Relationships between Student Learning Styles and Methods of Presentation for Engineering Technology Students

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I. **Introduction**

Many studies of student learning styles and personality types have been conducted that apply to engineering students. These studies were validated using large numbers of students and are used to empirically formulate a hypothesis concerning the principal learning styles[1] and personality types of engineering technology students. As an educator, you probably have an opinion of the learning styles used by the majority of your students. For instance, are your students primarily Active or Reflective, Sensing or Intuitive, Visual or Verbal, Sequential or Global learners? If you are not familiar with this terminology, you can test your own learning style at the North Carolina State web site[2]. The Myers-Briggs Type Indicator® (MBTI®) purports to determine a person's personality type among sixteen possibilities. This instrument has also been heavily used and reported in the literature in relation to teaching methods for engineering students. Literature and experience are used to formulate differences in personality types between engineering and engineering technology students. Suggestions are made with respect to teaching methods that should be used more in engineering technology education to provide enhanced learning for our students.

II. Learning Styles and Personality Types of Engineering Students

The 1988 seminal paper, with a 2002 author's preface, by Felder and Silverman[1] provides definitions of learning styles. Modifications have been made to these definitions and to the original categories since the original paper. For instance, Felder[3], provided recommendations on methods of teaching with respect to student learning styles in college science education. Felder[4] also provided a look at four commonly used learning style models and their applications, including the Myers-Briggs Type Indicator® (MBTI®)[5], which is widely used, in Industrial Human Resources departments to determine personality types. The MBTI® instrument, according to CPP Inc.[6], which owns the rights to the instrument, is used throughout the world and by 84 of the Fortune 100 companies. Montgomery and Groat[7] further developed the link between student learning styles and the MBTI®. Rosati[8] also provided correlation data between learning styles and personality types. Felder, et al[9], discussed the results of a study of engineering student performance and MBTI® personality types.

Learning styles, as defined and modified by Felder and Silverman[1] can be summarized as shown in Table 1[10].

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Table 1: Learning Styles

Active: Active learners like to try things out and see how they work and like to work with others.	**Reflective:** Reflective learners like to think things through first.
Sensing: Sensors like to learn facts, use well established methods and practical and careful.	**Intuitive:** Intuitors tend to work fast and be innovative and can often handle abstract and mathematical concepts well.
Visual: Visual learners like diagrams, pictures, graphs and films.	**Verbal:** Verbal learners get more out of words heard and written.
Sequential: Sequential learners like to work in linear steps that follow logically.	**Global:** Global learners like to jump in, absorb material nearly at random and then get the big picture.

There are many published results of studies using these learning styles and their relationship to success in engineering programs. One of the most general is a survey[10] of large numbers of students using an online site, which provided the following information:

80% of all students are **Active** learners
55% of students are **Sensors (60% for engineers)**
75% of all students are **Visual** learners
60% of all students are **Sequential** learners

MBTI® personality types have been used and studied for many years and have also been widely studied with regard to engineering students. The personality types, originally defined by Carl Jung (1875-1961)[11] can be briefly summarized using the descriptions shown in Table 2[12].

Table 2: MBTI® Dimensions

Extroversion (E) (discussion, trial and error, groups)	**Introversion (I)** (reflection, careful, work alone)
Sensing (S) (facts, applications, hands-on)	**Intuition (N)** (hunches, concepts, imagination)
Thinking (T) (logical, objective, cause and effect)	**Feeling (F)** (relationships, values, process)
Judging (J) (ordered, closure, formal)	**Perceiving (P)** (discussion, flexible, informal)

Felder[9] states that studies have shown that for engineering education:

1. Introverts typically outperform extroverts,
2. Intuitors outperform sensors,
3. Thinkers outperform feelers, and
4. Judgers outperform perceivers.

Results of MBTI® surveys of many students are shown in Table 3, below[13, 14, 15, 16]. These statistics show that engineers are generally more INTJ than the general population, which matches the above list from Felder[9] and appears to match public opinion.

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Table 3: Psychological Type Distribution (%)

	E	I	S	N	T	F	J	P
General Pop.	70	30	70	30	50	50	50	50
Engineers	33	67	53	47	74	26	61	39

Relationships between learning styles and MBTI® personality types were developed by Rosati[8] for Canadian engineering students. These relationships based on statistical correlations are shown in Table 4. Rosati[17] also concluded that all engineering students showed a clear preference for Active, Sensing, Visual, and Sequential learning. Female engineering students were significantly more Reflective, Verbal, and Sequential than their male counterparts. This also appears to correlate with public perceptions.

