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Using Phenomenography to Understand Student Learning in Civil Engineering*

J. FRANZ
Lecturer, School of Architecture, Interior and Industrial Design, Faculty of Built Environment and Engineering, Queensland University of Technology, GPO Box 2434, Brisbane QLD 4001, Australia
L. FERREIRA
Senior Lecturer, School of Civil Engineering, Faculty of Built Environment and Engineering, Queensland University of Technology, GPO Box 2434, Brisbane QLD 4001, Australia
D. P. THAMBIRATNAM
Professor, School of Civil Engineering, Faculty of Built Environment and Engineering, Queensland University of Technology, GPO Box 2434, Brisbane QLD 4001, Australia

Phenomenography is an area of research which focuses on identifying and describing the qualitatively different ways in which people understand phenomena in the world around them. Two units, structural analysis and traffic engineering, were selected for the purpose of understanding the various ways students relate to significant aspects of civil engineering. Integral to the study was the use of student group discussions which were recorded and analysed. The findings comprise descriptions of the different conceptions of learning held by students and lecturers in relation to specific engineering phenomena and their implications for teaching enhancement and curriculum development in civil engineering.

INTRODUCTION

IN ORDER to enhance teaching, and thereby increase the likelihood of more effective learning, it is essential to gain a better understanding of how students learn. Phenomenography is an area of research which focuses on identifying and describing the qualitatively different ways in which people understand phenomena in the world around them [1]. Underlying phenomenographic research is the assumption that human beings are guided in their action by interpretations they have constructed of particular phenomena [2]. Phenomenographic researchers share the conviction that improvement of complex activities such as learning requires an understanding of the interpretive nature of this relationship.

This paper reports on the results of a phenomenographic study undertaken within the School of Civil Engineering. After a brief discussion of the methodology used in the study, the paper describes work carried out with a group of third year students. Two topics from structural analysis and traffic engineering units were selected for the purpose of understanding the various ways students relate to significant aspects of civil engineering. Integral to the study was the use of student group discussions which were recorded and analysed. In addition, the two lecturers concerned with the units were interviewed in depth about teaching objectives and techniques.

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METHOD

How students go about experiencing and understanding a particular phenomenon in the learning context relates to how the learning task or context is perceived by the students and to their understanding of what constitutes learning [3]. To uncover students' and lecturers' conceptions of learning, we collected and analysed data using methods which have been successfully implemented by various researchers in a variety of phenomenographic studies.

To collect student experiences of learning, we conducted what Russell [4] describes as synergetic focus group discussions. In a detailed examination of its suitability for phenomenographic enquiry, Russell [4] concludes:

> The synergetic focus group method described here offers the researcher a variety of unsolicited conceptions through non-directed discussion. As lived experiences related to the phenomenon are shared by participants over an hour or so they explore qualitatively different conceptions of the phenomenon. The diversity of the conceptions form the categories of description which are the basis of phenomenographic analysis [4, p. 13].

With respect to this study, the discussions were carried out in the early part of first semester. In the structural analysis case, the topic, 'Method of Moment Distribution', a simple and popular method for analysing structure, was chosen for discussion. Two groups of seven students each were formed to represent a cross-section of the academic performance of the class. Each group was informed of the nature of the project and its goals. They were then asked to discuss how they learnt and understood the 'Method of Moment Distribution'. While the discussion was in progress, it was video and audio taped.

A similar approach was adopted in the area of traffic engineering in which two groups of six students each discussed the way in which they learnt the material covered in three lectures of the third year unit. The topic of this three-lecture unit is 'Urban Transportation Planning', with both the methodology and techniques used to forecast travel demand being covered. The main aim of the unit is to introduce the concept of planning for transport in urban areas. A secondary aim is to expose students to the process involved and to the analytical techniques used in urban transport planning. The unit is designed as an introduction to be expanded upon in a final year unit. Most of the students who took part in the Structural Analysis case study also participated in these discussions.

Once transcribed, the discussions were analysed. The approach is typical of phenomenographic inquiry, particularly that of Marton [5,6] Svensson and Theman [7], Dahlgren and Fallsberg [8] and Sandberg [9]. Briefly, it involves:

- familiarization with the data by viewing the video several times and comparing it for meaning with the transcription from the audio tape;
- selection of statements significant to the focus of the discussion;
- delimitation of parts representing conceptions of significant aspects of the phenomenon. This involved comparing significant statements in order to find cases of variation or agreement and grouping them accordingly;
- description of the similarity within each group with the help of actual words forming the significant statements.

