coping mechanisms; these opinions are the data for the study.

One of the rewards of interviewing is the provocative and insightful quotes one can extract from the transcripts. To ensure that the quotations selected were representative of the themes that students considered important, a thematic analysis was undertaken.

A *thematic analysis* is a qualitative approach in which the researcher attempts to understand the "lived experience" of the respondent, to see the world from his or her viewpoint, i.e. to understand "the meaning the subject is trying to communicate" (Konold & Well, 1981). The categories into which the themes or phrases are sorted are allowed to emerge from the data, and the conceptual categories established can then be tested and either reformulated, reinforced, or discarded by further analysis. Glaser and Strauss (1967) termed this simultaneous process of coding and analysis the *constant comparative method* and used the term *grounded theory* to describe the sequence of "discovering first the world as seen through the eye of the participants" (Hutchinson, 1988 p. 124) and the subsequent conceptualization of the interactions of these participants. Marton (1988b, p. 155) claims, unlike others, that in traditional content analysis the categories are established in advance, whereas in *phenomenography*, the categories emerge from the data. Marton coined the term 'phenomenography' in 1979 and defined it as research that focuses on the second-order perspective that is concerned with how the world of the classroom is construed by the students, -- who are the participants or actors in that world or sub-culture -- , and with analyzing the meaning that the participants give to the concepts they encounter within that world. This "second order," view of phenomenography must be compared with phenomenology, " the study of the life-world -- the world as we immediately experience it pre-reflectively rather than as we conceptualize, categorize, or reflect on it," (Husserl, 1970 as cited in van Manen, 1990 p 9).

The aim of the thematic analysis undertaken in this study was to make sense of what the students were saying about learning physics. As has been pointed out by Tappen and Brown (1989), the true meaning of a statement is the meaning of the speaker; in hermeneutic phenomenological analysis (van Manen, 1990) it is the task of the interpreter (in Greek mythology Hermes was the patron of interpreters) to make sense of the lived experience of the respondents as reflected in their statements. This is of necessity only possible from the vantage point or bias of the interpreter.

In this case the orientation of the author is that of a physics teacher and practitioner of educational research. These experiences provide a set of beliefs, assumptions, and values that influence the meaning given to the words of the respondents. These beliefs include an appreciation of the value of Piaget's work in illuminating the ability of some students of physics to master topics and skills others find impossible; the belief that students construct their own learning on the foundation of their own experience of the world and their conceptions of that world; and that students are often working at the limit of their own knowledge just as researchers are often working at their own limits of understanding of the student and his or her conception of the microworld of the classroom.

The initial analysis was thus not an attempt to determine an "objectively valid interpretation," but an "effort to obtain interpretive agreement" (Tappan & Brown 1989) within the interpretive community of physics teachers and educational researchers.

PRELIMINARY THEMES

When students were asked to describe what happened in a physics class they said;

> "A lot of science and math courses ... have standard methods of introducing something ... like covering it, like deriving it, and then like having examples." [McGF90#1 p. 13]

Students were familiar with such an approach and some went so far as to say that they liked it;

> " in our math class ... he would give us the theory and do examples, which is what I like best;" [JAC-11 p. 12]

There was, however, an almost universal perception of where the learning takes place;

> "I say the learning isn't in the classroom I say it's afterwards." [McGF90#3 p. 3]

> "I learn far more from my own reading and struggling through a couple of problems than I do just sitting there [in class]." [McGF90#5 p. 2]

Why working through problems on ones own was useful was hypothesized as;

> "the assignments lead my learning I guess ... when I understand why you go from one line to the next in an assignment ... I guess that's where the learning of the fundamental principle that underlines that (going from one line to the next) gets done; that's where the learning gets done" [McGF90#4 p. 11]

The situation was seen quite differently in a biology course however;

> "like you know in biology courses that the material is all presented to you in class." [McGF90#3 p. 5]

Biology was seen as a course that required one to, "just regurgitate, memorize," many facts, except in genetics where there was, "a little bit of math, a little bit of "what happens if this ..." . " [McGF90#9 p. 11] In contrast one was not being given new material in a mechanics class, Newton's laws had first been seen in high school, now one was solving what were seen as just new twists on old problems; problems that were developments of ones that had been seen before.

> "in CEGEP you learn how to calculate the tension in a massless string, in university you learn how to calculate the tension in a string of mass. That's like an analogy; It's a bit simplified in CEGEP, and when you get to university you learn how to do the more general case, but you have to know what tension is ... ." [McGF90#7 p. 10]

Not only did you have to know what the dictionary definition of tension was but;

> "You have to know what it represents, like the word. Not necessarily the dictionary definition but the physical definition of tension. You have to know what it represents as a general concept, and you have to know how to calculate ... using the tension, you have to know the whole process." [McGF90#7 p. 11]

The problems were becoming more like the real world, becoming more realistic. In this the students' views are in agreement with the views of the professors that physics is describing the real world.

