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Students' Perceptions of Teaching and Learning in First-Year University Physics

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Abstract

The transition from school to university involves substantial change in the structure and organization of teaching, and in the nature and purpose of learning contexts. This paper, which reports some data from a broader study of learning and teaching in first year university physics, focuses on aspects of the school-university transition. In particular, we report perceptions of first year physics students about how they should learn physics, what it is intended they should learn, and what they believe to be the functions of the various teaching situations in which they are placed.

Australian students experience their formal education in a series of separately-organised blocks: pre-school, primary and secondary school, and university or college. Each block has distinct characteristics, with research at each of these levels also tending to be distinctive. While research on undergraduate physics learning has explored issues such as cognitive learning (e.g., Guth & Pegg, 1994; McDermott, 1991; Searle, 1993), links between student learning and student learning approaches (e.g., Hegarty-Hazel & Prosser, 1991), and the impact of students' perceptions of the objectives of practical work on learning from that practical work (e.g., Kirschner, Meester, Middelbeek, & Hermans, 1993), much of this research has differences from research on school physics learning with the same broad focus. As Fensham (1992) has noted, one significant factor contributing to these differences is the likelihood that the university physics lecturer will not see teaching as problematic.

Another major factor in these research differences is the differing natures of each of the blocks of formal education. As students move between these blocks they experience a new scale and form of organization, new purposes and responsibilities, new power relations, and new social interactions. They are also taught, and consequently have to learn, in different ways. Perhaps the most marked of these transitions is that from secondary school to university. The student moves from a comparatively small institution, where he or she has been a notable individual in a class of thirty or fewe–often many fewer–to an enormous place of ten or twenty thousand people, where much of the teaching occurs in theatres holding two hundred or more strangers.

First-year undergraduates have moved from a system where they had ready access to their teachers, whose characteristics, methods and foibles they knew and who in turn knew them well, where they had the opportunity to question and clarify understandings (even if they did not exercise it as much as they should), and where they were likely to be questioned and have their understandings monitored; to a system of detachment, where the teachers (or a changing set of teachers) rarely recognise a student outside the lecture theatre as a member of their class let alone know a name or anything personal about him or her, where interchanges between teacher and individual students are rare, and where the teachers might test and judge students' progress from time to time but display to students little concern over any lack of progress. The shift in relations is from concern to indifference, and a shift in the balance of responsibility for learning from teacher to student.

The change from secondary school to university is so dramatic that a substantial proportion of students, who up to that point have been successful learners (as far as the system is concerned), fail to cope. The scale of this failure, both in numbers of individuals and in the individual traumas and losses of self-esteem, constitutes a serious social problem which merits more attention than it has received. Our general goal is to discover how the transition from school to university can become less disorienting. In this study, which is intended as the first of a series, our specific purpose is to uncover the perceptions held by first-year undergraduates of how they should attempt to learn physics, what they believe to be the functions of lectures, laboratories and other teaching situations, and what they think their lecturers mean them to learn. We used interviews and a questionnaire to probe these views, as well as observing students in lectures and laboratories.

The Study

The students in whom we were interested were taking first year physics at Monash University in 1994. They were enrolled for the Bachelor of Science, some in combination with a Bachelor of Engineering or Arts programs. Each week they were supposed to attend four one-hour lectures, including an occasional problem-solving class and a three-hour laboratory class. There were no tutorials. There was a Resource Centre, where students could obtain help from a lecturer.

Eight lecturers taught the course, each specialising on a topic. For most of the first semester two unrelated topics, taught by different lecturers, were covered each week. After the first three weeks the laboratory exercises were not tied tightly to the lecture topics. In the rest of the semester there were seven experiments which, though related to the topics in lectures, were arranged as a ring system, with each pair of students doing a different exercise, moving round to the next exercise the next week. The laboratories were staffed by graduate students and lecturers, each of whom stayed with the one set of exercises. Thus the first-year students usually moved to a new demonstrator each week.

The authors of this paper constituted the team of researchers. White and Gunstone are holders of an ARC grant for the research, and are long-term researchers into learning in science. Mills is a member of the Physics Department and directs the first-year physics program. Macdonald, McKittrick, Mulhall and Elterman have had long experience as teachers of secondary school physics.

