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# Empowerment to Learn in Engineering: Preparation for an Urgently-Needed Paradigm Shift\*

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This article describes a study funded by the National Science Foundation (USA) that seeks to understand the relationships between college engineering students' ways of learning and their professors' and instructors' ways of teaching. Phase 1 of the study involves an investigation of the learning styles, preferences and study habits of approximately 1,000 first-year engineering students at a large, research-oriented, public university in the USA. A battery of learning style inventories, surveys and questionnaires, and weekly journal-like responses to focused questions provides the basis for correlations between these dimensions of students' experiences and their academic success and retention. Focus-group interviews with randomly selected participants provide qualitative exploration of the statistical results. In Phase 2, teachers' instructional preferences, assumptions and ideologies are studied in order to find matches and mismatches between engineering students' profiles and the curricular and pedagogical experiences they have in college. The results of the study provide information for the revision of engineering curricula, the pedagogical training of engineering faculty and the preparation of engineering students for the academic challenges of higher education in the field.

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## INTRODUCTION

Recent research shows that only 43% of students who enter engineering programmes in American colleges and universities complete a degree in engineering [1]. Many of these students give up their pursuit of an engineering degree by choice; others are unable to learn successfully within engineering curricula, and enter alternative majors where they are more successful. Although it is tempting to interpret this poor retention rate in social Darwinist terms (the rigor of high expectations eliminates the low achievers,

while the best students rise to the top), administrators at many colleges and universities are concerned. First, high standards are what admits these students to engineering programmes to begin with, yet something fails in their initial educational experience, causing them to abandon an engineering degree. Second, the supply of well-trained engineers is not meeting a growing demand, which is expected to increase by 25-30% [2].

Under these circumstances, higher education cannot afford to *skim off* half of all entering engineering students. Consequently, there is an urgent need to investigate the relationship between the beliefs and learning strategies that new engineering students bring to their college programmes, and the educational experiences they have when they begin those programmes, to better determine those factors that contribute to students' success (and retention) or their failure (and disillusionment).

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The study described in this article seeks to undertake the following:

- Understand the relationships among first-year engineering students' learning styles, attitudes and academic success.
- Examine in detail the learning styles and strategies engineering students typically use in their approaches to learning specific content material in their engineering and science courses.
- Determine differences between the strategies employed by successful and unsuccessful students and relate these to retention.

In a second phase of the study, the results from Phase 1 are used to create instructional interventions for students to increase their success and levels of retention in engineering programmes. Efforts at faculty development can simultaneously improve engineering teachers' approaches to teaching and learning.

## SYMBIOSIS IN TEACHING AND LEARNING

Scientific evidence strongly supports the effectiveness of active learning and teaching. [3]. As Felder et al have put it, more student-centred approaches to instruction

*... have been shown in study after study to have positive effects on students' academic performance, motivation to learn, and attitudes toward their education and toward themselves [4].*

Yet while active learning has been used in many fields of instruction, much engineering education adheres to an old paradigm that treats students as passive recipients of knowledge transferred by *master* teachers. Many educational experts believe that a serious effort is needed within engineering programmes to prepare students for these *traditional* curricula (especially those students who do not learn best with such approaches), while simultaneously reforming teaching methods through new efforts at faculty development and curricular enhancement.

Although such enhancements have helped to inform faculty how best to teach in a more active, student-centred environment, the scientific literature on engineering education has little to say about how best to learn in this paradigm. Because active learning shifts many responsibilities to students, for example, they need to be skilled enough to be successful in their new role. However, a recent informal survey of 100

engineering students at North Carolina State University, Raleigh, USA, showed that the students strongly believe that teaching practices found highly effective in an active learning environment are ineffective. An overwhelming number of students considered *requiring them to search and generate information on their own* a bad teaching practice.

Such mismatches between students' expectations and teachers' strategies suggest the difficulties of reforming engineering curricula. Studies of learning styles show that some students are attracted to abstract, *what if* kinds of learning, preferring the hypothetical and theoretical over the concrete and specific. Other students are the opposite [5]. Some students are more disposed to action in their learning, or practicing and performing, while others are more disposed to reflecting and imagining (see Figure 1).

Similarly, faculty bring various levels of knowledge and beliefs about pedagogy to their teaching, some preferring a lecture/test approach in which they are the *sage on the stage*, and others preferring to be *guides by the side*, engaging students in active learning and hands-on applications of concepts. Studies of the way teachers respond to students' writing have shown that just as students can be *dualistic* or *reflective* thinkers, so can instructors [6]. Similarly, *received* methods of instruction place students in a passive role, which educational research has shown to be a less effective way to teach than more problem-based, project-centred and active learning methodologies that engage students in their studies and challenge them intellectually. Yet students may be so indoctrinated into these traditional methods that they interpret healthier pedagogical strategies as ineffective, resisting them as *busy work* and preferring modes in which they do not need to be fully engaged in their learning.