The lecturers responsible for teaching the 'Method of Moment Distribution' and 'Urban Transportation Planning' were also involved in the study. Each lecturer was interviewed by an impartial member of the research team who had experience in conducting phenomenographic research. The interviews were semi-structured with the questions focussing on the lecturer's understanding of learning in the context established for the respective student focus groups. On conclusion of the interviews, the audio tapes were transcribed, checked for accuracy by the interviewees, and analysed as previously described.

The findings of the study involving students and lecturers are presented in the following sections dealing with the respective cases.

CASE STUDY I: STRUCTURAL ANALYSIS

1. *Students' Conceptions*

From an analysis of the students' discussions, we identified two different ways in which learning in structural analysis is experienced. These conceptions are represented in Category No. 1 where learning is seen as memorizing information specific to the unit, and Category No. 2 where learning is seen as understanding information specific to the unit.

Category No.1: Learning is seen as the memorization of information specific to the unit.

In this category, learning is seen in quantitative terms as an accumulation of knowledge relevant to what is required to satisfactorily complete the unit. The focus is on the content given significance by the lecturer. Through a certain amount of note-taking, questioning, revision, and problem solving, unit material is understood to be absorbed. This is conveyed in the following statements by student participants:

> The problem that I have with them is that I haven't done enough of them.
> We need to do ten of these things.
> Yes, I think it is a case of just having to do some examples.

While this conception is normally associated with a passive understanding of knowledge transfer, this is not so in this case. For example, learning is viewed to be associated with the act of doing problems. In this context, learning requires the active participation of the student. Learning is deemed to be effective when current problems can be matched to those previously experienced. It is assumed that once there is recognition of similarity, relevant action can be automatically taken, action which incorporates the mechanistic application of appropriate methods in the correct sequence. In some instances, such as where no match eventuates a successful outcome is viewed to be impossible without some basic understanding of the character of the problem; an understanding which allows for the application of principles in an appropriate format.

Category No. 2: Learning is seen as understanding information specific to the unit.

In this category, learning is viewed as appreciating when to use particular analytical methods. Here the focus is on the problem/theory relationship; knowing what to use and when:

> I want to know when you use the three on two factor. Remember in our very first lesson, [the lecturer] telling us how to balance intermediate joints only—right, with your load you just take a guess and lock it at that point and then you work out the left hand side of it and increasingly rotate it until you balance that joint. Work from left to right hand side by using the thickness. Once you've balanced that joint then you get the movements balanced either side very close to each other...
> I think it would help if [the lecturer] actually explained where that came from.

Understanding is facilitated by adapting information to suit personal cognition:

> I find that if I try to think about it in class—to make sense of it—then I make up my own notes. I don't just copy [the lecturer's] notes from the board. No matter how obvious it might seem at the time I still write it down, so when I come back to it later on, I can find it simple to remember the lecture and when you were in the lecture.

Understanding is also facilitated by being able to visualize the problem as a whole:

> That's like some of the subjects, you're given work to learn that is a small picture of a bigger picture. For me, I can't understand the small part unless I've got an idea of overall where it fits in.

For some, understanding is facilitated in an experiential way by attempting to relate things to past experiences:

> It's like a roller. I've never seen a roller before and I can't understand how this thing rolls along and holds the structure there.

For others, understanding is facilitated by being able to discuss problems with other students:

> I think that it is good to discuss this with each other. It is different when [the lecturer] asks a question on a one to one basis. It is not until you go away and talk to other members of the class that you realize how much you have understood.

and/or with the lecturer:

> What I like about this subject is that the lecturers are prepared to see you outside of tutorial time. Quite often when you go to other subjects often run by other faculties, they just don't want to talk to you, it's just 'go away'. You've got no idea what it's about anyway and you can't follow the text book and your lecture notes have come out of the textbook anyway.

Generally, learning is facilitated by practical examples:

> I like to do the examples in class to get my confidence up.
> It's not really the kind of subject that you can get out of a book.
> No, it's a practical subject. I couldn't just read a book and then go and do it.