Table 4: Differences in average ILS responses for various student splits*.

ILS SCALE	**Male / Female**	**1st Year/4th Year**	**MBTI Dimensions**			
Number of responses	672 / 135	499 / 359	E/I	S/N	T/F	J/P
Active/Reflective (more ACTIVE)	male	4th year	E			P
Sensing / Intuition (more SENSING)			S		T	J
Visual / Verbal (more VISUAL)	male					
Sequential / Global (more SEQUENT.)	female	1st year	S			J

*High mathematical correlation found for items shown

III. Recommended Teaching Methods

Learning style and personality type studies attempt to determine engineering students' preferred learning methods. The purpose of the studies is to help instructors ensure that every style is addressed to some extent in the classroom. It has been noted[9] that to function successfully as an engineer in any capacity, individuals must develop skills characteristic of all learning style categories. This is also true of personality types, so these designations are not strictly to categorize individuals, but to help understand how to teach so that all students are learning to the greatest extent possible. Teaching methods have been recommended that purport to address all student learning styles so that each student has their preferred learning methods used during a portion of each course. Recommended methods are in addition or instead of the traditional lecture and some of these, by Felder[3, 4], are:

- Motivate presentation of theoretical material with prior presentation of phenomena that the theory will help explain and problems that the theory will be used to solve.

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- Balance concrete information (descriptions of physical phenomena, results from experiments, demonstrations, and solved problems) with conceptual information (theories and mathematical models).
- Make extensive use of sketches, plots, schematics, vector diagrams, computer graphics, and physical demonstrations.
- Use numerical examples to supplement the usual algebraic examples for illustration of abstract concepts.
- Use physical analogies and demonstrations to illustrate the magnitudes of calculated quantities.
- Give experimental observations before presenting general principles and have students (preferably working in groups) attempt the inference to the general principle.
- Provide time in class for students to think about the material being presented and for active student participation (individual or group class exercises)
- Encourage or mandate cooperation on homework (group work).
- Demonstrate the logical flow of individual course topics, but also point out connections between the current material and other relevant material in the same course, in other courses in the same discipline, in other disciplines, and in everyday experience.

Felder[3] notes that an instructor can accomplish this by placing much of the classroom material that is usually written on the board, in handouts and briefly go through the handouts in class. This makes more class time available for some of the above activities with a predicted gain in quantity and quality of learning.

More general recommendations for all students are also available and McKeachie[18] is one of the most quoted authors and proponents of "Active Learning"[19]. McKeachie discounts learning style generalizations except for gender differences. Descriptions of gender differences from the McKeachie book are shown in Table 5[20].

Table 5: Gender Differences

Interpersonal (more female)	**Impersonal** (more male)
Want to exchange ideas with others	Want to debate ideas
Seek rapport with the instructor	Want to be challenged by the instructor
Want evaluation to take individual differences into account	Want fair and practical evaluation
Resolve uncertainty by personal judgment	Resolve uncertainty by logic, judgment, and research

McKeachie[18] also makes recommendations concerning how to increase motivation to be able to include learning differences in style, culture, and physical ability. Some applicable recommendations are:

- Use collaborative and cooperative learning, groups, and exercises that reframe knowledge from different perspectives.
- Encourage experiential learning.

- Use decision-making exercises and creative activity.
- Use frequent feedback, self-assessment by the learner, and alternatives to pencil-and-paper tests that are grounded in the skills or knowledge being assessed.

IV. Recommended Teaching Methods for Engineering Technology Students

Our general assumption is that ET students have much in common with engineering students in terms of interests, personality types, and learning styles. This enables us to empirically extrapolate from the many surveys and studies on engineering students. We feel that the learning styles of engineering technology (ET) students are different from engineering students because ET students generally have a greater interest in how things work physically, and less interest in the theoretical background. Some general distinguishing characteristics that we hypothesize exist in most ET students with respect to engineering students are shown below.

- More interested in hands-on applications.
- More interested in projects.
- More interested in the applications of mathematics.
- Less interested in the mathematical theory.
- More outgoing.
- More team oriented.

