AC 2008-1089: COMPARISON OF TRADITIONAL AND INTEGRATED FIRST YEAR CURRICULA - GRADUATION SUCCESS AND MBTI DISTRIBUTION

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Comparison of Traditional and Integrated First Year Curricula – Graduation Success and MBTI Distribution

Summary

As engineering educators have struggled with how to increase retention, interest nontraditional students into the profession, and incorporate an expanding knowledge base into the curriculum, the systematic study of how students learn technical material has become increasingly important. It has become accepted that students have different learning styles and that alternate teaching styles and methods can assist the learning process. Many of the innovations in approach to engineering education and the decrease in emphasis on lecturing as the primary method of material delivery have resulted from knowledge and appreciation of student learning style.

Of the many diagnostic tools available to measure learning style, The Myers-Briggs Type Indicator[1] (MBTI) is probably the most commonly used. In 2002, the authors published a MBTI distribution study for University of Tennessee engineering graduates[2]. These students were educated in a traditional curriculum. This study provided us with insights about which personality types were ultimately successful in traditional engineering programs. There is now a sufficient number of our graduates that have been exposed to the significantly reformed Engage integrated first year curriculum[3], fully implemented in 1999, that a meaningful comparison study can be performed.

In this study, a comparison of graduation success and MBTI distribution is made between the approximately 1500 students who began engineering study just before the implementation of our new first year curriculum, and the first 1500 students who entered the new curriculum. The most significant effect of this curriculum change was a 6% increase in graduation rate for entering students. The on-time completion of first year requirements for engineering students increased 15% when this curriculum was introduced, this early advantage tapering down to 6% as students progressed through the remainder of the curriculum. Graduation rates increased more significantly for female students, and for most MBTI designations, by 4-letter type, 2-letter temperament, or single letter preference.

Use of the MBTI in Engineering Education

There is a substantial history of the use of the Myers-Briggs Type Indicator in engineering education. This test, which classifies people into psychological subgroups and is based on the theories of Carl Jung, is very popular for career counseling, work team formation, and personal development. The summary of its use in engineering education below is taken largely from our 2002 paper[1]. Another effective summary is given by Felder[4]. For the reader uninitiated with basic Myers-Briggs terminology and use, a primer is attached as an appendix.

Most of the applications of the MBTI in engineering education have been instigated or catalogued by Mary McCaulley at the Center for Applications of Psychological Type at the University of Florida. In 1976, McCaulley published one of the first descriptions of the use of this test in engineering education[5]. Using a preliminary database, she pointed out that engineering students tended to be more strongly introverted, thinking, and judging than college students in other fields, and appeared to have a good balance of practical sensing types and theoretical intuitive types. She points out that the domination of thinking types in the profession could lead to the neglect of the human side of projects, an undervaluing of the opinions of the "feelers" on the work team, and a lack of emphasis on explaining and selling projects to the public, because "the logic speaks for itself." She points out that intuitive students have an advantage over sensing students on standardized aptitude tests commonly used for college admissions, and this extends to all timed tests that are conceptual or symbolic in nature. Intuitives experience learning as rapid leaps of insight, while sensors emphasize thoroughness of understanding, and work in a slower, more linear fashion. An important conclusion of this first study was that people reach their potential when their profession requires them to use the preferences with which they are comfortable but also routinely asks them to "go against the grain" and develop other aspects of their personalities.

In the early 1980's, a consortium of eight engineering schools was formed that gathered MBTI data for 3718 engineering students[6]. This database confirmed that engineering students are dominated by thinking and judging types and are more introverted than other college students. There were substantial differences between the schools, but the overall trends remained the same. Several effects of learning style were first raised by this study. Female engineering students were observed to be more extraverted and more feeling than male engineering students and some significant differences were noted for minority students for the first time. Using MBTI information to predict retention of students was tried for the first time. It was noted that the practical and organized SJ temperament best survived the rigors of the first year and the logical and decisive TJ types showed the most percentage gain between freshman and senior year at one of the consortium schools. Engineering practice calls for teamwork and communication, and the negative implications of a curriculum that discourages feeling types, and to a lesser extent extraverts and intuitives was pointed out. First attempts to teach to a variety of learning styles were described and the primary role of the faculty in controlling the learning style/teaching style of the classroom was discussed.