Unlike the previous category of description where effective learning is understood in relation to having in memory a store of examples to match prospective problems, in this conception learning is understood to be effective when the problem is viewed in a way that suggests an appropriate action. Here, the emphasis is on conceptualizing the problem rather than just looking for a match from one's store of examples. The conceptualization is seen in various ways to be related to past experience of related problems as well as to one's desire to appreciate the significance and value of something. In this sense, effective learning is viewed in relation to being able to successfully apply theory in new situations.

2. *Lecturer's Conceptions*

Unlike in the previous situation where the data originated from several sources, in the situation represented here the data came from only one source—the lecturer. As such, the conceptions were more easily discerned. Whereas the analysis of student discourse revealed a less explicit understanding of learning as problem solving, in the lecturer's case, this was made very explicit. The analysis also highlights the difference in the students' and lecturer's conceptions. For the students, their conceptions were bounded by the course and its requirements, whereas for the lecturer, the conception was defined by professional practice and its demand for particular competencies.

Category No. 2: Learning is seen as understanding information specific to the discipline.

In this category, learning is understood as developing a body of discipline-specific knowledge. The knowledge pertains to the analysis of indeterminate structures. Specifically, it entails having a store of experiences comprising situations where particular methods have been applied in a particular way to a particular problem.

Learning is demonstrated ultimately by the capacity of the graduates to use their knowledge to resolve actual civil engineering problems:

> When they go into the field they will be engineers and before they can construct a building they have to design it. And before they can design, they do what we call analysis which deals with what kind of forces act, what kind of deflections occur, and what kind of members we are going to put in that building or bridge.

Category No. 3: Learning is seen as developing professional practice.

The emphasis on preparing students for the 'reality' of professional practice reflects a slightly different understanding of learning to that conveyed in Category No.2. In this category, the focus is on the use of 'real life' problems for student practice.

> *What I am getting at is, surely there is some uncertainty with anything in the world. How do you help students cope with that uncertainty?* (Question from the interviewer to the lecturer)
> A very good question, I think. Yes, definitely there will be unforeseen circumstance, funny structures, special cases. We discuss those when we study a particular structure and its behaviour. We all discuss the variations that can occur in either the loading or the structure itself, due to an error in the construction of the structure; what could go wrong; what could happen. So all these possibilities are covered to enable necessary action if this happens. Many situations are covered in this subject, so that they can relate to real life situation; to one or more of these. I can't guarantee there will not be something very different from what they have done, but having had this background, they should be

able to turn it around; to pick some of the types covered in the subject and apply them.

Having lecturers who have had a variety of professional practice experience is considered vital to preparing students for practice:

So you can almost guarantee that the situations that you present to students in a learning context parallel very closely situations in the real world?

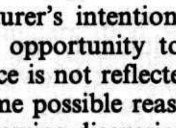
Definitely, because this is a special feature of the School of Engineering. Every lecturer has worked in the industry. They won't take them here otherwise. We have all got our hands soiled by working. When we were there, we understood in a certain manner. Now I'm here, I know the kind of thinking over there and I train them towards it.

Overall, there is very little variation between the lecturer's conception and those of his students. This is graphically illustrated in Fig. 1 which organizes the various conceptions in what is described in phenomenography as an 'outcome space'. In the case of the lecturer for example, the organization is hierarchical in that learning as understanding, is an aspect of learning 'as developing professional practice'. The outcome space represents the phenomenon as it is experienced in its various forms. One difference is where the lecturer's intention to provide the students with the opportunity to develop professional competence is not reflected in the students' conceptions. Some possible reasons for this are outlined in the following discussion section.

3. *Discussion*

The variation between the lecturer's conception and those of his students could be explained in terms of one or a combination of:

- The students are preoccupied with passing examinations and completing the course. As such, they are only prepared to adopt an atomistic/surface approach to their learning. An atomistic/surface approach is characterized by a focus on parts independent of other parts and by a reluctance to search for underlying meanings.
- Contextual factors such as workload and personal commitments are restricting students to an atomistic/surface approach.
- The students are experiencing difficulty with



Notes:
1 - Learning is seen as memorising information specific to the unit.
2 - Learning is seen as understanding information specific to the unit/discipline.
3 - Learning is seen as developing professional practice.
-- - Link to an "ideal" conception
— - Link to an "actual" conception

Fig. 1. The outcome spaces for learning the method of moment distribution.

understanding some of the significant concepts associated with structural analysis and are, subsequently, forced to adopt an atomistic/surface approach.
- Contextual factors such as course requirements are restricting the lecturer in his development of a learning environment that fosters holistic/deep learning. A holistic/deep approach is characterized by an interactive movement between the parts of a situation and the situation as a whole and by the desire to understand the situation as deeply as possible.
- The lecturer's appreciation of professional practice is too limited and limiting.

