Learning About Learning Styles: Can It Improve Engineering Education?

Julie Mills  
School of Natural and Built Environments  
University of South Australia  
Adelaide, South Australia

Mary Ayre  
Centre for Lifelong Learning,  
University of Glamorgan  
Pontypridd, Wales, United Kingdom

David Hands  
Submarine Corporation, formerly from School of Advanced Manufacturing and Mechanical Engineering  
University of South Australia  
Adelaide, South Australia

Pam Carden  
Centre for Research in Education, Equity and Work  
University of South Australia  
Adelaide, South Australia

Abstract

Individuals vary in the ways they prefer to receive, process and demonstrate their knowledge. Research suggests that mismatches between lecturers' expectations of the way students learn and students' own individual preferred learning styles lead to students' lack of motivation and interest, and may cause attrition. This paper describes how a teaching project at the University of South Australia aimed to achieve improvements in student satisfaction by redesigning approaches to teaching, learning and assessment of engineering courses to accommodate a range of learning styles.

Introduction

The Learning Styles project at the University of South Australia commenced in 2001 with a teaching and learning grant awarded to two of the authors. Whilst much of the professional development work and data collection in the project was completed in the first two years, the major achievement of the project has been the embedding of "Learning about Learning Styles" within the engineering programs. The project encompassed the three Departments of Engineering: Advanced Manufacturing and Mechanical Engineering, Electrical and Information Engineering, and Geoscience, Minerals, and Civil Engineering. The project had a teaching and learning focus, rather than research, with the primary aim of improving student and staff knowledge of individual learning styles and through this to increase understanding and improve satisfaction with teaching and learning across the three Departments. Improvement focused on widening the range of teaching, learning and assessment strategies currently
employed in recognition of the variety of learning styles present in classes of diverse students. This follows research findings that engineering students' motivation and success can be adversely affected if their learning styles, and the learning styles of the staff teaching them, are not taken into account (University of Western Australia, 1996; Felder, 1996).

Research on learning styles suggests that in engineering courses, learning is optimised by the application of different learning styles to these courses. Yet most engineering lecturers assume not only that all students adopt (or should adopt) a uniform learning style, they expect the same learning style to be applied to all areas of engineering studies (Felder, 1993, 1996; Holt & Solomon, 1996). This project set out to encourage engineering faculty to challenge these assumptions.

The project was developed with an 18-month implementation timeline and had two main aims. Firstly, the project team planned to foster an understanding of the variations in learning styles amongst students whilst presenting them with methods for coping with differences between learning and teaching styles. Secondly, the project aimed to raise awareness amongst teaching faculty of the variations in learning styles of their students, of the potential differences between their teaching methods and the learning styles of the students, and strategies to overcome these differences. The team was careful to point out that there was no expectation that differences would be catered to on an individual basis. Rather, the expectation was that faculty and students would be aware that differences exist, that not all styles could be catered to all the time, but that all styles could be catered to for some of the time.

Learning Styles

The term 'learning styles' refers to the ways individuals and members of cultural groups prefer to receive, process and present information and ideas. Some people, for example, find it easier to understand a new concept by reading a textbook, whilst others prefer a pictorial explanation. Likewise, people may vary in how they most effectively demonstrate their understanding: graphically, verbally, or in writing. David Kolb (1984), one of the main classifiers of learning styles, identified the four basic learning styles as: convergent (good at problem solving, decision making, and the practical application of ideas); divergent (good imaginative ability and awareness of meaning and values); assimilative (good at inductive reasoning and creating theoretical models); accommodative (efficient in carrying out plans and like getting involved in new experiences). He found that engineers usually have a convergent learning style.

There is some debate about the main influences on learning styles, with some authors (Felder, 1996; Kolb, 1984; Briggs-Myers, 1989) seeing the main influences as personality, life experiences, and the purpose of the learning. Others (Ballard & Clanchy, 1997) identify a particular set of life experiences: the expectations of teachers, as the dominant influence on learning styles.