The first-year program began on 28 February 1994. The first interviews of students occurred in the seventh week. We had invited students to volunteer for the project and obtained 33 participants. From this number we chose, at random, 20 to be in the first interview. We left the remaining volunteers so that we would have some for interview later in the year who were not affected by the questions we wanted to ask in this first stage.

The results of the first interview were not only valuable in themselves, but also influenced the contents of the questionnaire that we constructed and had answered in late July by all the first-year physics group. The responses to the questionnaire suggested further points for investigation which we probed in the second interview (September) of 20 students from the volunteer group, some of whom had been interviewed the first time.

First Interview

The first interviews, from the seventh week of the course, covered students' perceptions of the understanding they gained from, and the purpose of, lectures, laboratory classes problem classes, and doing problems in their own time, their ways of learning, and the reason why they were studying physics.

The interviews showed that at this early stage of the year most students had not adjusted to the teaching methods of the university. Few knew what they should be doing in lectures or how to make effective use of them. Nor were they clear about the purpose of the laboratory exercises which assumed preparation beforehand by the student. While the majority of interviewees asserted that they understood laboratory classes, they also saw that these involved no more than following directions unless the student prepared beforehand and the laboratory exercise followed soon after a lecture on the topic. The length of the laboratory exercises may have been a problem: one said "I am too busy *doing* the prac to think about it." Half of the interviewees observed that the lectures and laboratory classes did not fit together, yet half said the practicals were particularly valuable. Students were even more vague about the purpose of the problem classes with six of the twenty saying they got nothing from them.

When we asked students what they did if they could not follow something, it appeared that most lacked procedures or opportunities to resolve their difficulties. Only one said he had asked a lecturer for help, and several said they had not, or would not, ask the lecturer. The impression from this of people who were lost in the system was supported by the answers they gave to the question "Why are you studying physics?" Five said they did not know, and four because there was no more appealing alternative. A slight majority did say because they liked it, or needed it, or were good at it. This majority overlapped with those (11 out of 20) who said they were enjoying studying physics this year. The general tone of the responses suggested that most students had been disoriented by the transition from school, and that although a majority were beginning to make the best of it, a substantial fraction remained purposeless and helpless. We were anxious to explore the accuracy of this impression by a survey of the whole enrolment in the subject.

The Questionnaire

The questionnaire [Appendix 1] probed beliefs about the modes of teaching, aids to learning and reasons for studying physics. Responses were received from 207 of the 230 students enrolled. This high response rate was obtained by having the students complete the questionnaire in one of the problem-solving classes.

Lectures

The first 16 questions referred to lectures. They fall into three blocks, one about students' perceptions of ideal behaviour, one about what they get from lectures and one about their beliefs about lecturers' purposes for the lectures. Comparisons of responses to these blocks indicate difficulties the students have in benefitting from lectures. Examples are the pairs of questions 6 and 12, and 9 and 14. Where 60% of students think that lecturers intend them to get a thorough understanding (Q12), only 20% (Q6) found that lectures did that. Of course, the students might have ignored the stem of questions 12 to 16 (During lectures ...) and taken the comprehensive view that the lecturers intend thorough comprehension as an outcome of the total experience of the course, and do not mean lectures to do more than introduce topics. The 92% response to question 13, lectures as a foundation for further studying, is consistent with that. The large difference between agreements to questions six and 12 does suggest, however, that students might benefit from training in the use of lectures.

The difference in responses to questions about learning to do problems (Q9 and Q14) is also substantial: 82% to 56%. These percentages might seem high, but they do not necessarily mean that the students are taught how to do problems in lectures; they might reflect the belief found among a majority of interviewed students that learning to do problems is a major purpose of physics and that lectures provide a basic ingredient in the form of formulas, which they learn to use in other classes or by working on their own. On the other hand it may be that the students do not distinguish between the lectures in which information is presented and the problem classes, which are held in the same room and with the same people–lecturer and students–present. Of course it does not matter whether the students make that distinction, but it would matter if the 44% (Q9) who indicated that they did *not* get to know from lectures how to do problems believed that lectures should help them do this.