Despite the variation and the need to view the situation with respect to the above factors, the discussion highlighted various factors that were understood by the students and the lecturer to improve the quality of learning. These are described in their respective subsections.

Learning in class

Most of the content material was addressed during the lectures, which the students believe were delivered at an easy pace. The students appreciated the time given for questions and benefited from discussions which normally follow such questions. An important part of the learning process was the application of the theory to solve real world problems. This was achieved by discussing examples during the lectures.

For this to be effective, the lecturer should have practical experience. Relevance of the theory to real world engineering was understood to make the learning process more interesting and efficient. At one point, the students diverged somewhat to discuss the shortcoming in subjects such as mathematics which were taught by non-engineering lecturers who did not usually indicate the applications of the theory. Overall, it is essential to illustrate applications of the method to real life problems by the use of pictures and models of structures. Learning and understanding can be made easier and interesting with visual support of this type.

The particular process followed by the lecturer in the unit is: explain the theory, develop solution processes, and then apply them to a series of problems. The students then carry out independent solutions to typical problems, either as home work or in assignments, to enhance their understanding. The lecture notes form a reference base to reinforce theory when applying it to future problems in structural analysis. When there are doubts or lack of understanding, students are encouraged to ask questions in class and to discuss further the topic with other students. Most students make additional points to lecture notes to assist them in their learning. In this topic and in this unit, the need to revise previous work before a lecture was emphasized. When this was not done, the students found it difficult to follow the lecture.

Learning outside class

In this unit, it seemed that students preferred to work in groups of about four. This enabled them to complement and supplement each other's understanding and improve their overall learning ability. Problem solving, as mentioned earlier, is an important aspect of the learning process in this unit and hence the students spent a great deal of time working through problems. In their discussion, it was apparent that the few examples discussed by the lecturer in class went a long way in helping students with their problem solving. Some students studied and understood the worked examples prior to attempting problems outside class, while the others started on the problems and referred to the examples only when necessary.

Students had also to spend time at home reading through the notes and/or the text books to learn the theory. While doing so, they often encountered difficulties. When this happened they approached the lecturer in his office and discussed the difficult areas with him. In this respect, the students appreciated the availability of the lecturer to fill in the 'holes', when required. In a unit such as structural engineering, this happened many times. Hence, it is imperative that the lecturer is willing and able to spend time with the students. This suggests that it will be difficult and inefficient to have such a subject taught by a part-time lecturer, who will not be available to see the students when they need him or her the most.

Need for understanding

Students' understanding of the subject is revealed by their performance in examinations, by the questions they ask, by the answers they give to questions and, to a lesser extent by, their performance in tutorials, in which they can get individual help. Without a fundamental understanding of this unit, it is not possible to perform satisfactorily. Students who have not understood the unit perform poorly in examinations, as understanding rather than memorizing facts is of primary importance. There are several steps in the solution of a single problem, with every step having a distinct meaning and some of the steps being be peculiar to the problem at hand. In this unit, the application of techniques is important, not the ability to memorize facts.

The students solve several problems to enhance their understanding of the 'Method of Moment Distribution'. Confidence in their ability grows when students are able to solve problems correctly. If the solutions are incorrect, the student should revise the relevant theory and check their working, prior to rushing for help.

Ability to apply the learning in industry (real life)

Students who perform satisfactorily in this particular unit tend to perform equally well in the real world. This is because the unit covers theory, solution processes, applications to real life problems and the interpretation of the results. Due to its nature, it may appear that the unit is taught in isolation - but its relevance in the whole process of analysis, design and construction has been emphasized at the commencement of the unit.

In the early stages of the topic 'moment distribution', the theory and the relevant formulae are developed. This could be uninteresting to some of the students who will find it difficult to relate the theory to real life applications. It is usual for students to show signs of boredom during the early classes but later on they feel happier, as they can see the relevance of the theory.

An engineer gains valuable experience with time. It is possible that during his or her career, an experienced engineer will have the opportunity to observe that the behaviour of certain structures is different to what was predicted during the analysis and design. Unless that engineer has a strong theoretical background, it will not be possible to determine what has gone wrong in the analysis and to modify the analytical model. Experience alone will not be sufficient for this purpose; it must be backed by theory.

