Who Are Our Students? A Multi-Assessment Approach to Characterizing an Undergraduate Biomedical Engineering Student Population

David R. Hansberry
Drexel University, Philadelphia, Pennsylvania, USA, drh35@drexel.edu

David A. Delaine
Drexel University, Philadelphia, Pennsylvania, USA, dad49@drexel.edu

Donald L. McEachron
Drexel University, Philadelphia, Pennsylvania, USA, mceachdl@drexel.edu

Elisabeth S. Papazoglou
Drexel University, Philadelphia, Pennsylvania, USA, esp25@drexel.edu

Fred D. Allen
Drexel University, Philadelphia, Pennsylvania, USA, fda22@drexel.edu

ABSTRACT

The current student population in higher education consists of a diverse and rapidly changing collection of individuals with different personalities, learning styles, values and backgrounds. Learning is a highly personal activity and how any given student responds to a learning opportunity will depend on their individual characteristics. It is highly improbable, therefore, seems unlikely that optimal learning outcomes can be achieved by using only a single instructional style in such a varied and variable student population. A better approach would be to provide a diverse set of instructional methods matched to the diversity of the target audience. To create such a personalized level of instruction, a greater understanding of the students' personalities, learning styles and values is needed. As a first step, we applied a battery of various learning and personality tests to a segment of the undergraduate population of biomedical engineering students at Drexel University in order to obtain some sense of the level of diversity in this group. We uncovered considerable complexity, more than any one measure could adequately capture. Our findings indicate multiple assessments can provide valuable information that can be used by instructors to customize teaching methods to match relevant student attributes.

Keywords: learning styles, personality styles, engineering students, assessment

1. INTRODUCTION

It is clear that no two students are identical, let alone an entire class. Their personalities, interests, learning styles, values, strengths, weaknesses, attitudes, levels of motivation and diverse backgrounds all contribute to making each student unique. This represents a challenge to any instructor faced with even a moderately sized class. It can be predicted students will display a variety of intellectual, emotional and developmental responses to any given teaching style. In order to choose the most appropriate teaching style, then, faculty must be able to predict these responses. This, in turn, presupposes that faculty can develop an understanding of student characteristics sufficient to modify their teaching methods. Since any given class will consist of different students, and hence different learning styles, and with classes changing from year to year and even from term to term, we are presented with a difficult task of continually revising teaching styles to meet the needs of the current student population. Thus, our motivation in this study was twofold. First, we wanted to better understand the types of students in our classrooms. This is a necessary precondition so that instructional styles can be tailored to more effectively teach any population of students. Second, we wanted to develop a knowledge management system which would gather this information efficiently and present it to faculty in an easy-to-understand format requiring little or no additional time and effort to utilize. This work will address the former through analysis of a variety of assessments given to undergraduate biomedical engineering students at Drexel University. These students were evaluated using a variety of standard surveys along with survey developed in house on work and lifestyle issues. The surveys included the Index of Learning Styles, Myers-Briggs Type Indicator, Multiple Intelligence Test, Student Development Task and Lifestyle Assessment, Engineering Perspectives Test and a survey developed in house to gather information on extra-curricular activities, such as outside work, the Student Lifestyle Impact Survey. Our goal was to use the results of these assessments to classify and better understand the types of undergraduate biomedical engineering students at Drexel University. This, in turn, could potentially allow for the optimization of teaching methods according to specific student characteristics. Future work will explore how use of these assessments can provide instructors with valuable real-time information to customize their teaching methods for individual classes and most effectively reach a given student population for optimal learning.

2. ASSESSMENTS

Instructors have been using assessments to study education outcomes of engineering students since the 1970's (McCaulley 1976; Yokomoto and Ware 1982; McCaulley, Godleski et al. 1983; Godleski 1984; Felder 1993; Rosati 1993; Rosati 1997; Felder, Felder et al. 2002; Felder and Brent 2005). We have selected to use some traditional surveys and questionnaires as a baseline in combination with some newer assessments in order to achieve a more comprehensive profile of the characteristics of our engineering student population. This multi-assessment approach can increase the reliability of the results by providing a broader, more complex description of student characteristics as compared to a single assessment approach. This section describes the battery of assessment surveys used in this study.