People answer questionnaires serially, so their responses are not necessarily consistent from question to question, let alone block to block. Inconsistency is evident in questions 6, 7 and 8, which could be read as mutually exclusive but for which the percentages of agreements add to 141%. Perhaps questions 6 to 8, with 10 and 11, should have been presented as a choice between alternatives. That only a low proportion (20%) got a thorough understanding from lectures is not necessarily a matter for concern; all is well if the lectures are merely an element in the total process of gaining understanding. Responses to questions 46 and 47 suggest that students see them that way, with 14% singling out lectures and 20% the lecture notes as the *one* thing that most helped their learning only 5% singling out an alternative lecturer (or demonstrator) and 6% lecturer pace or clarity as the most needed change.

The combination of questions 6, 7 and 8 suggests that most students are getting something useful from lectures, even if they have to supplement them with further work. Responses to questions 10 and 11, however, show that a substantial proportion of students benefits little from them. Some of the 12% who agreed with question 11 are part of the 22% who agreed with question 10, but together they cover 27% of the students. This is a very high proportion to be getting little from lectures or to be unsure of what they learn from them, and suggests that either the lectures should change or that students need training in how to use them in learning.

The great majority of students in first year physics come straight from year 12 in secondary school, where they are taught in classes of no more than twenty or thirty people. They had opportunity to build a closer relation with their teacher than they do at the university with their lecturer, whom they see from a distance in a crowded lecture theatre. The lecturer has none of the out-of-class interactions with, or responsibilities for, students that the teacher has. Consequently, although 83% of students indicated that ideally they should ask questions in lectures when they do not understand (Q4), few in fact do so in the course of a lecture. Some do at the end of a lecture, and some go to the lecturers' offices at other times, so that 38% (Q38) claimed that they had found asking questions of lecturers particularly helpful to their learning. Asking of questions does not, however, appear a major activity: a systematic count of instances of asking would be a useful check on this. An analysis of the nature of the questions might reveal much about students' perceptions of the purpose of learning physics.

The lecturers provided students at the beginning of each class with summary notes. The students found these notes helpful (Q29: 90% agreement, and Q46, where 20% identified notes as the most effective element helping learning). While this has a positive interpretation, that the notes are well-designed, there are deeper considerations about students' perceptions of the nature of learning that we take up later.

Most of questions 1 to 16 addressed understanding and learning how to do problems. Question 15 is about a different and perhaps less easily defined outcome, appreciation of physics. It was, of course, open to the students to interpret the meaning of appreciation in any way they wished. Before the first interview we imagined that they would think of this as valuation of physics as an important part of human culture, as a liking for it, or recognition of its intellectual structure and harmony: something positive, at any rate. Everyone may form their own judgement of whether 73% believing lecturers intend lectures to develop appreciation of physics is a high or low proportion. Our view is that a quarter of the students thinking that their lecturers do not intend to use their major form of personal communication to promote appreciation of their subject is far too high a proportion.

Laboratories

There were two blocks of questions about the laboratory classes. Questions 17 to 22 asked students what they got, and questions 23 to 28 what they thought their teachers intended them to get, from the laboratory.

The high percentages of agreement with questions 23 to 27 (between 86% and 96%) imply that students were clear about the purposes of laboratory work. The high percentages of agreement with questions 18 (89%) and 19 (90%) show that the classes met expectations for two of the purposes, knowledge of how to do experiments and skills in using equipment. It is not certain what students took "knowledge of how to do experiments" to mean, but it seems probable from the much lower agreement with question 17 (about understanding of theory) that they read it as carrying out directions rather than learning how to design an investigation. Such an interpretation would be consistent with what they were asked to do in the laboratory. Students in first year are not given a problem and asked to devise a procedure for investigating it; rather they are supplied with apparatus and directions of what to do. They are learning to be technicians, laboratory assistants, rather than scientists. This helps them to become more proficient in routine aspects of measurement and analysis and provides a foundation for later training in the design of experiments. It is a matter of teaching judgement whether they should be asked sooner to plan an investigation.