Value of continuous assessment

Continuous assessment makes it necessary for the students to learn progressively and to be in touch with the work at all times. The weighting or marks given to individual items such of assessment is the motivating factor for students to learn and understand. Problems in the understanding of certain aspects of the topic or unit will surface continuously and there will be the opportunity to overcome these problems in stages as they occur.

Reference to prior knowledge

In order to develop the analytical skills necessary for understanding the topic 'Moment Distribution' or to understand other topics in structural analysis, it is necessary to use techniques and skills acquired earlier in the course. The students and the lecturer need to draw from previous knowledge, experience and situations.

Value of peer support

Understanding of a unit is made easier when students get together and discuss the topics covered in class. They find that it is not until after the lecture when they go away and discuss the topics amongst themselves that they realize how much they have or have not learnt.

Access to the lecturer

Even if the need rarely arises, lecturer should be willing and happy to see students outside class time. It is important for students to know they have access to their lecture, if necessary.

CASE STUDY II: TRAFFIC ENGINEERING

1. *Students' conceptions*

The analysis of the students' discussion revealed two different ways in which learning is experienced. These are represented by the categories: learning is seen as the memorization of information specific to the unit (Category 1); and learning is seen as the understanding of information specific to the unit (Category 2).

Category No. 1: Learning is seen as the memorization of information specific to the unit.

In this category, learning is understood in terms of memorizing what is likely to be covered in the end-of-semester examination. Students with this conception have a quantitative appreciation of learning. The engagement is solely determined by the amount and type of information needed to get a particular grade:

> Well, I find when it comes to exam time, you don't care about whether you understand it. You just want the marks. Nobody wants to fail.

With their focus on the content, the students' main aim becomes one of absorption which is facilitated through note taking, summarization and recognition of patterns:

> That's why for exams you have to go through all your notes and summarize the lot. I mean that's pretty easy though. All you have to do is just follow the pattern. Just learn the pattern and that's it.

The salient features of this conception, then, are as follows: learning is about absorbing unit-specific content; it is achieved through a familiarization of lecture notes and past examination papers; and it is demonstrated through the ability to regurgitate information specific to the unit.

Category No. 2: Learning is seen as understanding information specific to the unit.

In comparison to the previous conception, learning in this category is perceived as understanding rather than memorization. Here, understanding is considered an integral part of remembering, managing novelty and meeting the requirements of professional practice:

> It's OK just putting the theory down, but until you actually use it for something useful, it doesn't mean anything to you. It is much easier to remember when it is meaningful to you.

Like the previous conception, the focus is on the content specific to the unit and to civil engineering. In this conception, however, the intention is to understand the content through note taking, participating in the lectures and tutorials, and working through a variety of examples:

> The notes aren't just enough. You have to think through it and practice it.
> For an exam you have to be thinking broader than just the notes you've got. The notes give you the information, but you have to look wider for the exam.

While the focus in this conception is on the content, the content is more in the form of underlying principles and processes:

> By going through an example like the matrix one, does that then direct our study? Does that affect the way we approach the exam? So, maybe, we would be better not to do an example as such, but discuss the process more and set an example which everyone tries to learn how to do.

Despite this focus, there is still the preoccupation with passing the course and getting a job:

> For me personally, I have learnt the process and I just go with the process. It doesn't matter how much you understand because what counts once you leave here is what marks you have and what personality you have. Once you have a job, it all goes from there.

Generally, then, the accomplishment of learning in this conception is demonstrated by the capacity to apply what is taught in the *various* contexts being examined.

2. *Lecturer's conceptions*

Category No. 2: Learning is seen as understanding information specific to the discipline.

In this category, learning is viewed as appreciating information in a deep way, i.e. realizing its value and significance so that it may be of use in a variety of situations. The intention is for the information to be intrinsically meaningful. In part, this involves the acquisition of information pertinent to the profession:

> The main aim of the unit is to introduce the concept of planning for transport in urban areas. A secondary aim is to expose students to the process involved and the analytical techniques used in urban transport planning.

It also involves being able to see how things relate to each other. From this understanding, learning is facilitated by providing students with real world examples, by adopting a questioning attitude in one's teaching, and by encouraging discussion and practical problem solving experience:

> I try to give real world examples to make the topic relevant to students.
> I ask questions (repeatedly) as part of the lecture, for example, I stop talking and ask them to work in pairs for five minutes to come up with some ideas for solving a specific problem.
> I set tutorial problems and work through them afterwards.