> "physics is is more of the problem solving in the sense that you have a physical problem that's part of the world, part of the universe, and the way to solve that problem is using math" [McGF90#3 p. 3]

In solving these problems one now used different mathematical methods to what one had used previously. These mathematical methods were frequently described as "tricks." Interesting here was the perception some held that it was somehow cheating to use a mathematical technique that had not yet been covered in the physics class; cheating because, in the eyes of the student, by short circuiting the sequence that the professor was following, one might be missing out some essential step of the logical development.

Given that students think physics is a problem solving course or a course in which they learn by doing problems, leads to the question. How do students approach a problem?

> "last year I just did it," [McGF90#1 p. 10]

> "If I easily understood the topic ... I'll just tackle the problem," [McGF90#3 p. 7]

Students talked about the different ways they tackled problems they saw as "easy," compared with those they saw as "hard." When understanding failed there were different strategies that could be invoked.

> "there's intuitive approach and then there's the, you know, write down everything you know, write down your force diagrams." [McGF90#4 p. 2]

> " all the steps you're supposed to go through." [McGF90#2 p. 7]

Students describe a problem solving sequence that is similar to those described in study skills texts such as Pauk (1974): Read the problem through making sure you know what they are really asking; figure out what you have been given; drawing up a picture; perhaps breaking the problem into manageable parts; solve the algebra; see if the solution makes sense, agrees with ones intuition.

Students said that this sequence had been adopted after watching a high school teacher or college teacher use it to solve problems, sometimes after explicitly instructing the students to use such a scheme. Many however complained that when teachers required a rigid adherence to such a system it was seen as being too time consuming and they resented this rigidity . Also common was the view that they had observed and adapted the method that some particular teacher had used and said was a useful way to proceed. Both college and university students saw such a sequence being used in the courses being followed.

Following such a sequence was good because,

> "you can feel secure in it because like it's there's little doubt of its validity but uhm I think it takes a little bit of the interest out sometimes." [McGF90# 4 p. 2]

The final step in the process that was described was,

> "check that your answer meets what you expected the answer to be; it makes sense." [McGF90#2 p. 7]

This theme of making sense, of checking the answer against ones intuition was frequently elaborated with an example;

> "you can visualize a pulley and a block and what happens there: so if you ended up with an answer that show[ed] that ... your block went flying into the sky you would think; ok something wrong here." [McGF90#2 p. 8]

An alternate strategy for solving a less obvious problem;

> "read a question and look through [the notes, the text] and try and find another question that are [in] the same vein," [McGF90#2 p. 3]

was often described by the same student who had described the problem solving sequence at a different point in the interview. It did not appear that there was a distinct division between those adopting one or other of these strategies, but rather both seemed to be available and either could be called upon when one strategy did not lead to a solution, or when the student had gotten stuck.

If neither the text nor the notes yielded a solution a friend was asked. Asking a friend, or working through an assignment with a study group was a complex social process that mixes the cognitive and the cultural (Nespor 1990). There was;

> "you know the lecture about not copying each others assignments and stuff like that." [McGF90#2 p. 12]

In general students talked about starting by trying the problems on their own;

> "I try really hard ... [but] I've tended to more this year discuss my problems with others; they say in engineering you can not survive on your own and definitely the attitude even as promoted by teachers is that you should work together on assignments: I don't think that's the same way in physics; I get the impression it's much more on an individual kind of thing," [McGF90#4 p. 11]

but then,

> "I learn probably as much from kind of sitting around working out an assignment and spending a lot of time with my friends trying to work out ... as I do, you know, in class and everything ... its always give and take." [McGF90#2 p. 4]

Even though many students said that for them learning took place outside of the classroom the actions of the teacher in the class still have a powerful effect. For different students these actions mean different things, they are interpreted differently. At times it was as if students were talking about different professors in different classes; for example one noted,

> "he is copying from his notes which is something I don't particularly like ... if the teacher is thinking at the same time as you they tend to think at the same speed." [McGF90#2 p. 3]

On the other hand,

> "it's a bit peculiar with this teacher, he copies directly out of the book. That's something I noticed like from the second day. So it's in a way good because you don't have to take the notes and read the book. So it doesn't confuse you like a different notation."
> [McGF90#7 p. 12]

Still others discovered that they could follow the class paying attention to what was said rather than having to take notes; however;

> "it's a bit scary 'cause you get to the exam time and you don't have any notes."
> [McGF90#7 p. 30]

More prevalent was the perception that when the professor followed the text, "even the jokes were the same!" It was thought to be particularly limiting when the professor had written the text;