Whatever the causes of differences in learning styles, there is considerable evidence of disadvantage to students arising from a mismatch between lecturers' expectations of the way students learn, and students' own individual preferred learning styles. Research suggests that these mismatches in learning styles lead to lack of motivation and interest in students, affecting students' success, and causing attrition (University of Western
Other authors (Anderson, 1991; Beyer, 1993; Harding, 1996) have looked at gender and cultural influences on learning styles, and at differences between the learning styles of mature-age and younger students. Knowledge of these gender and cultural differences are important both for equity reasons, and to support the academic welfare of international students. However, it is acknowledged that the whole field of learning styles is viewed as somewhat controversial. There are two reasons for this controversy: firstly, the danger of stereotyping - assuming that all women, or all international students, for example, will have the same learning styles. Secondly, the fear that learning methods that differ from those of the dominant majority may be viewed by some faculty (and some students) as less valid, or less effective than those favoured by the dominant group. Despite these reservations the evidence of improved student learning and satisfaction resulting from consideration of differences in learning styles was, in our view, sufficiently compelling to recommend this approach to improve teaching and learning.

Learning Styles and Engineering Education Holt and Solomon (1996) point out that because engineering education relies so heavily on problem solving and engineering science (Kolb's convergent and assimilative learning styles), it tends to exclude divergent and accommodative learners from effective learning. Worryingly, it also limits the opportunities of all learners to develop the skills required for proficiency in two other key areas of engineering: design and invention (requiring a divergent approach), and business management (requiring accommodative skills).

US academic engineers Felder and Silverman (1988) sum up the situation as follows: Learning styles of most engineering students and teaching styles of most engineering professors are incompatible in several dimensions. Many or most engineering students are visual, sensing, inductive, and active and some of the most creative students are global; most engineering education is auditory, abstract (intuitive), deductive, passive, and sequential. These mismatches lead to poor student performance, professorial frustration, and a loss to society of many potentially excellent engineers.

An alternative to Kolb's system for identifying learning styles is the Myers-Briggs Type Personality Indicator (Briggs-Myers, 1989), which relates particular types of learning styles to personality types. This system categorises personality on four scales, giving rise to the identification of 16 personality ‘types’. A study by Kramer-Koehler, Tooney and Beke (1995) used the Myers-Briggs test in two consecutive years to assess the learning styles of all first-year (about 200) engineering students at a New York university, and found that only 16% of the class had the ‘typical’ engineering personality profile of ISTJ (Introvert, Sensors, Thinkers, Judgers). On the basis of the class learning styles profile identified, a new core curriculum was designed which introduced engineering science and mathematical concepts only on a “need to know” basis, and incorporated cooperative learning and the development of oral and written communication skills, at the expense of lecture-based teaching: first year retention rates improved by 50% as a result. Felder, Felder and Dietz (2002) conducted comparable research at another American university, and concluded that the restructuring of course instruction to allow for all learning types led to improved student outcomes.

Richard Felder (1999) has devised a learning style model and inventory for use especially in the engineering and science disciplines. Combining the work of Knowles and Myers-Briggs, this instrument assesses students on four dimensions of preferences,
using 44 questions each with answers (a) or (b) corresponding to one or other extreme of the dimension (eg. active or reflective). The four dimensions are

- **active - reflective** This dimension refers to processing of information. Active learners prefer trying things out and working with others. Reflective learners prefer to think things out and work alone.

- **sensing - intuitive** This dimension refers to ways of receiving information. Sensors like learning facts and using tried methods in practical settings. Intuitors are innovative and enjoy abstract concepts.

- **visual - verbal** This dimension refers to ways of perceiving sensory information. Visual learners relate well to graphs, pictures, diagrams etc. Verbal learners enjoy reading and lectures.