Learning is demonstrated through the application of particular techniques to specific transport planning problems. The factors that influence learning include: class size, time allocated to tutorials, student motivation, and the time allocated to the component:

> The main factors in helping students to learn is class size. It is also difficult to sort out problems in the tutorial time allocated. Other factors include: student motivation (This is not seen as a topic which is central to their degree. Only a few will go onto specialize in

transport); and, three lectures is a very brief segment in which to introduce the topic.

Category No. 3: Learning is seen as developing professional competence including the capacity to learn.

While it is the lecturer's ultimate intention that students who elect to do the unit in fourth year develop professional competence in the area of transport planning, in the third year component the objective is for all students to acquire a basic understanding of the nature of transport planning. With this experience, it is understood that students will be able to make a more informed decision about their course of study for fourth year.

In this context, then, the conception of learning as developing professional competence is an ideal one rather than a working one. It is ideal in the sense, that while the lecturer values it as a relevant understanding, it is not regarded as being appropriate in the present situation.

Category No. 4: Learning is seen as personal change in attitudes, beliefs and behaviour.

In this conception, learning is seen as personal development as well as professional development:

> I think learning is the acquisition of new knowledge leading to personal development. It is also the acquisition of the ability for critical thinking and self-development. As a result, the teacher's aim is not to 'put into the mind knowledge that was not there before... but to turn the mind's eye to the light so that it can see for itself' (Plato, *The Republic*)

Again this appears to be an ideal conception. There is no evidence in the data that reflects this as a working or enacted conception, although, it is acknowledged that the lecturer's approach to teaching may be influenced implicitly by the conception.

Comparing the lecturer's and students' outcome spaces, it is evident that at one level there is a high correlation between the lecturer and the student with respect to their understanding of learning (Fig. 1). It is also evident that the lecturer's aspiration for a higher level of learning is not being realized by the students. In part, this can be attributed to the fact that the traffic engineering component represents only a small component (three lectures) of the unit.

3. *Discussion*

The main issues to arise from the group discussions can be conveniently categorized into three headings, namely: the role of the lecture; learning outside the lecture; and the role of assessment. A summary of the issues raised by the students is given in this section.

The role of the lecture

From the discussion, the students generally felt it important that the material covered in lectures relates to practical applications. The frequent use of 'real world' examples is essential for three reasons, namely: to make the material relevant and therefore worth learning; to make the 'theory' fit into relevant applications; and to reinforce the potential uses of the topic in a future career.

In the case of urban transport planning, civil engineering students find it difficult to relate the material to a future career in their chosen profession. This is in spite of the fact that it is common for transportation planners to have a civil engineering background. However, at the third year level, many students see themselves as structural or other 'mainstream' civil engineering specialists.

On the issue of how much information should be given out to students in the form of hand-outs, it was interesting that most students agreed that hand-outs should leave room for students to make their own summaries of lecture content. The use of hand-outs should be restricted to more detailed flow-charts to save 'note taking' time. Students should be given the opportunity to fill-in the 'gaps' during the lecture. Understanding will be enhanced if notes taken during the class are mainly students' summaries of the material covered.

The frequent use of questions by the lecturer is useful in helping with the writing of notes during the lecture. Students need to be able to ask questions either during the lecture or soon afterwards (e.g. in a tutorial class). The lecturer's approach to classroom interaction has a significant influence on how much students will learn in a subject. The use of discussion as part of the lecture was strongly supported.

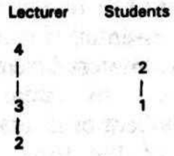
Class size was considered important in learning outcomes. Large classes were universally condemned as they discourage interaction with the lecturer.

Learning outside the lecture

Discussion centred on the need for tutorial sessions so that students could work in smaller groups and applying what was taught in the lectures. Students need to feel they can ask the 'silly questions', without feeling intimidated by the lecturer or tutor. Each tutorial session should be related to the lecture which just precedes it. Tutorial problems should be short so that students know that they will be able to solve them in the allocated time.