Given this diversity of approaches (and an increasing emphasis on active learning in some engineering programmes), the potential for mismatches between students' learning styles, preferences and practices on the one hand, and teachers' pedagogies on the other, is considerable. To understand and solve such mismatches requires seeing education as a kind of symbiosis involving complex relationships between students' and teachers' beliefs and practices.

To explore these relationships, more robust research is needed to relate various aspects of what students bring *to* their educational experience – in the form of knowledge, attitudes, beliefs, strategies, skills and ways of learning or thinking – and what experiences they have when they enter the college environment. Levin and Wyckoff, for example, in studying factors that contribute to the persistence and success of

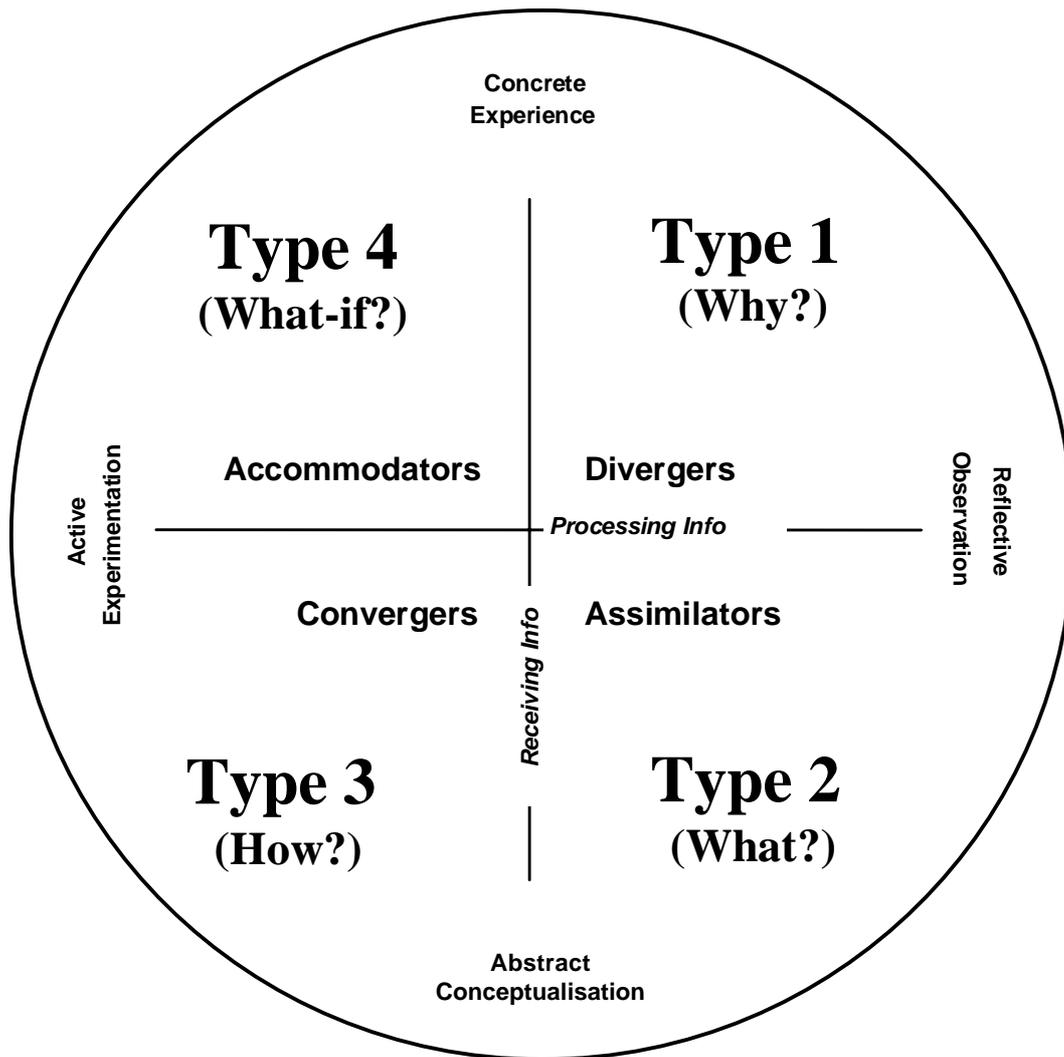


Figure 1: Model of Kolb's main learning styles, which combines Kolb's Learning Styles Inventory [8] and McCarthy's 4MAT model [9], from which the Learning Types Measures (LTM) were developed [10].

engineering students, identified six predictive pre-enrolment factors: high school grades, placement test scores in algebra and chemistry, gender, focus on science interest and reasons for choosing engineering. Predictors at the end of the first and second year of college study included grades in specific science and mathematics courses [7].