In 1987, McCaulley explored the question of MBTI and retention more thoroughly using the latest updates of available databases[7]. Details are given for retention by type in different engineering majors. Overall results are similar to the previous study but also show a significance of IN and IJ remaining in engineering with students most likely to leave showing extroverted spontaneity or innovation (EP and EN). Suggestions for increasing retention included accommodating extroverts in group discussions and out-of-lecture projects, accommodating both sensors and intuitives on lectures by working examples and describing the concept, and coaching the dominant T and J types in acceptance of ideas from feeling and spontaneous types.

McCaulley's 1990 paper[8] extended these arguments and suggested that engineering design with its complete problem solving cycle was the logical place in the engineering curriculum to emphasize teaching to different learning styles. It is pointed out that the description of Perry's highest stage of intellectual development can be interpreted as balancing of many and sometimes opposite Myers-Briggs viewpoints. Other problem solving and design models make it clear that good problem solving involves activities that require input from all learning styles, and a similar argument can be made for what has been called creative problem solving activities[9,10].

More recently, Rosatti[11] has contributed and compared Canadian engineering students to the available data and a study of engineering students at Georgia Tech[12] has confirmed previously reported trends.

Since 1990 and the formulation of the National Science Foundation coalitions addressing engineering education issues, these ideas have been commonly accepted in the engineering education community. Most engineering schools are trying to improve the problem solving ability of their graduates by development of education innovations to retain a wider variety of learning styles in their student body.

Narrative

A comparison study of two student groups was performed for this study. The first group consisted of students who entered the University of Tennessee as first semester engineering students between the years 1995 and 1998. They participated in a traditional first year curriculum, which consisted of 13 credit hours taught by engineering professors. This curriculum, called Basic Engineering, consisted of a one-hour seminar to introduce the profession, a 3 credit hour graphics course, a 3-hour statics course, a 3-hour particle dynamics course, and a 3-hour introduction to programming course. The statics and dynamics courses were in lieu of a mechanics physics course, with a little more engineering emphasis than would be seen in a standard physics course. No rigid body dynamics was covered in the "dynamics" course. Students were expected to complete the Basic Engineering courses in the first two or three semesters, depending on starting math background. These courses were the responsibility of different departments in the college, with no central control or coordination between instructors.

The second group of students started engineering study at the University of Tennessee between 1997 and 2001. They participated in a reformed first year experience, called the Engage curriculum. Details of this curriculum have been reported before[3]. This curriculum was under the control of a core group of faculty, who designed the curriculum to take advantage of some of the findings of the NSF engineering coalition schools of the early 1990's. The curriculum consisted of two 6 credit hour courses, covering the same material as before, but with a team learning and project design emphasis. They were team taught with sensitivity to applying collaborative learning techniques. This curriculum was piloted for two years (1997-8) and then fully implemented with all first year engineering students beginning in 1999. This curriculum accommodated students who were not calculus ready, although to begin the first course, students had to qualify for pre-calculus, one semester behind the "showcase" starting point.

Basic demographic data, entering high school grade point averages, math component of ACT, and number of males and females, for our two student groups are shown in Table 1. Other than this change in approach to first year engineering education, there were no changes to admission criteria or major curriculum changes during the period 1995-2001. Both groups contain only students who began engineering coursework at the university. Minority enrollment remained constant at about 12% of the entering class during this period, and the entering classes were approximately 20% female. During the average 3-year difference between entering year for the Basic Engineering group and the Engage group, the average entering high school GPA increased from 3.4 to 3.5, and the average math ACT score increased by 0.75 point, consistent with recent trends for entering students.