There is a marked difference between the perception that students are meant to gain understanding (90%) and whether they do get it (62%). This could be a result of the limitation of the "experiments" to following directions. It could also follow from poor linking of lectures and laboratories. Linking refers to a mental action by the students. Unsatisfactory linking can have two causes: the lecture and the laboratory programs really are unrelated, or they are related but the students do not perceive that they are. Attending to the first cause is simple. It requires no more than analysis of the programs. The second is more difficult. Research with secondary schools students (e.g., Baird, 1990; Tasker, 1981) has found that students often fail to look for connections between lessons, even when they are of the same mode and only a day apart. They are even less likely to look for them when they are of different modes - lecture and laboratory - and weeks apart. Something can be done about timing, and about referring to the other mode in lecture or laboratory, although the arrangement where there is a cycle of laboratory exercises, with each pair of students doing them at different times, prevents easy linking. Something might also be done about training students in the strategy of linking, though this sort of skill takes so long to develop it can hardly be the responsibility of the first-year teachers of one subject. The roots of the strategy must lie years back, in secondary and primary school.

Responses to two questions raise particular concerns. Only 40% agreed that they enjoy the laboratory classes. This is sad. Normally, people like doing things, exercising mind and hands in carrying out precise meaningful operations. Yet fewer than half of the first year students found physics laboratory fun. Presumably this was the fault of the laboratory classes rather than of the students. The survey does not reveal the cause of the students' reaction. It could be that the experiments were dull; it could be that there was so little time to do them that students felt rushed; perhaps the lack of link with lectures was responsible; the demonstrators could have been unhelpful; the system where students were with a different demonstrator for each exercise might be too impersonal.

The second question of concern is number 22, where 25% of the students claimed to be getting very little from the laboratory classes. Judgements about these percentages are subjective; for us, this is too high to be tolerated.

Aids to learning

Questions 29 to 30 asked students whether particular materials or activities had been particularly helpful to their learning. A student could check all, or none, of them. There was, however, a tendency to respond to such a list by discriminating and checking about half of the questions. The median percentage of agreement for this list is 64%, about what one might expect.

Some questions all students experienced–lecturers, laboratory classes, problem classes, demonstrations, lecture notes, text book and assessment tests. Others required the students to act–going to the Resource Centre, discussing, asking questions. Comparisons across these two classes must consider that difference.

Within the universally-experienced aids, the printed lecture notes were easily the most helpful. There is a remarkable difference between the response to question 29 (the notes) at 90% and to question 30 (the text book) at 57%. One interpretation is that the notes were wonderful and the text book woeful. Perhaps a better text was needed. But a more subtle and possibly more accurate interpretation is that the students focused their attention on success in examinations rather than on learning for its own sake, and saw the notes as the better guide to what would be examined. If the prescribed text book was so much less helpful than the printed notes, where would other books come? Is it likely that the students were reading widely, building up their own appreciation of physics? Or were they sticking to receiving the facts and algorithms chosen by their lecturers?

The percentages agreement for questions 33 and 34 (about the laboratory and the problem classes) were 64% and 67%. The laboratory was discussed in the previous section. The problem classes dealt with skills that the students surely perceived as central to success in examinations. The response may indicate that the conduct of the problem classes needed consideration.

There is a low percentage of agreement (51%) that the Assess tests (computer-based tests done every two weeks) helped learning. This may reflect students' general perception that tests measure but do not aid learning, or may indicate that these particular tests did not relate to what students thought they should be learning.

Four questions refer to an aid and actions that require the students to take initiative. The aid is the Physics Resource Centre, where a member of the physics department waited for students to come for help with problems. Few students did come, so the 36% response might mean that the students did not think they needed help, or that they thought the Centre did not give that help, or that they had forgotten that it was there. Further investigation is needed to find out which is the reason.

Students did help each other and they did ask demonstrators questions. The 64% agreement for question 37 seems reasonable; what the survey does not tell, however, is what the students discussed. It may be that discussions focused on the problem exercises rather than on the concepts of physics. This, too, requires further investigation if we are to have a clear picture of the intellectual engagement of physics students. We also need to know what kind of questions the students ask demonstrators. The stem of the question referred to "helpful to learning," but the students might have meant that they asked demonstrators about what to do next in a laboratory exercise rather than about the meaning of a concept.