While such studies show relationships between retention and basic measures of success, they examine mostly external factors subject to the criticism of the self-fulfilling prophecy: successful students are successful, and therefore continue in and finish their programmes of study. Little is known, for example, about why some successful learners (those who bring motivation, skills, knowledge, good prior performance and high IQs into college [8]) fail to thrive in engineering programmes, often transferring into other courses of study where they become successful and complete their degrees.

## THE CURRENT STUDY

A new research effort led by the authors has surveyed over 1,000 first-year engineering students who started their college careers in mid-August 2002. The main data collection tools included three survey instruments: the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS); the Learning and Study Skills Inventory (LASSI); and the Learning Type Measure (LTM). In addition, students responded to weekly surveys designed to assess their attitudes towards various aspects of learning, as well as more open-ended questions that elicited journal-like written responses.

The PFEAS is a multiple-choice survey consisting of 50 items that tap into incoming engineering students' attitudes in 13 key areas, including their general impressions of engineering, what they think engineers do and how they contribute to society, how they feel about working in groups, and how much they enjoy

science and mathematics courses [9]. A typical item from the PFEAS, for example, is a statement, such as a reason for studying engineering, with which the student strongly disagrees, disagrees, agrees, strongly agrees, or is neutral. The Pittsburgh survey has been used and tested extensively [10-13].

The LASSI survey consists of 80 items designed to gather information about students' study habits and practices, and their awareness of how study strategies relate to skills development and learning. Students are presented with options that they rate on a scale of relevance to themselves. The survey elicits information on ten scales: Attitude, Motivation, Time Management, Anxiety, Concentration, Information Processing, Selecting Main Ideas, Study Aids, Self Testing and Test Strategies [14][15]. On the Anxiety scale, for example, an item might include the statement, *When I am studying, worrying about doing poorly in a course interferes with my concentration.*

Among the surveys used in this study, the Learning Type Measure (LTM) is the most important because it provides a profile of a student as a learner. The LTM is based on the work of learning theorists and provides a profile with affinities to the model developed by Kolb (see Figure 1) [16]. The 26-point questionnaire *measures individual preferences for selecting, organising, prioritising and representing knowledge, information and experience* [17]. For example, students decide whether they learn best collectively or alone, or whether they have difficulty with instructors who follow rules or who are emotional.

The results of the LTM place the learner into one of four categories, with possible overlaps among them. Type 1, *why* learners (*divergers*) prefer listening and discussing ideas, and learn best by relating new ideas to prior knowledge and personal experiences. They are comfortable in situations that allow them to use language strategies to connect people to ideas. They thrive in environments where there is respect for everyone's ideas and where divergent thinking, opinion generating and subjective interpretations are encouraged [18].

Type 2, *what* learners (*assimilators*) have a preference for critiquing information and collective objective data that support their ideas. They learn best by assimilating abstract facts into coherent theories, preferring to form judgements based on verifiable data. They are most comfortable in situations that allow them to use their *tough mindedness* to deduce correct and precise answers.

Type 3, *how* learners (*convergers*) prefer experimenting and testing ideas. They learn best by using *down-to-earth* problem-solving strategies to make

sense of ideas. They like to work with concrete, real-life circumstances and to test whether something is workable. They do best in contexts that privilege individuality and experimentation. They also excel at tasks that require straightforward, objective thinking resulting in a measurable product.

Type 4, *what-if* learners (*accommodators*) prefer original thinking and trial-and-error problem solving. They learn best by looking for patterns and relationships that connect their personal experience to new information. They are comfortable when exploring multiple applications of ideas, and enjoy creativity and originality. They know how to generate stimulating and thought-provoking discussions that have social significance. They do best in environments where there is a convergence of ideas and a respect for the unconventional.

Although most people do not represent these four categories in a *pure* way, they tend to lean towards a category in their learning styles and preferences. Thus, it is possible, based on the results of the LTM instrument, to see tendencies in learning styles among a population of the size of the cohort in the present study.

In addition to these three survey instruments, students also responded to sets of questions presented to them electronically. Some questions were presented in survey form, while others asked students to write open-ended responses. Survey questions asked students to judge the applicability of an item on a scale of *rarely*, *sometimes* and *usually*. Each week, students were presented with six such questions representing a particular domain of learning activity, such as study habits, awareness and use of learning resources, teaching styles and perceptions of performance. In the study habits cluster, for example, students were presented with statements such as *I am able to figure out for myself how to learn new information and material* and *I change my environment, depending on what I am trying to study or learn.* These surveys were re-administered towards the end of the academic semester, providing an index of change or lack thereof.