2.1 Myers-Briggs Type Indicator

The Myers-Briggs Type Indicator (MBTI) is a psychometric assessment based on Carl Jung's psychological types (Jung 1971 (orginally published 1921)). The MBTI helps identify and explain consistent differences in how people use their minds. Results indicate the preference for each of four dichotomies. The assessment is widely used and has applications in education, career development, team development, psychotherapy and organizational behavior. The four dichotomies are listed below.

1. *Sensing/Intuition*: Someone who is sensing will be detail-oriented, trusting of facts and focus on concrete reality, while someone who is more intuitive will be concept driven, idea-oriented and focus on possibilities.
2. *Thinking/Feeling*: A person who applies thinking judgment uses a logical analysis of sensing/intuitive information to find the objective truth. An individual who prefers feeling judgment uses personal values to assess sensing/intuitive information to determine its importance. Feeling judgment is based more on the

consequences of decisions for other people while a person using thinking judgment is more concerned with empirical truth or falsehood.

3. *Extraversion/Introversion*: An extroverted attitude is derived from the outer world of people, things and actions is thus more empirical in its outlook. An introverted attitude is more focused on the inner world and self-reflection and is thus more rational in its approach.
4. *Judging/Perceiving*: An individual prone to judging attitudes want to reach a conclusion as fast and efficiently as possible, while a person with a perceiving attitude prefers to gather as much information as possible prior to reaching a conclusion.

Previous psychometric studies have determined that engineering curricula are mostly tailored to students who are intuitive, thinkers, introverts, and judgers. Such students do better academically (McCaulley, Godleski et al. 1983; McCaulley, Macdaid et al. 1985; Rosati 1993; Rosati 1997) perhaps as a result of having students' personality types match the expectations of the instructors. To test this idea, studies have examined the effect of tailored teaching styles to see how students performed when exposed to instructional styles more in line with the students' personalities. Both Godleski (Godleski 1984) and Felder (Felder, Felder et al. 2002) found that altering a teaching style to meet the needs of different psychological types resulted in enhanced student learning and improved performance. For example, theoretical teaching instead of practical teaching favored students who were more intuitive than sensors, but the sensors outperformed the intuitive learners in courses taught with practical real world examples. What is not clear at this time is whether or not the discipline and practice of engineering requires certain personality types or whether the fit between instructors and curricular expectations is a legacy effect. In other words, are engineering faculty the product of curricula that unconsciously select for certain personality types which, in turn, promulgates the same selection process in subsequent generations? Such an effect would naturally inhibit the development of diverse perspectives and approaches in engineering, reducing the potential for innovation.

2.2. Index of Learning Styles

The Index of Learning Styles (ILS) was developed by Richard Felder and Barbara Soloman of North Carolina State University to determine students' preference of four different learning styles. The four learning styles analyzed come from the Felder-Silverman Model (Felder and Silverman 1988; Felder 1993) and are described below:

1. *Active/Reflective*: Learners are a combination of both active and reflective learning but typically will have a tendency for one over the other. The difference between the two is that an active learner prefers to understand something by discussing or physically doing something with the information, while the reflective learner tends to understand through introspection.
2. *Sensing/Intuitive*: Sensing learners are patient with facts and prefer learning facts compared to the intuitive learner who prefers innovation and discovering relationships. A combination of both qualities is desirable in an effective learner.
3. *Visual/Verbal*: The visual learner tends to prefer learning with some type of visual aid (i.e. diagrams, video, demonstrations, etc.). The verbal learner excels more with oral and written instructions. The best learners can process information in either format and thus are a combination of both learning styles.
4. *Sequential/Global*: Sequential learners progress through a logical stepwise fashion in order to understand something while the global learner typically understands the large picture but struggles to connect the smaller parts and thus has a more difficult time explaining how they understand a concept.