Table 1: Demographics of Student Groups

Basic Engineering (N=1224)				
	HS GPA Average	Math ACT Average	N-Female	N-Male
1	2.91	21.75	56	355
2	3.47	25.87	92	316
3	3.87	29.99	102	303
All	3.40	25.76	250	974
Engage (N=1071)				
	HS GPA Average	Math ACT Average	N-Female	N-Male
1	3.00	22.95	57	289
2	3.60	26.58	72	298
3	3.91	30.32	83	272
All	3.50	26.58	212	859

The two test groups are shown subdivided into thirds, representing the lower (1), middle (2) and upper (3) third of the students based on entry qualifications. This division of students is based on the success prediction index, or SPI, an indicator used at the University of Tennessee College of Engineering. It combines the two measures we have for all entering students, high school GPA and ACT scores, into a single number. We have found that this combined number correlates better with student success than the individual indicators, presumably because the ACT represents innate ability and the high school GPA is an indication of student perseverance. The SPI is calculated as 10 times the HS GPA (on a 4 point scale) plus the Math component of the ACT.

Results

The results of this study are shown on the following tables. The effect of the new first year curriculum on graduation rate was of prime interest. Secondly, the effect of the new curriculum on personality types who were successful in engineering was of significant interest.

Basic six-year graduation data is shown in Table 2. The overall graduation rate was increased 6 % for the Engage students, from 40.5% to 46.6%. These rates are for students entering and finishing in the College of Engineering. Graduation rates for students entering the College of Engineering and graduating from the University of Tennessee are considerably higher, but not of interest here. We know from previous studies[3], that the on-time completion of first-year requirements jumped 15% for these students, and it is gratifying to see that this translated into a significant increase in graduation rate several years later, despite no other changes in curriculum. This increase in overall graduation rate was statistically significant at the 95% confidence level, as was the increase for both male (4%) and female (12%) students considered separately. Interestingly, looking within groups, the difference in male and female graduation rate was not significant for the Basic Engineering group, but was statistically significant for the Engage group. This indicated the new curriculum was not only more conducive to graduating female engineers than the traditional one, but it favored females more than males within the curriculum.

Table 2: Graduation Data					
All		Total	Male	Female	
Basic Engineering		40.50	41.07	39.68	***N=1252***
Engage		46.56	45.41	51.59	***N=1437***
Strong Preference		Total	Male	Female	
Basic Engineering		40.36	41.04	37.43	***N=466***
Engage		47.42	47.99	47.73	***N=595***
by SPI Score		Total	Male	Female	
Basic Engineering	1	23.08	22.84	24.62	***N=1224***
	2	40.75	41.71	37.50	
	3	50.90	52.80	44.86	
Engage	1	26.63	25.99	29.69	***N=1071***
	2	48.92	47.65	54.17	
	3	63.38	62.87	65.06	

Next we subdivided our two test groups and looked only at those who showed “strong preferences” on the MBTI. This was done by eliminating students from the database whose raw preference score on the four MBTI scales (Extroversion – Introversion, Sensing – Intuitive, Thinking – Feeling, and Judging – Perceiving) were less than 10 in either direction (out of a maximum score of approximately 50). Since students with these low MBTI preferences can easily exhibit many learning style possibilities, it was thought that this iteration might produce clearer trends. For these overall graduation numbers, the same statistical significance pattern remained, with the exception that there was no longer any statistical significance for a difference in graduation rate between males and females of strong preference in the Engage curriculum.

Dividing the groups into thirds based on entering qualifying scores produced interesting results. Graduation rates ranged from 23% for the lower qualifiers to 63% for the upper group, a range of abilities very familiar to teachers of first-year engineering students at large universities. The overall graduation rate was increased with the change to the

Engage curriculum for all students, and the effect increased from 3.5% for the lowest qualifying group to 8% for the middle group to 12.5% for the highest qualifying group. For level 3 qualifiers, this effect was statistically significant. For these highest qualifiers, the effect was 10% for males and 20% for females. Both of these differences were statistically significant.