Open-ended journal questions asked students to elaborate on their experiences and beliefs by freely typing at least five sentences in a response box. A question in the teaching preference cluster, for example, asked students to *describe the instructional setting (large lectures, small groups, labs) with which you experience the most frustration.* In an excerpt from a typical response, a student writes that his

*... most frustrating classes are ones with large lectures. Primarily my chemistry class*

*is really frustrating because many concepts are unclear, yet it is impossible to pose a question to the professor due to the mass of students within the class.*

Each student answered three such journal questions (of six per form), or 27 questions during the semester, yielding a total of approximately 27,000 responses of 50-200 words.

## ANALYSIS OF DATA

Information gathered in this study consisted of large amounts of quantitative data (learning styles inventories, demographic information including previous success in high school, gender and ethnicity, grades in current courses, etc, and responses to items on weekly surveys) and qualitative data (journal responses and transcripts of focus-group interviews).

Analysis of quantitative data has been correlational, statistically relating various measures using ANOVA, regression and factor analysis. Journal responses have been analysed both quantitatively (eg mean length of entries in words, mean sentence length, use of specific punctuation, predominance of certain linguistic structures such as conditionals, etc) and qualitatively (content analysis and error analysis). Additionally, the journal responses of cohorts created from the results of learning style inventories have been examined qualitatively for various patterns of response. Statistical software is currently being developed for some of these analyses.

A composite picture of each student's learning style has been created from the results of the inventories. An index places students into one of four type quadrants using terminology from the LTM: *why* learners (1), *what* learners (2), *how* learners (3) and *what if* learners (4).

## RESULTS

Because at the time of writing, not all data from Phase 1 had been collected, including final course grades at the end of the second semester of study, analysis is ongoing. The results of quantitative analysis from the first semester are reported here.

### Consistency Measures

The results of correlations between different survey items show that students are responding accurately, consistently and predictably. For example, there is a statistically significant inverse relationship between responses to the items *I take too many breaks when*

*I am studying* and *The schedule I have developed for studying for each of my courses is effective.*

This consistency is also demonstrated in relationships between inventories and survey questions; for example, students with higher levels of educational anxiety as measured by the LASSI had lower SAT scores, were concerned about their performance, and were more likely to respond *sometimes* or *usually* to the question, *I wonder if I am well prepared for the academic demands of being a university student.*

Furthermore, students with poor time-management skills were more likely to feel a connection between their study habits and their grades, to express frustration in their organisational skills and to say they take too many breaks when studying. Similarly, the better the student is in test taking strategies, the higher their SAT score. Thus, the information captured in weekly surveys and journal responses, in the three inventories and in other data, such as standardised admissions tests, appear to be mutually supportive along some dimensions.

### LTM Subscores and Demographics

Students who scored highest in one quadrant of the LTM were examined. Figure 2 gives the percentage of the participants by each of their strongest LTM subscore. Distributions for ethnicity and gender groups can also be seen.

The results show that the largest group in any category is represented by the HOW learners. Examining the way that each ethnic group or gender is represented in each LTM quadrant, it can be seen that more females are *LTM 1 - WHY* than males and more males are *LTM 4 - WHAT IF* than females. The underrepresented minority group looks similar to the white/Asian group. In the student population studied, it is apparent that the largest proportion of students (49%) prefer Learning Type 3 - HOW. Together with LTM Type 2 - WHAT, these two groups comprise 69% of the freshmen engineering students.

In 1983, an extensive study was performed on eight engineering schools to measure the psychological type effects on the educational and career development of engineering [19]. The results of the 1983 study showed that the engineering students were almost equally divided between the Sensing type (53%) and the Intuitive type (47%). More recently, Harb, Terry, Hurt and Williamson assessed the learning preferences of engineering students at Brigham Young University [20]. The following approximate distribution was found: 10% Type 1, 40% Type 2, 30% Type 3 and 20% Type 4. The results found here are consistent with those found in these studies.