The ILS has been used to evaluate engineering students and faculty from around the world (Montgomery 1995; Rosati 1996; Constant 1997; Buxeda and Moore 1999; Paterson 1999; Rosati 1999; Buxeda, Jimenez et al. 2001; De Vita 2001; Zywno and Waalen 2001; Kuri and Truzzi 2002; Livesay, Dee et al. 2002; Lopes 2002; Smith, Bridge et al. 2002; Zywno 2002; Dee, Livesay et al. 2003; Seery, Gaughran et al. 2003; Zywno 2003; Felder and Brent 2005). The results of these studies are collectively presented in Table 1. This data presents some interesting disparities between engineering students and faculty. It is worth noting that engineering faculty from this study were pointedly more Reflective, Intuitive and Global learners than their engineering student counterparts. In contrast, both groups heavily favored Visual learning. It remains to be determined whether engineering students who become engineering faculty are selected for these learning style qualities or migrate to them as they mature and develop in their respective fields. Nevertheless, these data delineate a genuine disparity between teacher and student which could translate into a learning barrier in the classroom.

Table 1: Collective Index of Learning Styles from references.

	Type of Learner								Number of
	Active	Reflective	Sensing	Intuitive	Visual	Verbal	Sequential	Global	Participants
Engineering Students	64%	36%	63%	37%	82%	18%	60%	40%	2506
Engineering Faculty	45%	55%	41%	59%	94%	6%	44%	56%	101

2.3 Multiple Intelligence Test

Howard Gardner has spent his career defining intelligence, which he describes as, "a bio-psychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in culture." (Gardner 1999) He originally described seven unique human intelligences, allowing for the potential development of others. We examined the original seven plus his recently proposed naturalistic intelligence (Gardner 1999). These separate intelligences are used to measure intelligence with a different resolution (through the Multiple Intelligence Test) than conventional intelligence assessments. The separate intelligences are described below (Gardner 1999).

1. *Linguistic*: Linguistic intelligence is one of the two types of traditionally valued intelligence by schools (the other being Logical-Mathematical Intelligence). People who demonstrate this intelligence typically excel at reading, writing, speaking, and learning languages. Writers, lawyers, journalist, speakers, teachers tend to have a high linguistic intelligence.
2. *Logical-Mathematical*: Logical-mathematical intelligence is characterized by the ability to analyze problems logically, reason with numbers, think scientifically, or perform complex mathematical calculations. Along with linguistic intelligence, logical-mathematical intelligence assessments are often applied to students. High logical mathematical intelligence is often found in mathematicians, engineers and scientists.
3. *Musical*: According to Gardner, musical intelligence has a similar structure to the linguistic intelligence. However, musical intelligence focuses more on performance, composition and a strong ability to learn from listening. People with a high musical intelligence are typically musicians, composers, or writers.
4. *Bodily-Kinesthetic*: Bodily-kinesthetic intelligence consists of using your body or part of your body to learn and help solve problems. This intelligence is useful for athletes, surgeons and mechanics.
5. *Spatial*: Spatial intelligence, also known as visual/spatial intelligence, entails learning best visually with the ability to direct space. Typical careers for spatial learners include pilots, sculptors and graphic artist.
6. *Interpersonal*: People with high interpersonal intelligence are typically outgoing and can recognize others' feelings very well. They are also generally very social and might have careers in sales, politics and acting.
7. *Intrapersonal*: Intrapersonal intelligence involves understanding oneself. Such people are typically in touch with their own ideas and values. Their careers could involve philosophy, writing and other fields where a person often works alone.
8. *Naturalistic*: The naturalistic intelligence entails knowledge of the outdoors, flora, fauna and more generally the environment. People who score highly in this style of intelligence might be predisposed for careers as biologists, environmentalists and farmers.