The 38% agreement response to question 38 is interesting. On the one hand it is low; one might like to think that university learning involves deep and frequent interchange between teacher and students, when the reality is that it is almost entirely a one-way delivery and reception system. On the other hand 38% is much higher than observation of behaviour suggests. Students rarely asked a question during a lecture. At the end of a lecture a handful might have spoken with the lecturer, and this handful included frequent questioners so that the average student never was part of it. Few students found their way to the lecturers' offices. Perhaps large enrolments make it inevitable, but there is a gulf between lecturer and students that must have a significant effect on the students' learning.

Reasons for studying physics

As with the previous block, students could check all or none of questions 40 to 45, but most tended to check about half of them.

Interpretation of the responses is again subjective. Ours is that many students take physics as a service course necessary for further progress in engineering or science. Not so many take it for its own sake, as an exciting and challenging aspect of human culture. There is overlap between responses to questions 44 and 45, but together they cover 31% of students who either did not know why they were doing physics or because it was the least worst option open to them. This poses a huge challenge to the teachers of first year physics. Faced with a class of 200, of whom 60 have no real purpose for being there, they have to give the subject meaning and interest. Part of the solution to this problem may lie outside their power, being a broader social issue. Nevertheless the lecturers must do what they can about it, for unless the sleepwalking 30% can be given a sense of purpose they will be a drag on their fellow students as well as a source of depression for their teachers.

Second Interview

In the middle of second semester six of us interviewed 20 volunteer students. Apart from being volunteers, the 20 appeared to differ little from the total student group: there were the same proportions of males and females, much the same distributions among the different course enrolments (B.Sc.,B.Sc./B.Eng.,B.Comp.Sc.,B.A./B.Sc.), and not-too-different test performance in first semester (the sample group had three more HD results in first semester than the proportional share).

We designed the protocol for the interview from our consideration of the responses to the survey. There were questions about understanding and how the students tried to learn, about their appreciation of physics and about the organization and delivery of the subject. The students responded willingly to these questions.

The results of the interviews are broadly consistent with those from the survey. Although most students might be learning physics reasonably well, we do not have a picture of intellectual ferment, of excited pursuit of knowledge for its own sake or the joy of learning. Rather we have dependence, compliance with directions and lack of initiative, with isolation a concern for the few. The subject is learned for a credential, not for its own sake. Students have a vague awareness that things should be better, but lack the knowledge or the opportunity or the confidence to assist in change. Physics is no worse in this regard than other subjects; indeed, the survey suggests that it is better than most. Consequently much of the results of the interviews, and of the survey, bear on matters that concern first-year science, and possibly all first-year university studies in general.

Understanding

Our first question was "When you say you understand Physics, what sort of things are you saying you can do?" Nearly all (17 of 20) answered in terms of being able to explain. Although 17 also mentioned being able to use equations and do problems, more than half (12) rated qualitative understanding above quantitative skills. The students clearly had a broad and defensible view, if not necessarily a detailed or sophisticated one, of what is involved in learning physics with understanding. It is a matter of concern that their responses to our next question, whether explaining concepts in physics and why things happen is an important part of what they are required to do, contrasted markedly with their perception of understanding. Only three said explaining was an important part; 17 said no, or not much. When we probed this further, with questions about parts of the delivery of the course, we found that laboratory classes were the only place where students felt called upon to explain - in laboratory classes and laboratory reports 16 said explaining was important. Perhaps the most significant response concerned examinations, where only one student said that much explaining was required. No student said that explaining was an important part of problem work or Assess tests.

This contrast between students' perceptions of understanding and of what they are called upon to do may be responsible for much of their dependent and solitary intellectual life. If it is, although a matter for concern it is also encouraging because it is easily changed. New forms of assessment and new class activities are available that would involve the students in explaining concepts and phenomena.

Dependence

The students were dependent in ways consistent with lectures being a prominent teaching mode. They relied on the printed notes that were distributed at each lecture. Eighteen of the 20 said the notes were helpful, two qualifying that by saying "if they are brief." Of the remaining two, one was an ESL student who found the pace of lectures based on printed notes too fast; the other, the only one who demonstrated independence in this regard, preferred to write his own notes because he found he learned from the act of constructing them.