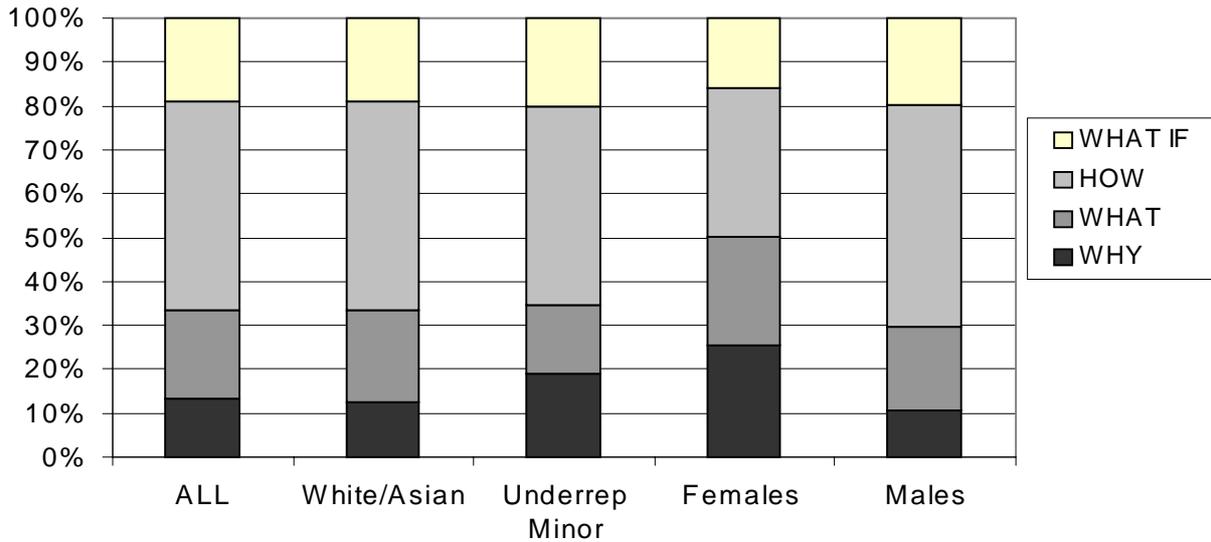


Figure 2: Distribution of LTM 4 quadrants (all groups calculated to 100%).

Students in the study were examined by how they scored on the LTM and then how their attitudes on the various surveys correlated with the score on the LTM. ANOVAs (with the independent variable being the highest quadrant on the LTM and the dependent variable being the question on a journal assignment, subscores on LASSI or subscores on Pittsburgh Freshmen Engineering Attitude Survey) showed some statistically significant relationships by each of the four LTM quadrants (see Table 1). The following results are indicative:

- LTM 1 (WHY?): Students who scored the highest in this quadrant on the LTM were more frustrated by their skills in getting themselves

organised to study, questioned their commitment to the engineering field and felt more concerned about their academic performance. The Pittsburgh Survey (taken in the first week) showed that they had the least confidence in mathematics, science, engineering and computer skills, and some confidence in writing and liberal arts studies. These students, compared to students who scored higher on the other LTM quadrants, showed more anxiety on the LASSI subscale; and scored high on the Study Aide subscale of the LASSI that indicated they use more resources to learn.

- LTM 2 (WHAT?): Students with this LTM subscore as the highest stated they used textbooks to help them more than students with other LTM

Table 1: Averages on survey items for each LTM subgroup.

| Average on Survey Questions Asked during the Semester |  |   |  |   |  |
|---|--|---|--|---|--|
| Scale: 1 = rarely; 2 = sometimes; 3 = usually         |  |   |  |   |  |
| LTM Quadrant  | Textbooks help me  | Prefer to study alone   | Instructor is available outside of class (start of semester) | Instructor is available outside of class (middle of semester) | Homework promotes my understanding of the material |
| 1 - WHY   | 2.43+++  | 2.21^   | 1.20   | 2.60  | 2.50   |
| 2 - WHAT  | 2.53   | 2.66^   | 1.24   | 2.52  | 2.52   |
| 3 - HOW   | 2.56   | 2.45^   | 1.17   | 2.51  | 2.47   |
| 4 - WHAT IF   | 2.36#  | 2.35^   | 1.34#  | 2.36*#  | 2.29*  |
|   | Frustrated by my skills to get myself organised to study (start of semester) | Frustrated by my skills to get myself organised to study (middle of semester) | I question if engineering is right for me                    | Grades reflect abilities                                      | Concern about my performance in some courses       |
| 1 - WHY   | 1.89+##  | 1.37  | 1.88**   | 2.14+++   | 2.30+##  |
| 2 - WHAT  | 1.63   | 1.27^^  | 1.52   | 2.36  | 2.01   |
| 3 - HOW   | 1.69   | 1.41  | 1.46   | 2.28  | 2.11   |
| 4 - WHAT IF   | 1.89*##  | 1.59*   | 1.65*#   | 2.02*##   | 2.18   |

subscores; they preferred to study alone and felt grades reflect their abilities. The Pittsburgh Survey corroborated that these students prefer to work alone instead of in groups or teams (see Table 2). They scored high on the Concentration Subscale of LASSI – they have the ability to direct and maintain attention on academic tasks.