The role of assessment

The use of continuous assessment was preferred by students as a means of obtaining feed-back and hence improve understanding of the topic. Final examination seems to play a large part in what is learnt, as well as with respect to the learning process itself. In this particular topic, students appear to be almost totally driven by the final examination. Traffic engineering is not part of the 'core' of civil engineering disciplines. Therefore, students may be more inclined to look upon it as



Notes
1 = Learning is seen as memorising information specific to the unit/discipline.
2 = Learning is seen as understanding information specific to the unit/discipline.
3 = Learning is seen as developing professional competence.
4 = Learning is seen as personal change in attitudes, beliefs and behaviour.
-- = Link to an "ideal" conception
— = Link to an "actual" conception

Fig. 2. The outcome spaces for learning urban transportation planning.

interesting but not essential material for a future career. This may partly explain their almost total focus on assessment as the driving force behind learning effort and process. However, the group discussions suggest that assessment-driven-learning is widespread. For example, one group discussed at length the fact that the entire course is not structured in a way which is conducive to learning ('we learn to get marks, not to understand it'). The time pressure means that what is not assessable is not learnt, and what is learnt is done to maximize final marks.

CONCLUSION

In summary, the study identified three different, yet interrelated, ways in which learning was conceptualized by a group of civil engineering students and two of their lecturers. At the most fundamental level, the students saw learning as acquiring knowledge for the purposes of getting a qualification and securing employment. Consequently, when there was little perceived relevance, as with some students in Case 2, they adopted an atomistic/surface approach to learning. This was characterized by an emphasis on the content to be assessed and by a concentration on the literal aspects of the tasks. Where the students were involved with content more directly in line with their expectations, as in Case 1, their learning was more holistic. Within this deeper frame-of-reference, they focused on relationships and the 'reality' of the situation. This second conception of learning as understanding is exemplified in the following extract from the students' discussion:

> That's like some of the subjects; you're given work to learn that is a small picture of a bigger picture. For me, I can't understand the small part unless I've got an overall idea of where it fits in.

For both lecturers, this was the approach to learning that they sought to encourage. In general, the lecturers' saw learning as acquiring knowledge for the purpose of being able to act in a professional (expert) manner. With this conception, teaching focused on the content related specifically to the discipline. Through note taking, questioning and revision, and problem solving, discipline-specific information was understood to be absorbed. Learning in the context was viewed to be effective when the information absorbed was appropriately applied to various 'real world' problems.

In conclusion, the study highlighted the necessity for lecturers to understand the factors motivating students to learn. The overall approach adopted by most students was shown to be related to their expectations of their role in the discipline. With the emphasis in teaching on active learning using 'real world' examples, students were able to adopt a deeper approach to learning.

The study also highlighted other factors which supported a deeper approach to learning. These included: the need for the lecturer to be available to answer questions either during the lecture or afterwards; the need for 'note taking' by the students themselves during the lecture, and hence the requirement that lecturers provide the opportunity for this to occur; and, the need for lecturers to consider more closely the impact of assessment and workload on student approaches to learning.

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Luis Ferreira is a Senior Lecturer in transportation in the School of Civil Engineering, Queensland University of Technology. He graduated with a B.Sc. in aeronautical engineering from Queen Mary College in 1974. He obtained an M.Sc. in transport planning and management from the University of Westminster in 1976 and a Ph.D. from the University of Leeds in 1984. He has had 20 years experience in transportation planning, research, management and consultancy. His current research interests include urban travel demand modelling; transport evaluation methodologies; and the use of optimization techniques in railway operations and planning.

David Thambiratnam obtained his B.Sc. (Engin) degree in civil engineering, with first class honours, from the then University of Ceylon, and his M.Sc and Ph.D degrees in structural engineering from the University of Manitoba, Canada, where he was a Commonwealth Scholar. David has extensive industrial, teaching and research experience in structural engineering and has worked in Sri Lanka, Canada, Singapore and Australia. Currently, he is a Professor in structural engineering at the Queensland University of Technology and his research interests include, structural dynamics and vibration, earthquake response of structures and finite element modelling of structures. For the past 10 years, he has been involved in several activities with the objective of enhancing teaching and learning at University level.

Jill Franz is Co-ordinator of Interior Design and Chairperson of the Research Committee in the School of Architecture, Interior and Industrial Design, Queensland University of Technology. Jill's qualifications include a Bachelor of Applied Science (Built Environment) from the Queensland Institute of Technology, a Diploma of Teaching from the Brisbane College of Advanced Education and a Master of Educational Studies from the University of Queensland. Current research includes a Ph.D. in design practice.