Gardner's theory of multiple intelligences is clearly valuable for identifying the specific strengths and intellectual tendencies of students when compared with a traditional unitary definition of intelligence. In a recent Austrian study, Gardner's approach was used to uncover differences between engineering students majoring in vehicle technology or aviation and non-engineering students attending the Institute of Theoretical and Applied Translations (Millward-Sadler, Casey et al. 2010). The study reported that the engineering students ranked higher in kinesthetic and logical intelligence when compared to the non-engineering students. The students with majors in non-engineering fields, on the other hand, scored higher in linguistic and intrapersonal intelligence. In contrast, these investigators found reported similar scores among all students in their high interpersonal and spatial intelligence (Millward-Sadler, Casey et al. 2010). These results underscore our contention that the student population in higher education is very diverse in characteristics related to learning.

2.4 Student Development Task and Lifestyle Assessment

The Student Development Task and Lifestyle Assessment (SDTLA) was designed by Winston, Miller and Cooper of the University of Georgia (Winston, T.K.Miller et al. 1999). It is given to university students to ascertain the students' developmental stages in terms of life purpose, mature interpersonal relationships, academic autonomy and the establishment of healthy lifestyles and facilitate personal growth in these areas. It is based on Chickering's theory of student development in which seven skills have been identified as vital to the personal development of university students (Chickering 1993 (orginally published 1969)). They are obtaining competence, managing emotions, enhancing autonomy toward independence, moving towards more mature interpersonal relationships, establishing a personal identity, developing purpose and establishing integrity (Chickering and Reisser 1993). This evaluation helps reveal another dimension of students that intelligence and personality assessments don't necessarily provide. The SDTLA has been validated, most notably in a large meta-analysis involving 1458 students from the USA and Canada (20 private, 4 liberal arts, 19 four-year public and 3 two-year public colleges) (Wachs and Cooper 2002). The SDTLA was administered to students when they were freshman in college and then again when they were seniors. The researchers found that students made developmental gains as they grew older and spent more time in college (Wachs and Cooper 2002).

2.5 Engineering Perspectives Study

The Engineering Perspectives Survey designed by Li and coworkers (Li, McCoach et al. 2008) to measure college student attitudes about engineering, both as a field of study and as a career choice. Li found that students generally thought engineering was valuable to society but didn't find the profession especially interesting. Furthermore, students were deterred by the belief that the work involved in getting an engineering degree was too great and the field, in general, is too demanding (Li, McCoach et al. 2008). The Engineering Perspectives Study assessment (2008) provides useful insight relevant to a student's choice to pursue studies and a career in the engineering field and furthers our understanding of the engineering student population.

2.6 Student Lifestyle Impact Survey

The Student Lifestyle Impact Survey was designed by the authors to monitor curricular and extracurricular activities in order to assess the impact of lifestyle choices on academic performance. The survey evaluates extracurricular jobs, coursework, daily time devoted to homework, extracurricular student activities, family and social obligation, as well as other measures that collectively determine how consumed students are outside of the classroom. This is a measure that one may expect to vary generationally as well as economically.

3. Results / Discussion

Surveys were made available online for each of the previously mentioned assessments using the Academic Evaluation, Feedback and Intervention System, created by UNTRA Corp as part of the School's knowledge management system for academic performance and assessment. Biomedical engineering students from the Drexel University at three different academic levels of a 5-year bachelors program participated. Participation was voluntary and all students signed consent forms as required by the approved IRB protocol. Freshmen, pre-juniors (third year) and seniors (fifth year students) were recruited to participate. Each student accessed the surveys through a password protected Web site which allowed all surveys to be administered independently and on the students' own time. Participation in this work was compensated with extra credit towards coursework (up to 4% if all surveys were completed). The ultimate goal of the project is to incorporate such student profiles in an Instructional Decision Support System to help steer curriculum evolution with respect to evolving student needs.