Looking within test groups, there is a consistent picture of the traditional curriculum being neutral to discouraging for female students, with the most pronounced effect being for the highest qualified students (a "close to" statistically significant difference in graduation rate of 52.8% for level 3 men and 44.9% for level 3 women in the traditional curriculum.) In contrast, the graduation rates for women were higher than the men for all levels of ability under the Engage curriculum.

Table 3 is a comparison of MBTI distributions for the 16 4-letter MBTI types. It contains number of students entering, number finishing, graduation percentage, and a normalized graduation percentage for each MBTI type for both the Basic Engineering group and the Engage group. The distribution of types is consistent with that previously reported for engineering students [1]. All MBTI types are well represented in engineering students, and all graduate under either curriculum. The effect of the curriculum change was generally small and not statistically significant for most types. Although the base study groups each contained about 1500 students, this was not a sufficient number to demonstrate changes for most individual types, if those differences exist.

Table 3: MBTI Distribution

	Basic Engineering				Engage Program			
Type	Start	Finish	Grad %	Norm.Grad.	Start	Finish	Grad %	Norm. Grad.
ENFJ	29	12	41.38	1.02	41	16	39.02	0.84
ENFP	83	26	31.33	0.77	90	25	27.78	0.60
ENTJ	62	27	43.55	1.08	97	38	39.18	0.84
ENTP	92	31	33.70	0.83	145	57	39.31	0.84
ESFJ	61	29	47.54	1.17	56	28	50.00	1.07
ESFP	48	20	41.67	1.03	48	19	39.58	0.85
ESTJ	149	59	39.60	0.98	157	94	59.87	1.29
ESTP	79	34	43.04	1.06	100	43	43.00	0.92
INFJ	32	14	43.75	1.08	33	16	48.48	1.04
INFP	40	15	37.50	0.93	63	27	42.86	0.92
INTJ	59	23	38.98	0.96	64	34	53.13	1.14
INTP	113	41	36.28	0.90	118	47	39.83	0.86
ISFJ	79	40	50.63	1.25	72	41	56.94	1.22
ISFP	41	10	24.39	0.60	33	17	51.52	1.11
ISTJ	183	81	44.26	1.09	228	120	52.63	1.13
ISTP	102	45	44.12	1.09	92	47	51.09	1.10
Total	**1252**	507	40.50		**1437**	669	46.56	

E/ISTJ types are the most common engineering types for entering and graduating students under both curricula, representing about 30% of engineering students. The only statistically significant effect of the new curriculum was to increasingly favor the graduation of the E/ISTJ types. This was considered surprising because the presumption that the integrated and collaborative Engage curriculum would broaden the success of less common MBTI types. The authors postulate that since the new 6 credit hour integrated courses were more complex and required following extensive rules and procedures for success, that this fit well with the practical, organized, and "follow the rules" nature of the SJ temperament.

Table 4 shows graduation rate by 2-letter temperament and single letter preference. While the graduation rates increase for all temperaments and single letter preferences, only the SJ temperament change was statistically significant with the move to the new curriculum. The change in curriculum did not effect the distribution of single letter preferences graduating, although in each case the preference for the Introverted, Sensing, Thinking, and Judging in the traditional curriculum was reinforced slightly in the change to the Engage curriculum.