- **sequential - global** This dimension refers to progress toward understanding. Sequential learners prefer taking logical steps toward an outcome. Global learners grasp the big picture quickly and work out the steps later. (Adapted from Fowler, Allen et al. 2000)

These dimensions are assessed as continuum where a learner may be located at any point on the axis between the two extremes. The scoring system ranges from 11a to 11b for each of the four dimensions, with only odd number results possible. For example, if a learner scores 1a or 3a on the active-reflective dimension it would indicate that they have a mild preference for active learning styles, whereas a score of 9b or 11b would indicate a strong preference for a reflective learning style. Scores of 5a or 7a would indicate a moderate preference for the active learning style.

Overall the literature supports the notion that Engineering students have a diversity of learning styles but that few courses are structured to cater for this variety. Studies have shown, however, that once faculty awareness has been raised and the teaching adapted to accommodate all learning styles, student outcomes and attrition rate have responded positively.

**Project Methodology**

The Felder instrument described previously, known as the 'Index of Learning Styles' (ILS) was originally developed in 1988 and has been widely used for a number of years in several universities. A summary of applications and an assessment of the reliability and validity of the instrument has recently been published (Felder and Spurlin, 2005), and concluded that the ILS is a suitable instrument for assessing learning styles, based on reliability and validity data. It was also concluded that the ILS has two major applications, firstly "to provide guidance to instructors on the diversity of learning styles within their classes and to help them design instruction that addresses the learning needs of all of their students" and secondly to "give individual students insights into their possible learning strengths and weaknesses" (Felder & Spurlin, 2005, p.110). These were exactly the purposes for which the ILS was employed within this project. The latest version of this instrument (Felder, 1999) was used to assess the learning styles of engineering faculty and students in this project.

The team began by presenting as many students as possible with the self-assessment ILS questionnaire so that each individual student would be aware of their preferred learning style. Team members attended lectures for a variety of first and third year courses and gave students a comprehensive overview of what the findings may mean.
Strategies for coping with difference were also handed out, and students were encouraged to retain their results for future reference.

Concurrent with the approach to the students, the team held workshops and discussion sessions for faculty members to raise their awareness of the differences they may encounter amongst students in each class. To this end the collated results of the student questionnaires were returned to faculty members. Faculty were also asked to complete the ILS questionnaire themselves so they were aware of their own learning preferences. Discussions were held over ways and means of presenting coursework in a variety of ways that catered for all learning styles some of the time.

In Semesters 1 and 2 in 2001 and Semester 1, 2002 most first year students and some second and third year students across the three departments had completed the learning styles assessment. This was also extended to a cohort of engineering students in Singapore and to students accessing the bridging program course ‘Introductory Communication’. Student assessments were collated in course groups and the group analyses provided to faculty teaching these courses. Students retained a copy of their own assessment for future reference. A summary of the number, year level and department or course of the students tested in each semester is given in Table 1.

It is possible that the results of about 10% of the nearly 700 students tested appear twice in that table. The first time the ILS questionnaire was administered to students, in Semester 1, 2001, it was distributed in orientation week to department first year cohorts who were present at the time, thus students were not within a particular course. The second time it was administered, in Semester 2, 2001, it was given to 7 course groups across years 1 to 3. Two of these groups were first year groups, therefore some first year students may have completed the questionnaire twice. Since all results were returned for processing anonymously, no individual student could be identified thereby making it impossible to eliminate this duplication from the results graphs. However, as the intention of the graphical results was to inform faculty about the general range of learning styles of students in their course or department, this was not considered to be a problem. For students who undertook the questionnaire more than once, this was considered by the project team to be a useful way of providing reinforcement of the importance of understanding personal learning styles to those students.