- LTM 3 (HOW?): Students in this quadrant are very similar to LTM 2 students. They use textbooks to help them more; they did not question if the engineering field was for them and felt grades reflected their abilities.
- LTM 4 (WHAT IF?): Compared to the other three groups, LTM 4 students, by mid-term, did not feel that the instructors were available outside of class. They were frustrated in their organisation at the beginning of the semester and at mid-term. They did not feel that homework promoted understanding of the material. By mid-term, they had the most trouble getting to class on time than other students who scored higher on other LTM quadrants. They scored low on the motivation and time management scales of the LASSI, eg they may not possess the diligence, self-discipline and willingness to exert the effort necessary to successfully complete academic requirements. They did not think of engineering as a rewarding career.

**LTM Scores as a Function of Grades**

The average GPA of all students were gathered at the end of the first semester. As shown in Figure 3, WHAT learners had an average GPA of 3.3: 77% of

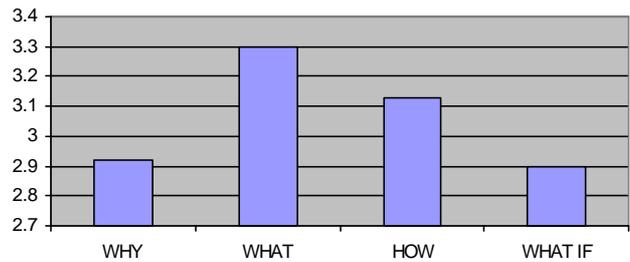


Figure 3: Average GPA at the end of first semester by LTM quadrants.

these students scored above 3.0. Students in the WHY or WHAT IF categories had the lowest average GPA, with only 46% and 45%, respectively, having a GPA above 3.0.

**Change Over Time**

An analysis of students’ responses to weekly surveys show that the entire cohort’s experiences in their first semester of an engineering programme led to some changes in perceptions, attitudes and behaviours, while other factors did not change. Statistically significant results show, for example, that students consulted their teachers more often, became more aware of campus resources and were less inclined to feel that athletics interferes with their studies (all of these elements lying to some degree outside the specific classrooms in which they are learning and involving external, rather than internal, forces).

At the same time, they do not perceive their writing skills to improve, there is no increase in their tendency to summarise their notes after class sessions and there is no change in their perception that they

Table 2: Average on Pittsburgh freshman engineering attitude survey factors.

| Scale: 1 <i>strongly disagree</i> to 5 <i>strongly agree</i> |   |   |                           |                                   |
|--|---|---|---------------------------|-----------------------------------|
| LTM Quadrant   | Confident in maths and science  | Confident in engineering/ computer skills | Confident in liberal arts | Prefer to work alone/not on teams |
| 1 - WHY  | 3.64**  | 3.56**                                    | 2.69++                    | 2.50##+                           |
| 2 - WHAT   | 3.96  | 3.80                                      | 2.62                      | 3.18                              |
| 3 - HOW  | 3.94  | 3.85                                      | 2.46                      | 2.83                              |
| 4 - WHAT IF  | 3.96  | 3.82                                      | 2.86*##                   | 2.75##                            |
| *  | LTM Quadrant 4 is statistically different from all other quadrants; p<.05 |   |                           |                                   |
| **   | LTM Quadrant 1 is statistically different from all other quadrants; p<.05 |   |                           |                                   |
| #  | LTM Quadrant 4 is statistically different from quadrant 3; p<.05          |   |                           |                                   |
| ##   | LTM Quadrant 4 is statistically different from quadrant 2; p<.05          |   |                           |                                   |
| ###  | LTM Quadrant 4 is statistically different from quadrant 1; p<.05          |   |                           |                                   |
| **   | LTM Quadrant 4 is statistically different from quadrant 3 and 1; p<.05    |   |                           |                                   |
| **#  | LTM Quadrant 4 is statistically different from quadrant 3 and 2; p<.05    |   |                           |                                   |
| +  | LTM Quadrant 1 is statistically different from quadrant 4; p<.05          |   |                           |                                   |
| ++   | LTM Quadrant 1 is statistically different from quadrant 3; p<.05          |   |                           |                                   |
| +++  | LTM Quadrant 1 is statistically different from quadrant 2; p<.05          |   |                           |                                   |
| ###+   | LTM Quadrant 1 is statistically different from quadrant 2 and 3; p<.05    |   |                           |                                   |
| ^^   | LTM Quadrant 2 is statistically different from quadrant 3, p<.05          |   |                           |                                   |
| ^  | All quadrants statistically different from each other; p<.05              |   |                           |                                   |

take too many breaks while studying (all of these elements lying to some degree within the domain of students' own academic work and habits, and involving internal, rather than external, forces).