Table 4: Graduation Rate by Temperament and Single Preference

	Basic Engineering				Engage Program			
Temp.	Start	Finish	Grad %	Normalize	Start	Finish	Grad %	Normalize
SJ	472	209	44.28	1.09	513	283	55.17	1.18
SP	270	109	40.37	1.00	273	126	46.15	0.99
NF	184	67	36.41	0.90	227	84	37.00	0.79
NT	326	122	37.42	0.92	424	176	41.51	0.89
Total	1252	507	40.50		1437	669	46.56	
	Basic Engineering				Engage Program			
Pref.	Start	Finish	Grad %	Normalize	Start	Finish	Grad %	Normalize
E	603	238	39.47	0.97	734	320	43.60	0.94
I	649	269	41.45	1.02	703	349	49.64	1.07
Total	1252	507	40.50		1437	669	46.56	
S	742	318	42.86	1.06	786	409	52.04	1.12
N	510	189	37.06	0.92	651	260	39.94	0.86
Total	1252	507	40.50		1437	669	46.56	
T	839	341	40.64	1.00	1001	480	47.95	1.03
F	413	166	40.19	0.99	436	189	43.35	0.93
Total	1252	507	40.50		1437	669	46.56	
J	654	285	43.58	1.08	748	387	51.74	1.11
P	598	222	37.12	0.92	689	282	40.93	0.88
Total	1252	507	40.50		1437	669	46.56	

In Tables 5, 6, and 7 the effect of curriculum change on temperament was examined for the base database, the strong preference database, and the subdivided by ability database. Table 5 is for all students, while Tables 6, and 7 look at male and female students separately. The trends observed in previous tables continue, with increasing graduation rates with the change in curriculum, the effect increasing with entering ability, and no difference for the "strong preference" group. Increases for the practical and logical SJ temperament type are statistically significant and increases for the spontaneous and reality-based SP temperament are close to statistical significance. For the harmony seeking NF and theoretical and logical NT temperaments, results are mixed and show variation by gender and ability level in no clear pattern.

Table 5: Temperament – All Students

	All Students		*Strong Preference*			*by SPI Score*	
Temp.	BE	E	BE	E	Category	BE	E
SJ	44.28	55.17	42.78	54.58	1	30.67	34.23
					2	42.68	59.54
					3	60.67	72.73
SP	40.37	46.15	43.24	55.29	1	25.53	23.53
					2	45.16	51.81
					3	54.55	67.16
NF	36.41	37.00	36.21	40.00	1	20.69	18.87
					2	47.17	33.33
					3	41.43	59.09
NT	37.42	41.51	37.61	41.71	1	20.91	28.70
					2	41.84	41.18
					3	50.93	52.48

Table 6: Temperament - Male Student Graduation Rates

	All			*by SPI Score*	
Temp.	BE	E	Category	BE	E
SJ	44.76	55.76	1	29.69	34.88
			2	45.61	58.33
			3	61.82	73.56
SP	40.54	45.11	1	25.61	23.44
			2	45.33	52.11
			3	53.85	63.27
NF	36.17	38.28	1	22.45	14.63
			2	45.24	35.00
			3	42.00	61.70
NT	39.15	39.57	1	20.83	28.57
			2	42.86	38.46
			3	57.69	52.81

Table 7: Temperament - Female Student Graduation Rates

	All		*by SPI Score*		
Temp.	BE	E	Category	BE	E
SJ	44.14	58.06	1	36.36	33.33
			2	36.00	62.86
			3	57.50	70.59
SP	42.86	61.76	1	25.00	25.00
			2	44.44	50.00
			3	58.33	77.78
NF	37.50	40.00	1	11.11	33.33
			2	54.55	28.57
			3	40.00	52.63
NT	29.82	45.00	1	15.38	29.41
			2	35.71	63.64
			3	33.33	50.00

Conclusions

The most significant effect of the change to an integrated, team and design oriented first year curriculum was a 6% increase in graduation rate. Graduation rates increased for most MBTI preferences, by 4-letter type, 2-letter temperament, or single letter preference. This effect was not uniform. The new integrated curriculum increasingly favored higher qualified entering students and females over males, with a 20% (45% to 65%) increase in graduation rate for the top third of female students compared to the traditional curriculum.