At the same time that students and faculty were being introduced to the Learning Styles Project, the project team began building a website to provide more comprehensive knowledge of the project and of learning styles in general. The website was designed as a device for dissemination of information and ideas for use by both faculty and students. As well as giving basic information on learning styles and the ILS questionnaire, the site outlines strategies for teaching and learning incorporating the variety of learning styles amongst students. An annotated reference section and a discussion board are also featured with the intention that it will remain an ongoing and evolving outcome of the project. http://www.unisanet.unisa.edu.au/lsproject/learning_styles_home_page.htm
## Improving Faculty and Student Understanding of Learning Styles

Since the aim of the project was to raise awareness of the diversity of learning styles amongst both faculty and students, dissemination of information was tackled at two levels. For faculty it was important that they realised the variation of learning styles that existed amongst students in their courses and tried to work towards catering for all types in their teaching. For students it was necessary that they knew and understood their own preferred learning style, but it was also important to give them information on how they might work around differences between their learning style and the teaching they received.

### Faculty
To assist faculty to improve their understanding of learning styles, the project was launched in late 2000 with a workshop for all faculty who had volunteered to take part.
(21 faculty members, spread quite evenly across the three departments and representing about 35% of the academic faculty in the three departments). The first workshop activity involved faculty assessing their own learning styles using the Felder ILS questionnaire. These results were collated and have been compared with student results in Table 2. Faculty then discussed how learning styles could influence teaching, how they could reassess their own teaching methodology and, where necessary, how to modify it to accommodate the wide range of student learning styles. A follow-up workshop was held at the start of 2002. This reiterated the importance of understanding what learning styles are and how differences can affect student performance. Strategies for changing teaching styles were discussed with the emphasis on the need for minor adjustments rather than viewing it as a major undertaking.

Faculty who had opted into the project met together informally, and the discussion generated at these meetings contributed to an informed approach in broadening teaching and assessment methods. At a meeting early on in the project, for example, the implications of the learning styles profiles shown in Figure 1 were discussed, in particular, students’ marked preference for visual learning styles.

**Students**

In Semester 1, 2001, 116 students were assessed during Orientation week from four Engineering courses, Engineering Materials N, Engineering Physics, Computer Graphics for Engineers, and Science for Engineers. This involved not just the administration of the questionnaires, but addressing the students about the meaning of learning styles, the aim of the project, and the strategies they can take to adapt their learning to diverse teaching styles. The project was also expanded to include the course Introductory Communication, which was seen to have added benefit, as this course is a component of the University access bridging programs, which allow entry into all the University's science and technology programs. Many of these students subsequently entered non-engineering programs, thus spreading the learning styles discussion beyond the boundaries of the three engineering Departments. Following all the assessments the results were collated and presented to lecturers to enable them to identify the various learning styles of students in their courses. All students were advised to retain a copy of their Learning Styles assessment so they could reflect on the result and develop strategies for coping with any discrepancies they may encounter between their preferred learning styles and faculty teaching styles.

In the first week of semester 2, 2001 a total of 365 students across the three Departments of AME, GMC, and EIE and across undergraduate year levels 1 to 3 were assessed. Members of the project team again spoke to the students giving them an outline of the learning styles and how students could use the knowledge of their individual styles to help with their learning. Following assessment, individual group profile and total student results were circulated to faculty, and course coordinators provided feedback to students.

The data collected from engineering students in both semesters 1 and 2 of 2001 (i.e. excluding the Introductory Communication cohort) has been aggregated to construct the learning style student profiles shown below (Figure 1). Comparative graphs of student and faculty (21 responses) results were also made (Figure 2). The vertical axis in each graph represents the % of students (and staff in Figure 2) from the total number assessed (478 students and 21 staff) who scored that value on the learning styles continuum for each dimension. The horizontal axis represents the student or staff
members' scores on the Felder scoring system explained previously.
Figure 1: Felder Learning Styles student group profile, all engineering departments 2001
In the above graphs, a score of 1-3 indicates a mild preference for one or the other (a or b) dimension but shows an essentially well-balanced approach to learning. A score of 5-7 indicates a moderate preference for one dimension of the scale and shows that a student will learn more easily in a teaching environment that favours that dimension. A score of 9-11 indicates a strong preference for one dimension of the scale and implies that a student may have real difficulty learning in an environment that does not support that preference.