However, when examined as a function of LTM scores, differences in changes became more discernible (see Table 3). For example, the *Why* group became less frustrated with their skills in organisation, while the *How* group felt their writing skills were stronger by the end of the semester. The *What if* group had found resources by the end of the semester as compared to the beginning of the semester. When correlated to those factors across the entire group that seem to contribute to students' success, such differences may be especially helpful in targeting certain educational interventions towards the most vulnerable groups.

**Miscellaneous Observations**

When asked why they chose engineering as a field of study, the majority of students responded that they liked science and mathematics; yet an equal majority rated mathematics and chemistry as their *most frustrating courses* over other courses (including English) in their curriculum.

When asked to judge which instructional method was most frustrating to them, a majority of students chose *large lectures* over laboratories and smaller classes. There was a statistically significant relationship between students' perception of their writing skills and their time-management skills.

**PRELIMINARY CONCLUSIONS**

It is speculated that most engineers would have an LTM score that would show them higher in the WHAT and HOW categories of learning preferences. Students who have high scores on the LTM in the WHY and WHAT IF quadrants may have more difficulty in a traditional educational system that has tended to produce engineers who are WHAT and HOW types, while the engineering professions are eager to train and hire more speculative, inventive, *outside-the-box* thinkers – those who fit the profile of LTM types WHY and WHAT IF; yet their educational experiences are not well matched to their learning styles and preferences. As further correlations become available, it may be possible to pinpoint certain key factors affecting students' success and retention across the entire cohort of first-year students. Based on performance measures at the end of the first semester, this hypothesis appears to be supported.

The original hypotheses (that traditional engineering education may be a deterrent to innovative thinkers, that students are not aware of their learning strategies, and that students who lack confidence may have more difficulty in engineering) are still being supported. More information about the relationship of the above findings to the *retention* of these students will give greater insight into these hypotheses.

As soon as further measures of success are available, as determined by grades in courses and early dropouts, the researchers will be able to relate these

Table 3: Percentage of change over time in select areas, by LTM.

|  |     |     |     |     |    |
|--|-----|-----|-----|-----|----|
| I have found organised activities and resources sponsored by the College of Engineering that have helped me integrate into the Freshman experience (if student said <i>rarely</i> at the beginning of the semester and <i>usually</i> towards the end of the semester then the difference score is +2) |     |     |     |     |    |
| Difference score:  | -2  | -1  | 0   | 1   | 2  |
| 1 WHY  | 20% | 48% | 28% | 4%  | 0% |
| 2 - WHAT   | 21% | 41% | 33% | 5%  | 0% |
| 3 - HOW  | 22% | 46% | 27% | 4%  | 1% |
| 4 WHAT IF  | 19% | 52% | 23% | 6%  | 0% |
| My writing skills are strong (if student said <i>rarely</i> at the beginning of the semester and <i>usually</i> towards the end of the semester then the difference score is +2)   |     |     |     |     |    |
| Difference score:  | -2  | -1  | 0   | 1   | 2  |
| 1 WHY  | 2%  | 19% | 46% | 28% | 5% |
| 2 - WHAT   | 3%  | 19% | 47% | 26% | 6% |
| 3 - HOW  | 1%  | 17% | 42% | 33% | 7% |
| 4 WHAT IF  | 2%  | 29% | 48% | 17% | 3% |
| I am frustrated by my skills in getting myself organised to study (if student said <i>usually</i> at the beginning of the semester and <i>rarely</i> towards the end of the semester then the difference score is -2).   |     |     |     |     |    |
| Difference score:  | -2  | -1  | 0   | 1   | 2  |
| 1 WHY  | 8%  | 45% | 41% | 7%  | 0% |
| 2 - WHAT   | 5%  | 32% | 54% | 8%  | 1% |
| 3 - HOW  | 4%  | 39% | 46% | 12% | 1% |
| 4 WHAT IF  | 4%  | 42% | 47% | 6%  | 1% |

measures to items and item clusters on the LTM, LASSI, Pittsburgh Inventory, weekly surveys and journals. The results will yield a clearer picture of student success as it relates to types, styles and habits, which can then be used to examine teaching practices and the structure of the curriculum, and develop both faculty-development initiatives and student interventions to increase success and retention rates.