A popular reason for the value of the notes was that they enabled the students to concentrate on what the lecturer was saying. That is fine, if it means that the students are reflecting on the meaning of the content, its implications, and its relation to other topics and practical applications. It is less satisfactory if it means that the notes tell students which parts of what the lecturer says are the ones that matter for tests.

The students were much clearer about how they used the lecture notes than the textbook, in ways that illustrate dependence. Eight said they used the notes for general revision, seven (who might overlap with the eight) when revising for tests and four when doing problems. Only two said they used the notes to go beyond what they were told, in adding their own notes or summary. Our impression is that most students depended on the notes for focussing their revision for examinations.

Perhaps the most significant thing about the textbook is that it was *the* textbook. The students used it less than the printed notes and for more varied purposes. About half read it on particular topics or to review a lecture and a quarter as part of preparation for examinations. The most common use was for the exercises at the end of each chapter and for worked examples that showed students how to do problems.

It is, of course, a matter for debate as to how much direction first-year students should receive. The intention of the lecture notes is good and the students' reaction to them shows that they were well-constructed. Our concern about dependence should not be interpreted as a recommendation to "kick away the crutch" of the lecture notes, but rather to build into the course tasks that encourage the students to look for information in further places. An example is an exercise in which they are to compare the treatment in two texts of a given topic.

Solitariness

Although the students were dependent, they did not know how to seek support - or at least were not very good at doing so. They did know that they needed help. When we asked whether they would find small discussion groups helpful (we could have used the word tutorial), 17 said yes, and half of these said they would benefit most from discussing the meanings of concepts, as against the doing of problems. This wish is consistent with students' appreciation that explaining is an important part of understanding. They did have other resources, such as the problem classes, for learning how to do problems.

About half the sample said they worked regularly with friends, though none of them mentioned reflecting on, or working out meanings and implications; they referred only to doing problems, laboratory preparation and going over Assess tests. Rather sadly, three said they knew no other students, though two said they would like to.

When we followed up by asking what interest they would have in voluntary regular meetings of students organised by the Physics department, again the sample split in half. Some said they had such meetings already and that it helped to have ideas from other students. The others were less sure, indicating that "learning" had to be enforced. They were the dependent ones, as well as the more solitary ones.

Another aspect of solitariness is isolation from their teachers. We asked how often they had asked the lecturer something; half said never, five said often. In most cases where a question was asked, it was at the end of a lecture. Few had been to a lecturer's office and most did not know where the offices were.

The main reason why students said they would not ask a question relates to social context. They were embarrassed or scared to ask, because they might look silly. It is important to note that this perception does not seem to be the result of put-downs or other adverse events that actually occurred. It was not a consequence of the actual lecturers, but of the general context of the large lecture. This interpretation is supported by responses to our next question, whether it would help if the lecturer were available at a given time in a classroom. Half were definite in saying yes, another quarter were unsure but thought it could be. Some said no because they felt there was sufficient access already.

Isolation also appears in failure to use the Physics Resource Centre. Since half of the sample said they had *never* been to the Centre, they had no direct knowledge of whether it could help them. Another four said they had been once, four twice; the remaining two had been more than five times. Three even said they did not know where the Centre was, or what happened there. It may be that the students did not need the Centre, as six claimed. This was, however, unlikely; surely all could have benefitted, even the able students, by exploring further into a topic. In this way, paradoxically, failure to use the Centre was related to dependence: the students accepted that all that was necessary was to pass the examination and learning beyond that was pointless.

Students' perceptions of understanding, their recognition that they are tested on problem-solving rather than on explaining, their dependence and solitariness were all connected with their skills of learning. Our impression, and probably theirs, was that they needed guidance on how to learn and specifically on how to learn in the university.

When we asked whether they knew how to learn well in lectures, laboratory and problem classes and in their own time, many seemed never to have thought about their capacity to learn or how they did it. Three said they did know how to learn well and five that they were learning better in semester 2 than in semester 1, but since they could not say how, this may have represented an acceptance of the university's methods rather than an active adaptation to new ways of learning.