Translation of these differences into general learning styles and personality types for ET students and from this into recommended teaching methods is difficult. However, using the list above, some recommendations concerning ET students can be formed.

ET Student Learning Styles

If the learning styles and definitions shown in Table 1 are considered, it is our conclusion that ET students are generally Active, Sensing, Visual, and Sequential learners. Since this is also the case for the majority of engineers, there must be some differences. The most obvious answer is that ET students probably display more of some of these characteristics. The percentages of ET students shown, in Table 6 below, are for discussion only, but we believe that most ET educators will agree that the definitions shown apply, consistently, to many ET students.

Table 6: Projected ET Student Characteristics

Active: *Active learners like to try things out and see how they work and like to work with others*. Engineering-80% Engineering Technology-90%?
Sensing: *Sensors like to learn facts, use well established methods and practical and careful*. Engineering-60%, Engineering Technology-80%?
Visual: *Visual learners like diagrams, pictures, graphs and films*. Engineering-75%, Engineering Technology-85%?
Sequential: *Sequential learners like to work in linear steps that follow logically*. Engineering-60%, Engineering Technology-80%?

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ET Student Personality Types

Considering the definitions of Personality Types shown in Table 2, it is our experience that ET students are generally more Extroverted and more Sensing than engineering students. Our perception is that the percentage of ET students in each of these categories would be higher, as is shown for discussion, in Table 7, below. It is not clear how ET students would be evaluated in terms of the Thinking/Feeling and Judging/Perceiving categories. However, our perception is that ET students are more Feeling and Perceiving than engineering students and would probably correspond more with the statistics of the general population discussed earlier. It is our opinion that the majority of ET faculty would agree that these definitions portray the characteristics of ET students to a greater extent than those of engineering students.

Table 7: Projected ET Student Characteristics

Extroversion (E)-discussion, trial and error, groups: Engineering=33**%**, ET=60%? **Introversion (I)-**reflection, careful, works alone: Engineering=67**%**, ET=40%?
Sensing (S)-facts, applications, hands-on: Engineering=53**%**, ET=70%? **Intuition (N)-**hunches, concepts, imagination: Engineering=47**%**, ET=30%?
Thinking (T)-logical, objective, cause and effect: Engineering=74**%**, ET=50%? **Feeling (F)-**relationships, values, process: Engineering=26**%**, ET=50%?
Judging (J)-ordered, closure, formal: Engineering=61**%**, ET=50%? **Perceiving (P)-**discussion, flexible, informal: Engineering=39**%**, ET=50%?

Suggested Teaching Methods for ET Students

Recommended teaching methods by Felder[3, 4] and McKeachie[18] are generally good for all types of students. However, the following methods appear to have particular value for ET students and are presented in two groups, one which is thought to be currently used throughout ET and the other that, perhaps, should be used more in ET classes.

Generally used in Engineering Technology Education

- Presentation of explanations of problems and phenomena that later theory will help explain.
- Extensive use of sketches, plots, schematics, computer graphics, and physical demonstrations.
- Use of numerical examples.
- Use of descriptions of physical phenomena, results from experiments, demonstrations, and solved problems.
- Use of physical analogies and demonstrations to illustrate the magnitudes of calculated quantities.
- Experiential learning in laboratories
- Collaborative learning for laboratory exercises

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Should be used more in Engineering Technology Education

- Use of collaborative learning in the classroom. (e.g. group problems)
- Use of decision-making exercises and creative activity.
- Use of frequent feedback, self-assessment, and alternative testing methods.
- Provide time in class for students to think about the material being presented.
- Encourage or mandate cooperation on homework.
- Point out connections between current material, other relevant material in the course, in other courses in the same discipline, in other disciplines, and in everyday experience.

V. Conclusions

Our hypotheses are that ET students are generally more Active, Sensing, Visual, and Sequential than engineering students when using the learning styles model[1] and more Extroverted and Sensing when using the MBTI® personality type definitions. These differences were empirically converted into recommended teaching methods that tend to follow current ET teaching practices with respect to visual and hands-on learning. However, several recommended teaching methods should be used more in ET, namely team learning in the classroom and encouragement of group learning for homework. The results in this paper are empirical, but, hopefully, will provide the basis for discussion and perhaps encourage statistical studies of engineering technology students learning styles and personality types with respect to best teaching practices.

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