The most notable characteristic of the student learning styles profiles (Figure 1) is the strong skew towards visual, as opposed to verbal, learning styles. The other learning styles are fairly evenly spread across the range, though no students at all were assessed as strongly sequential learners and there is a stronger tendency towards
sensory rather than intuitive learning. The extension of the questionnaire to a cohort of engineering students in Singapore was undertaken to explore any cultural differences or similarities in learning styles compared with the results from South Australian students. The team found little difference between the two campuses.

Whilst some allowance needs to be made for the different sample sizes in drawing conclusions from Figure 2 (478 students, 21 faculty), these graphs demonstrate the variation of styles amongst all participants, but specifically the similarities and differences between faculty and students. There were relatively few differences between faculty and students in the sensory/intuitive, visual/verbal and sequential/global dimensions. There were marked differences, however, in the active/reflective dimension, showing a clear preference for active learning amongst students but with strong preferences for reflective learning by faculty.

Finally, at the start of semester 1, 2002, information about learning styles was again passed on to students from courses in first and third years. 147 students were assessed and results were circulated to faculty who reported back to the students. These results showed no marked differences with those obtained in 2001. Learning styles assessments have continued for all first year students since 2002, but the data has not been collected, rather the purpose has been for student development.

### Developing and Implementing Teaching, Learning, and Assessment Strategies and Resources

The lecturers who opted into the project were requested to demonstrate how they would ensure their teaching methods would accommodate all learning styles, and to develop new resources if necessary. As was to be expected, each lecturer tackled this requirement in a different way. An example of one of the approaches utilised follows.

#### Engineering Materials

The lecturer of this first year, Semester 1 course provides all students with a 'Tutorial Book' that outlines how the course is structured and the tutorial schedule. It also provides reference material, details about assessment methods, and other general information. Since the inauguration of the Learning Styles Project the Tutorial Book contains an additional page that explains how the teaching, learning and assessment methods employed in this course cater for all learning styles. This additional page is summarised here:

- **Lectures** illustrated with photographs, sketches and graphs, cater for both visual and verbal learners. They are designed in a logical progression of facts and concepts, and thus also cater for sequential learners.

- **Tutorials** are mainly problem-solving exercises, which should be attempted before the session, either in groups or individually, catering for active or reflective learning styles. When appropriate, group work is also permitted in the tutorial itself. Demonstrations and videos assist those with visual and sensing learning styles.

- **Case study sessions** require group work, catering for active learning styles. Within the group, students are also expected to perform individual tasks, which is where reflective learning is required. Groups in which all learning styles are represented will be those
which work most effectively. The sensing and sequential learners will contribute their logical thinking and apply the established procedures to the problems while the intuitive and global learners will more readily solve complications and look at the overall problem.

**Assessment** has 3 components which are sufficiently varied in format to cater for all learning styles: assessment of the case studies, regular quizzes, and an examination. Marks for the first 2 components are awarded in the ratio 3:7, and only those students who achieve less than 50% for these two components have to take the exam. Students who score 50% or more and choose not to attempt the exam will maintain their combined continuing assessment mark up to a maximum of 74%. For the students with a continuing assessment mark of 50% or more, the exam is a means of improving their overall mark.

**Evaluations**

At the end of semester 2, 2001, and the end of semester 1, 2002, a learning styles specific evaluation was administered to several courses involved in the project in which students were asked to evaluate their own understanding of learning styles and how teaching relates to them. The main purpose of these evaluations was to determine whether the Learning Styles project had been effective in raising awareness amongst students about learning styles and whether students felt that teaching in the course addressed their preferred learning styles. Results were forwarded to respective faculty members responsible for teaching those courses.