There was a more positive response about laboratory classes than for lectures or problem classes. Only two gave an unqualified yes about lectures, with three more saying it depended on interest, the topic or the lecturer - which we interpret as saying they did not really know *how* to learn from lectures. More focussed were the further three who said they found preparatory or subsequent reading helpful; they at least had some notion of how lectures fitted into their patterns of learning. The same applies to the four who said they learned well (not *knew how* to learn well) from laboratory classes if they read about the practical exercise beforehand. Only three said they knew how to learn in problem classes and only two in their own time.

Clearly, students were perplexed by this question. They seemed to interpret "learning well" as working hard or doing things to guarantee a good examination result. They lacked knowledge of specific strategies of learning. They were aware, however, that they needed to improve. Fifteen agreed that they should change the way they learned, but none had any real notion of how to do that. Half thought that during the year they had in fact changed the way they learned, but were vague about the form of the change.

Learning is the core business of students. It is strange, though common, that few if any have any idea of how to go about it. Until they do, they are condemned to dependence.

Purpose

It is consistent with students' dependence and their perception that they were learning how to do problems rather than to understand, that they saw physics as a service course, a means to an end rather than an intellectual adventure of interest for its own sake. There is, of course, a range of positions within the sample.

When we asked how much of what they were learning is important, carefully not defining what we meant by important, 13 said all or most of it. These 13 split between 8 who said technology depended on it and 5 who mentioned understanding of the world. At a personal level, both those who thought it was important and those who did not referred only to the relation to careers.

We wanted to know whether the students found physics interesting. We obtained the two-edged result that 12 said yes, or most of it, plus a further 5 who said parts of it. About half said they enjoyed physics more than any other subject, some rather surprisingly, given what had gone before, saying that it made them think and led to more understanding. Again, about half reported that the physics laboratory classes were more enjoyable than those in other subjects, of which the commonest was Chemistry. Physics appealed through variety, challenge and understanding, while others found Chemistry laboratory easier, more focussed.

These results are two-edged, because although it is good that so many said physics is interesting, given the general picture we have formed from the survey and the interviews it suggests much improvement is necessary in the other subjects that these students took.

We noted that those who said that only parts were interesting did not refer to topics but to activities such as demonstrations and videos that made their learning more tangible, while those who found most or none of it interesting referred to topics. We need to explore this further. There is a hint in the responses of two sorts of reaction, not mutually exclusive, from those who enjoyed new topics and challenges and from those who were happy when they had mastered a topic.

Conclusion

The origins of this research were in some rather general notions of the first two authors that we could take the approaches we have used to successfully explore the processes of high school science teaching and learning (e.g., Baird, Fensham, Gunstone, & White, 1991) and use these in the context of undergraduate science learning. However the distinctive characteristics of university learning, to which we referred in the introduction to this paper, mean that the detailed planning of the research and our approaches have had to be different from those we used in school contexts. The two broad conclusions we now draw from the preceding detailed description also reflect the distinctive characteristics of university education. These two conclusions concern student difficulties in first year physics, and the role and place of affect in this learning.

The difficulties students describe in their experiences in first year physics have one consistent feature - the difficulties are not specific to the subject of physics. That is, student problems tend to be generic to first year, to reflect a lack of understanding of how to use appropriately the very different learning contexts that characterise tertiary institutions. In both our interview and survey data there is surprisingly little mention of anything specific to the subject matter on which we focussed.

Affective aspects of learning are evident at a number of points in our data. Clearly these are significant, but this significance is frustratingly problematic. On the one hand affect is clearly important; on the other the university context might almost have been designed on assumptions of irrelevance of affect. This issue is an obvious example of a difference between school and university, and of one that is not at all specific to any one subject. Recognition of the importance of affect and the extent to which this is not seriously addressed in the structuring of university teaching provides a number of apparently obvious suggestions for change in the context of first year - smaller classes, more interactive lectures and problem classes, more attention in planning and teaching to explicit linking of the components of subjects, linking demonstrators with students rather than experiments, professional development for staff, raising the status of teaching, providing academic orientation for students in the early part of the year, and so on. In practice, many of these suggestions demand resources and hence are difficult to implement. Even so, change is necessary.