3.1 Myers-Briggs Type Indicator

The MBTI was taken by 46 males and 31 females (Table 2). The results indicate the biomedical engineering students at Drexel University tend to use a sensoring approach, are extraverts with a slight tendency to have a judging attitude, and are evenly balanced between using thinking (logical analysis) and feeling (value and consequences-based) judgment. What is most notable are the differences between males and females in each category. Female respondents had a higher proportion of individuals biased towards using sensoring, feeling, and judging attitudes than their male counterparts. Female respondents were also more prone to be extroverts compared with their male colleagues. Thus, there appear to be two different psychometric populations distinguished by gender within the School that consistently share the same learning space. Since engineering curricula are often tailored to intuitive, thinkers, introverts, and judgers as previously discussed (McCaulley, Godleski et al. 1983; McCaulley, Macdaid et al. 1985; Rosati 1993; Rosati 1997), it is apparent that such an engineering curriculum would be biased against a segment of our student population, particularly the females. A change in instructional style might produce a significant return on investment given that this information is accurate and sufficient.

Table 2: MBTI Results from 77 Drexel University Biomedical Engineering Students.

	Indicator Type								Number of Participants
	Sensing	Intuition	Thinking	Feeling	Extraversion	Introversion	Judging	Perceiving	
Men	57%	43%	67%	33%	48%	52%	48%	52%	46
Women	68%	32%	32%	68%	68%	32%	58%	42%	31
Total	62%	38%	50%	50%	58%	42%	53%	47%	77

The MBTI has been shown to be a useful assessment technique for characterizing aspects of our student population; however, we believe the engineering students are more complex than what the MBTI results alone would suggest. In fact, we content that these results only give a limited overview of the population in terms of attributes relevant to learning. The MBTI should not be used as the sole assessment tool but rather as a component in a suite of evaluation methodologies to more fully characterize engineering students.

3.2 Index of Learning Styles

A total of 111 students took the ILS assessment, including 60 males and 51 females. Table 3 shows the results and highlights the differences between male and female learning styles as well as trends between grade-levels. Trends involving the three groups of undergraduate students (freshman, pre-junior, and senior) were consistent for active/reflective and visual/verbal; however, the senior students seemed to shift from being primarily intuitive learners to more a sensing style and from a sequential approach to global learning. This is somewhat consistent with previous data on engineering students indicating that most students in the field were active, sensing, visual, and sequential learners (see Table 1). The observation that seniors were more globally oriented then their freshmen and pre-junior counterparts might be due a maturation of learning approaches, although this cannot be determined since the three populations represent separate individuals. The ILS data for engineering faculty displayed a slight trend for global over sequential learning (Table 1) and this might be reflected in the change of approaches shown by the seniors, either in terms of selection (sequential learners are not as well retained) or instructional influence (faculty teaching styles alter the students' learning strategies). The engineering faculty, however, are more reflective and intuitive than their student counterparts, suggesting the engineering students still haven't developed as learners in the same manner as the faculty. This may be a matter of different generational styles or indicative of a maturation process. In either case, there appears to be a potential mismatch between faculty and students in terms of learning styles. Interestingly, the ILS data support the MBTI results showing females as more sensing learners than males in this population. Additionally female respondents displayed a tendency to be more active and sequential learners than male respondents, but at the same time less visual than their male counterparts.

Table 3: Results from Index of Learning Styles assessment.

	Type of Learner								Number of Participants
	Active	Reflective	Sensing	Intuitive	Visual	Verbal	Sequential	Global	
Male	53%	47%	53%	47%	94%	6%	56%	44%	60
Female	68%	32%	69%	31%	80%	20%	67%	33%	51
Freshmen	57%	43%	57%	43%	86%	14%	61%	39%	45
Pre-Juniors	65%	35%	55%	45%	82%	18%	77%	23%	32
Seniors	60%	40%	71%	29%	94%	6%	47%	53%	34
Total	59%	41%	59%	41%	89%	11%	62%	38%	111

3.3 Multiple Intelligence Test

The results from the multiple intelligence tests (data not shown) demonstrate the similarities in types and distribution of intelligences between the freshmen, pre-juniors, and seniors.