An important question was whether a curricular reform of this magnitude could affect the MBTI distribution of engineering graduates, with the resulting implications for changes in the engineering culture. While there are many observed differences in MBTI preferences between the two groups in this study, statistical significance was elusive for these changes, even with 3000 participants. It may be that a 12-credit hour (8-9% of required graduation credit hours) curriculum reform may not be enough to significantly affect the distribution of graduates and the undergraduate engineering culture.

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Appendix – MBTI Primer

The Myers-Briggs types are based on the theory that all of us are born with preferences. A preference is simply a *preferred* way of doing things. However, a tendency or preference does not mean it is the only way of behaving. The Myers-Briggs types are determined by locating the test taker on four preference continuums. These preference continuums are:

Extraversion (E) and Introversion (I)

Sensing (S) and iNtuition (N)

Thinking (T) and Feeling (F)

Judging (J) and Perceiving (P)

Extraversion (E) and Introversion (I)
Extraversion (E) and Introversion (I) refer to preferences of how a person chooses to interact with the world and where they get energy. An extravert becomes more energized as there is more interaction with people, and loses energy if thinking alone. The introvert is worn out at the end of interacting with lots of people, and becomes energized with private time. An extravert may talk quickly, while an introvert may rehearse before speaking. The extraverted student is the one that raises their hand before the teacher has finished asking the question, while the introvert may only answer when called upon.

Sensing (S) and iNtuition (N)
Sensing and Intuition have to do with how a person gathers data. The sensing person is focused on the "here and now." Sensing people are interested in concrete answers and prefer specific details and facts. Intuitive people are characterized by thinking about the future and all of the "what ifs." They prefer abstract thinking, and become bored with facts and details.

Thinking (T) and Feeling (F)
Thinking and Feeling have to do with how people make decisions. Thinkers base their decisions on logic and fairness. They are more concerned with the absolute truth than with being liked, and don't have emotions about situations – they resolve them with logic. Thinkers will engage in conflict if that's what it takes to prove their point. Feelers are more concerned with if everyone is happy at the conclusion of a decision rather than if the right decision was made – in fact, the right decision is the one that satisfied everyone! Feelers avoid conflict since they are more concerned with the relationships between people.

Judging (J) and Perceiving (P)
Judging and Perceiving have to do with lifestyle orientation. This preference has perhaps the least descriptive names, because it has nothing to do with being judgmental or perceptive. Judgers are scheduled. They prefer life to be planned and orderly. They don't like change, and are anxious to get things executed and finished. They are dependable and responsible. Perceivers are spontaneous, flexible and adaptable. In fact, they won't make a decision until the very last minute so that they can gather all their options and make the best decision.

The Myers-Briggs Types
The Myers-Briggs Types are made up of combinations of the preferences, one for each preference continuum. There are sixteen four-letter MBTI types. Example descriptions of two of the sixteen types follow:

ISTJ
ISTJ is the most common type among practicing engineers. They are usually quiet and can appear withdraw because of the I, but most of them make good use of their quiet time by thinking of ideas and how facts go together. As S's, they concentrate on executing the job at hand, using logic (a T trait) to figure out the solution. Their J preference enables them to schedule and plan ahead, and they don't like to have to adapt and change once they start down a path. ISTJs are dependable, organized, goal-oriented, and focused on the facts.

INTJ
INTJs combine their love of personal reflection with a structured and logical assembly of endless possibilities. They excel at coming up with new schemes. However, their structure and logic can make them self-assured and righteous about their ideas. If they aren't careful to consider others in the group, they may not be heard – simply because of how they present their ideas.

Another common classification using the MBTI preferences is called the four **temperaments**. This classification combines people who share two MBTI preferences in a manner described by Kiersey and Bates[13]. These temperaments are the **SJ**, practical and organized and often motivated by what they "should do"; the **SP**, reality-based and spontaneous, motivated by what is "fun to do"; the **NT**, theoretical and logical, motivated by accumulating competencies; and the **NF**, intuitive and seeking harmony, motivated by finding "meaning" in work and life.