The list of obvious suggestions in the paragraph above has nothing that puts responsibility on the students. This is a particularly difficult area: as we note earlier in the paper the development of appropriately metacognitive skills and behaviours among learners needs to occur much earlier than first year of university. There are other aspects of school responsibilities in these data. On more than one occasion during our interviews students indicated some frustration with having been told very often in their year 12 studies that this year (year 12) was the hardest of their academic lives. This is but one example of the problems that arise for students when their school treats year 12 solely as an end in itself and ignores the subsequent learning contexts in which many of the students hope to find themselves after year 12. In our discussions of the data through the paper we have made reference only to the university teaching and learning context. In no sense does this mean that we see the transition from school to university as being only the responsibility of the university.

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Appendix 1

Questionnaire given to first-year physics students, responses and the percentage who agreed with the statement (Questions 1 to 45, $N = 207$).

	In physics this year:	% Agreement
	During lectures ideally I should,	
1	Write onto my copy of the lecture notes everything the lecturer writes	56
2	Take down everything that is said	12
3	Understand what is covered	96
4	Ask questions if I don't understand	83
5	I'm not sure what I should do	7
	From lectures I get,	
6	A thorough understanding of the work	20
7	A basic but not complete understanding	83
8	Information but not understanding	38
9	To know how to do problems	56
10	Very little, apart from the printed notes	22
11	I'm not sure what I get	12
	During lectures I think lecturers intend us to,	
12	Get a though understanding of the work	60
13	Get a foundation for my further studying	92
14	Learn how to do problems	82
15	Develop an appreciation of physics	73
16	I'm not sure what they intend	11
	From lab classes I get,	
17	Understanding of theory	62
18	Knowledge of how to do experiments in physics	89
19	Skills in using equipment	90
20	Enjoyment	40
21	Greater confidence as a student in physics	58
22	Very little	25
	In lab classes I think lecturers and demonstrators intend us to get,	
23	Understanding of why things are happening	90
24	As practical application of the theory	96
25	Skills in using the equipment	94
26	Knowledge of how to do experiments in physics	95
27	Understanding of what to do in the experiment	86
28	I'm not sure what they intend	11
	The following have been particularly helpful to my learning,	
29	Printed lecture notes	90
30	The text book	57
31	Videos	52
32	Demonstrations	75
33	Lab classes	64
34	Problem classes	67
35	Assess tests	51
36	Physics Resource Centre	36
37	Discussing physics with other students	64
38	Asking questions of lecturers	38
39	Asking questions of demonstrators	72
	I am studying physics,	
40	Because I enjoy it	63
41	Because I require it for my degree	57
42	Because I was good at it in Year 12	60
43	Because physics is important	63
44	Only because no other subject appealed to me	22
45	I don't know	14

Appendix 1 (Continued)

	N	% Agreement		N	% Agreement
[a]46 *What is the one thing in this subject that most helps your learning?*					
Lecture notes	42	20	Lectures	28	14
Doing problems	21	10	Lab classes	19	9
Problem solutions/worked examples	16	8	The text book	15	7
Problem classes	14	7	Private study	9	4
Discuss with friends	7	3	Assess tests	6	3
Demonstrations	5	2	Physics Resource Centre	5	2
Nothing/I don't know	5	2	Ask questions of lecturer/dem	2	1
Other responses	11	5	No answer	12	6
[a]47 *If there was one thing in the subject you could change to help your learning, what would it be?*					
Have small practice classes/tutorials	32	15	Lecture/lab class linked	19	9
Nothing/don't know	16	8	Lecture pace/clarity	12	6
Parallel lecture topics	12	6	Alternative lecturer/dem	10	5
Better text book	9	4	More problem classes	8	4
More problems	6	3	More detailed lecture notes	5	2
Shorter pracs	5	2	More demonstrations	1	-
Other responses	45	22	No answer	23	11
[a]48 *Briefly write below what you actually do when you don't understand something in physics.*					
Use the text book	112	54	Consult friends	85	41
Ask lecturer/demonstrator	35	17	Physics Resource Centre	35	17
Use lecture notes	34	16	Nothing	19	9
Use other texts	17	8	Do more problems	16	8
Think about it	15	7	Use worked examples	12	6
Leave it till pre-exam time	7	3	No answer	10	5
Other responses	16	8			

[a] Questions 46 - 48 were open-ended.