Regardless of year in school, the Drexel biomedical engineering students' intelligences followed similar trends. Collectively the Drexel students' top-four intelligences were logical-mathematical, interpersonal, bodily-kinesthetic, and intrapersonal. It was surprising to see some consistent differences between Drexel's students and the Austrian engineering students (Millward-Sadler, Casey et al. 2010) who had higher spatial intelligence and lower intrapersonal intelligence. Again, this points out the need to conduct these kinds of surveys on an on-going basis as student populations potentially change through the incorporation of students from different cultures and ethnic backgrounds.

3.5 Student Development Task and Lifestyle Assessment

The SDTLA results indicated differences in both gender and class responses (data not shown). Females typically had higher scores for the Developing Autonomy Task, which includes emotional autonomy, independence, academic autonomy, and instrumental autonomy. However, the males tended to score higher in the Establishing and Clarifying Purpose Task and the Mature Interpersonal Relationship Task. When comparing the freshman, pre-juniors, and seniors we notice the highest scores coming from the freshmen, then pre-juniors with the seniors having the lowest scores. This was true for all three tasks: Establishing and Clarifying Purpose, Developing Autonomy, and Mature Interpersonal Relationship. This is surprising given the results of Wachs, et. al.(Wachs and Cooper 2002), who saw an increase in scores from freshmen up to seniors. A plausible explanation would be that our results come from three independent groups while the Wach et. al. study examines one group as it progresses through college. Our freshmen students could simply have a higher baseline score that will still increase as they progress through, while the seniors had a lower baseline score as freshmen and then progressed to their current level. Future monitoring of our freshmen students will allow us to test this hypothesis.

3.6 Engineering Perspectives Study

The data from the Engineering Perspective Study is displayed in Table 4 below. The table has four ranked sections that are composed of a subset of sections (not shown). The Interest section refers to the students' interest in engineering, the Career section refers to the students' perspective of an engineering career, Difficulty is the students' perceived difficulties of an engineering education and career, and the Negativity refers to the students' thoughts on a negative perception of an engineering education and profession. Numbers are on a scale 1-7, with 1 corresponding to strong disagreement and 7 corresponding to a strong agreement of the survey question.

Table 4: Engineering Perspective Study Data

	Fresh		**Pre-Junior**		**Senior**		**Department**
	Male - 26	Female - 26	Male - 24	Female - 9	Male - 17	Female - 15	117
Interest	5.58	5.39	5.53	5.64	5.53	5.03	5.45
Career	5.57	6.01	5.67	6.04	5.74	5.50	5.75
Difficulty	5.35	5.99	5.90	6.07	6.02	5.84	5.86
Negativity	4.69	4.38	4.70	4.85	5.22	4.98	4.80

As a group, male and females students found engineering to be equally interesting. However, women perceive engineering to be a more promising career with less negative perceptions than the men. Senior students found engineering more difficult than their younger counterparts while also having a more negative perception of engineering.

3.7 Student Lifestyle Impact Survey

The 11 question Student Lifestyle Impact Survey gives insight to how students' lifestyle and extracurricular responsibilities effect their education. As students progress from freshman to seniors they take on more responsibilities according to the survey. A third of all seniors have jobs outside school compared to less than a fifth of freshman; while as many as 25% of seniors are affected by social and family obligation, two and half times more than the freshman. Seniors spend more time in extracurricular activities / groups, take less class credits and yet manage to spend almost an hour more on homework each day than the freshman biomedical engineering students (assuming the answers are an accurate reflection of actual time spent). These results might be expected given that senior students have been immersed in the Drexel and Philadelphia environments for the longest period of time. They've had the opportunity to find activities outside of school to immerse themselves in, whether academic, professional, or social. In addition, they will have developed better time management techniques allowing them to participate more fully in both academic and non-academic activities.