> "There are a couple of difficulties with the [name] course. The prof wrote the book and I don't think that is entirely fair to the student because the student is getting the same point of view in the lecture as they get from the text book.... sometimes a different phrase will, you know, send a light bulb off in your head and you actually understand" [McGF90#5 p. 13]

There were similarly divergent views of the professor's practise of omitting steps in derivations or problem solutions with the comment, "for you to do later". Some saw this as an attempt to save time, to cover the curriculum that had been dictated by the dean, by someone in authority. [A pressure that students also saw as affecting the time that was spent answering questions in class.] Others saw the omissions as part of a deliberate strategy to have them, the students, work through the algebra, the reasoning, and saw it's purpose as being;

> "just to help us brush up on our integration, or just to help us, by doing it ourselves we'd understand better you know" [McGF90#1 p. 2]

One dilemma posed by the interaction of the affective and the cognitive was addressed by a recent study in Holland (Brekelmans, Wubbels, & Créton 1990) which showed that for grade 9 high school students there was a significant correlation between students' liking for physics, and their perceptions of the teacher's behavior as being friendly and helping; and that there was a significant correlation between students' cognitive performance and their perception of the teacher as strict and leading. This tension between the affective and the cognitive sides of teaching is one that teachers must constantly grapple with. If one is to attract and keep students in physics for the long term one might have to compromise content for process in the short term.

The ways in which the students' interpreted the actions of the professor depended not only on the students' perceptions of his or her personality but also on whether or not the professor was in the student's field of concentration, and the interpretation of these actions changed as the student progressed from high school to college to university. As an example of this progression of expectations was the way students talked about getting help and asking questions in class.

At high school,

> "well high school, basically they hold your hand all the way through" [JS91#4 p 14]

At CEGEP,

> "And here it's kind of like, if you need some help you can go see them as often as you want, you know" [JS91#4 p14]

At university,

> "we have to phone them to make an appointment; and I haven't, no I've never went to see one of my professors yet. Like maybe you can catch them before class or after class, but most of the time you just depend on tutorials and your friends to answer most of your questions" [JS91#2 2nd p7]

The increasing remoteness of the teacher/professor was anticipated, both by high school students of college teachers and by college students of university professors, and in some cases the expectations were fullfilled;

I "What do you think that the teachers [at university]are going to be like?"
R "What I've heard is that they're more into research than into teaching" [JS91#1 p5]

"First [... name of subject...] class we walked in and he goes, I'm here to lecture not to teach" [JS91#1 2nd p3]

"teacher said, you can't ask questions now." [JS91#2 2nd p3]

In comparing a mathematics class and an engineering class an engineering student said,

"he answers questions and he makes sure people understand whereas the ... math teachers, they just do it. You can ask questions but he'll just answer the same way he described it." ...."In our statics we have about 75 or 80 ... they're mostly civil engineers and that so the professor feels closer to his students ... the class isn't that much smaller he just knows a few students." [McGF90#10 p. 12]

The engineering professor was seen as more personable, he bought donuts to class, he joked around and got to know people,

"I guess in a way it would help learning also because you are more interested in the class." [McGF90#10 p. 13]

Even though the student said that he had not taken advantage of the donuts offered at the start of an early morning class the offering had clearly had an effect. Even though the teacher, according to this student knew only the names of a few students in the class what had made an impression was the effort the teacher had made. The challenge for the professor is to determine what to do to enable the student to better succeed. Should one distribute donuts as the professor who "cared" was described as doing? Should one take the time to explain "at our level" in-class questions even if that means covering less content? How can one reconcile the student perceptions with the professor's lament, "But I have so much material to cover?s" [LOD RN #1]

CONCLUSIONS

Ethnographic studies such as this one set out, for all to see, the perceptions of the students. As teachers we may not agree with the statements, may not like what the students say, but we cannot deny them. The lived experience of the student is often at odds with the intentions of the teacher.

Many students see a physics course as a test of their ability to memorize formulae and then to apply the right one at the right time. One dimension of the learning task in physics is solving problems; all the students saw themselves learning physics by solving problems, by struggling with the ideas themselves rather than by merely listening to an exposition of the ideas. When talking about problem solving most students talk about "making sense," about interpreting the answer in terms of their intuition, their experience of the real world. If teachers are to help students learn physics they must look beyond the students ability to solve problems either singly or in groups and admit that the social and human experience of the student is as important to the success and perseverance of the student as is the content and cognitive experience. What can the teacher do to enhance this experience? The teacher must first ask of himself or herself whether teaching is an activity that is done by an active teacher to a passive learner or whether it is a joint endeavour. If the teacher is to learn what the students' preconceptions are he or she must be prepared to ask, and then to listen. Only by listening to what the student has to say can the teacher learn what the student's conceptions are. Having acquired some appreciation of these beliefs the teacher can then build on them and in so doing must provide the student with opportunities to express, in his or her own words, and in ways that connect to his or her own experience, the new concepts.

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