**Findings from Evaluations 2001** Only 35% of the students evaluated in semester 1 felt they had improved their understanding of learning styles, (this includes those who did not do the assessment in orientation week,) with 78% indicating that they did not feel that the teaching in the course had specifically addressed their preferred learning styles or didn't know if it had. All students evaluated in Semester 1 were in first year courses. Semester 2 evaluations showed a marked improvement with 58% of students reporting that they had improved their awareness of learning styles in the courses. Some of the first year students would have been exposed to Learning Styles assessment in both orientation week and their second semester courses and hence also received the evaluation twice. Students evaluated in later year courses in semester 2 had received only the exposure to Learning Styles incorporated within their courses that semester. The discrepancies between the two semesters suggests that either the link between teaching and learning had not been made strongly enough in the first place, or there was a need for reinforcement of learning styles throughout the year, particularly for early year students..

**2002** Evaluations in Semester 1, 2002 gave similar results to Semester 2, 2001 with the first year course, Introduction to Electrical Engineering, having all students recalling learning styles (although a small sample (16 students)). This course also had the best response to the positives of the teaching in the course. It should be noted here that this was the only course that outlined in the course handbook what learning styles are before outlining how the course was addressing the issue.
Overall, findings from the evaluations suggest that:

- There is, in the main, a lack in course design that addresses learning styles specifically
- Learning styles should be reinforced at regular intervals throughout the year (to students and faculty)
- Details of how different learning styles can affect learning need to be included in handbooks, not just how the course will address them

**Mainstreaming of Learning Styles Understanding**

One of the final challenges facing the project team was that of ensuring that the progress made in the engineering departments during the project, regarding student and teacher awareness of learning styles, was not lost as soon as the funded project was completed. The concept of "mainstreaming" the project approaches into the ongoing teaching and learning practices of the departments was adopted to address this, through both faculty and students.

**Mainstreaming via Faculty**

The team perceived this to be a two way process using 'directive down' and 'encouragement up' to get the required results. A mentoring system was informally instigated during the project time frame with committed faculty members passing on information and ideas to colleagues. This system has continued with informal, collegial discussions being held to maintain awareness of the project and subsequent presentations made by one of the authors at teaching workshops within the Division. It was also recommended that this should be picked up through the portfolio of the Dean, Teaching and Learning, with Learning Styles figuring as part of that umbrella.

The project team also requested that Heads of Departments direct faculty to include a section on Learning Styles in each course handbook. This would encourage faculty to constantly rethink their teaching practices in line with divergent learning styles. The web site will be a valuable tool in this process.

**Mainstreaming via Students**

A specific session on Learning Styles has been allocated during Orientation week each year since 2003 so that as many first year engineering students as possible are informed of the implications of learning styles for learning and teaching. This session is conducted by the first author often with support from campus Learning Advisors. Reiteration of the value of learning styles needs to done at regular intervals throughout the year and it is hoped this will be done at all year levels by those faculty who have been actively involved in the project, with 'refresher’ ILS questionnaires allowing students to note any changes as they progress through their university career. This can be achieved through the web site, where students can also access the 'Strategies for learning' page to help them in their course work.
Conclusion

There is considerable evidence from previous studies to show that faculty assumptions about "typical" learning styles of engineering students are inaccurate and that a wide range of learning styles will actually exist within any engineering class. This has been reinforced again by the results of the current project. It is therefore important to raise the awareness of faculty responsible for engineering education about the likely effects on student achievement if teaching and assessment practices do not accommodate this range. This paper discusses a project that focused on awareness raising, and education about learning styles, for both faculty and students in a variety of engineering disciplines at the University of South Australia. The primary requirements for improved teaching and learning in this area are improved knowledge and understanding of learning styles, and reflection on practice, followed by any necessary modifications to practice in the light of this knowledge. The project initiated a process for faculty and students to achieve this, but also highlighted the necessity for mainstreaming this process if the improvements to teaching and learning are to continue. The Learning Styles Project web site is an important resource to support mainstreaming. Another strongly recommended strategy to achieve mainstreaming is to include learning styles information in course handbooks along with the web site URL, giving students, as well as faculty, continuing access to information on all aspects of learning styles.

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