Although each individual survey or assessment has merit on its own, we believe that connecting the surveys together can provide insights into student characteristics and trends. For example, the Student Lifestyle Impact Surveys also indicated a difference between male and females students in their approaches to the curriculum. Freshmen females register for fewer classes and credits than their male counterparts. Although the reasons are unclear, freshmen women may be intimidated by the course work/field. This hypothesis is supported by the initial higher perceptions of difficulty indicated by freshman females in the Engineering Perspectives survey, female respondents ranking the difficulty level as 5.99 vs. 5.36 for male respondents (on a scale of 1 to 7 with 7 being the most difficult). However, freshmen data alone do not tell the whole story. Data collected on pre-juniors and seniors demonstrate that as the women progress through the program, they take on *more* courses than their male counterparts. These students are also more likely to work in part time jobs and participate in extracurricular activities more often than male pre-juniors and seniors. Interestingly, upper division women engage in slightly fewer hours of homework per week perhaps indicating a better command of time management techniques or simply less time available to study. This is also reflected in the Engineering Perspectives results, where senior women rank the difficulty of engineering at 5.84 vs. male respondents' ranking of 6.02. It is interesting to note that as women progress through the curriculum, their perceptions of the difficulty goes down while the reverse is true for male students. While it is clearly possible to read too much into these data, the class populations being composed of different individuals, the finding does demonstrate the need to multiple assessments in terms of both tools and replication.

4. Conclusion

Results from these assessments describe a complex undergraduate biomedical engineering population. Overall, we found these particular biomedical engineering students to be more sensing than intuitive, extravert than introvert, visual than verbal, active than reflective and sequential than global. Furthermore, the results indicate these students highly value their health, honesty and family security. Continued studies on the freshman population as they progress to their senior year will allow for the testing of various hypotheses concerning the meaning of the current results of the SDTLA, Engineering Perspective Study and the Student Lifestyle Impact Survey. Our data support the use a multi-assessment approach when evaluating student populations to tailor teaching styles for optimal learning. Such an approach provides a more comprehensive description of the student population. Using only the ILS or other single measure results is a limited description of the students which may be misleading. Multi-assessment evaluation is a necessary tool to most accurately determine what "type" of students you are teaching. We believe it is necessary to understand students' personalities, interest, learning styles, values, strengths, weaknesses, attitudes, motivation and background to effectively teach them. Based on this understanding, a teacher can then attempt to modify their teaching styles to best meet the needs of the students. This is the ultimate goal – to effectively tailor teaching styles to meet the needs of ever-changing classrooms filled with unique students.

This goal explains the lack of statistical analysis in this paper. Our overall objective is to understand the students who populate our classrooms. To that end, it is not important whether or not females in a particular sample are statistically significantly different from males in their responses to a particular question or survey. What is important is who are the students, how diverse is the population in attributes likely to impact learning and how can an instructor compensate for that diversity in his or her instructional approaches. A statistical analysis adds little of value to the discussion and may actually detract from understanding classroom diversity. If one concludes, for example, that female freshmen rank engineering as statistically significantly more difficult than males, how does that help understand Sally's or George's learning needs? In point of fact, statistical significance often obscures individual differences and give rise to bias, i.e., Sally is a female and therefore Sally must think engineering is difficult regardless of what Sally actually believes. This is the very thing we are trying to avoid by promoting this multivariate assessment approach.

This does leave us with the problem of how to use these data. The current study is actually the first step in a three-step process, the other two phases of which are in-progress. Step two is the determination of how the attributes uncovered through these various assessments affect student performance. We are currently investigating this through the use of extra-curricular learning experiments. The third step is to incorporate the results into a useable format for application in classroom instruction. The idea is to provide data on student attributes for a given class in the appropriate context. For example, if students are determined to be visual learners, that datum will be accompanied with links to definitions and suggested approaches appropriate to visual learning. The idea is to provide just in time, in context instructional support to the faculty instructor based upon the most relevant individual characteristics of his or her current students. In effect, we are attempting to use appropriate information systems techniques to reestablish the faculty-student mentoring relationship in the modern university environment.

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