## IMPLICATIONS AND PHASE 2 RESEARCH

The results of this first phase of the project have allowed the formulation of specific objectives for the second phase, currently under development: Effectiveness of Cognitive Empowerment of Engineering Freshmen. By using the data to describe the matches and mismatches between students' styles and strategies and the content of courses and instructors' teaching styles and strategies, a taxonomy is being developed to help students to know when and why to select a particular strategy for the mastery of different types of information and teaching techniques.

The objective of Phase 2 will be to increase students' awareness of their own learning, while simultaneously increasing the number of learning strategies they have at their disposal. Such strategies will enable them to become effective and efficient learners who can modify their individual strengths and preferences to overcome the inherent mismatches between learning and teaching styles and strategies that are prevalent in undergraduate engineering programmes.

In addition, data from teachers of courses in the first year of study have already begun to show possible relationships between teaching styles, methods or ideologies and students' abilities to thrive in different learning environments. The LTM model, for example, suggests that Type 1 and 4 teachers will be disposed in their instruction towards enabling self-discovery and helping students to act on their own visions, they will be interested in promoting individual growth and encouraging personal insight, and they will prefer group work, discussions, and active learning methods in their classrooms. Type 2 and 3 teachers, on the other hand, will be more disposed towards the transition of knowledge, will favour accuracy, productivity, competence and practical applications, will use measured rewards and favour more traditional teaching methods (lectures and tests) [21].

Although the LTM was not administered to instructors of first-year engineering students' courses, an electronic survey was devised to tap into their educational beliefs and practices. This preliminary survey of teachers representing both the mathematics/science

side and the humanities side of engineering students' first-year curriculum indicates a strong match between these LTM types and their own teaching preferences. The mathematics and science instructors, for example, were far more likely to describe a *good student* as one who attends lectures, puts in his or her best effort, has good study/testing skills, solves problems, understands concepts, reads before class and works hard. Instructors in the humanities side of the students' first-year curriculum, by contrast, were far more likely to characterise a *good student* as one who participates in class discussions, is insightful and actively engaged in his/her own learning, reads and thinks critically, has a genuine interest in academic inquiry, engages actively with materials and continuously rethinks his/her assumptions.

When asked how they like to spend class time, the mathematics and science instructors were far more likely to favour lecturing, doing example problems on the board, giving quizzes and reviewing homework, while the humanities instructors were more likely to favour guided discussions, group work, in-class writing, *workshops*, and responding to students' questions.

Clearly, the differences being discerned in students' approaches to studying and learning are matched (or not matched) by their instructors' approaches to teaching. The implications of this part of the research may well point towards strategies both for increasing the awareness and skills that students can bring into diverse classrooms with a range of assumptions about learning, and for increasing awareness among teachers of alternative methods that best match the styles of their students. This is a process already bearing fruit in some workshop-based instructional programmes for faculty [22].

By working from *both ends*, the authors consider it possible for engineering schools and curricula to create environments where students of all types can thrive, bringing to the diverse engineering professions the range of intellectual and social abilities that professionals appear to value.

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**Conference Proceedings of the  
6<sup>th</sup> UICEE Annual Conference on Engineering Education  
under the theme: *Educating for the Right Environment***

edited by Zenon J. Pudlowski

The 6<sup>th</sup> UICEE Annual Conference on Engineering Education, under the theme of *Educating for the Right Environment*, was organised by the UNESCO International Centre for Engineering Education (UICEE) and was held in Cairns, Australia, between 10 and 14 February 2003. This 6<sup>th</sup> Annual Conference of the UICEE was an academic activity that, basically, commenced the 10<sup>th</sup> year of the UICEE's operations.

This volume of Proceedings includes papers submitted to the Conference and offers a strongly assorted collection of highly informative articles that describe various international approaches to engineering education research and development, as well as other specific activities.

The 71 published papers, representing 23 countries, provide an excellent summary of the fundamental issues, concepts and achievements of individual researchers, as well as the concerns of and challenges to engineering and technology education in different cultures. The papers have been organised into the following groups:

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- New trends and approaches to engineering education
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- International examples of engineering education and training
- Multimedia and the Internet in engineering education
- Important issues and challenges in engineering education
- Quality issues and improvements in engineering education
- Case studies
- Specific engineering education programmes
- Course development in engineering education

The diversity of subjects, concepts, ideas and international backgrounds in this volume of Proceedings illustrate the increasingly multidimensional and international nature of UICEE-run Conferences, as well as its relevance in the global affairs related to engineering and technology education.

In order to ensure their high quality and the value of the Proceedings for the future, all papers have undergone assessment by independent international peer referees and have been professionally edited. As such, it is envisaged that this volume will provide excellent reference material and a source of information on academic achievements and current debate in engineering and technology education.

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