Architecture, Architectural Engineering and Engineering Technology Student Learning Styles as Compared to Engineering Science Grades

Abstract:

Architecture, Architectural Engineering and Engineering Technology students in the same college with engineering students may be asked to meet the same level of rigor as the rest of the college. Architecture, Architectural Engineering and Engineering Technology students may be housed in separate colleges from Engineering and have different accreditations and licensure processes than engineering. Are Technology and Architecture students fundamentally different than engineering students? College entrance exams and math placement exams have been used previously to identify how this student population may be different than traditional engineering students. However, this research identifies differences on a more basic level. Grades for Engineering Statics have been compared to a survey instrument in use for almost 30 years, the Index of Learning Styles (ILS). Junior level Architecture, Architectural Engineering, Construction Management, and Fire Protection and Safety students were asked to complete the ILS. Within the core group of students, distinct differences were identified. Further, these results were compared to a review of over 2,500 students who previously reported learning style preferences as a validation of the results.

Introduction:

This research project targets a group of students from previous studies. The students are in the following programs; Architecture (ARCH), Architectural Engineering (ARCE), Fire Protection and Safety Technology (FPST) and Construction Management Technology (CMT). Although it may not initially seem like these groups are associated, these students tall take courses in computer aided drawing and even those in FPST may end up in the construction industry as a sprinkler designer or alarms installer. With the exception of the ARCE engineers, faculty has pondered the question as to whether the architecture and technology students are unique from engineers, especially in their learning styles.

In a similar study, students were asked to participate in an interdisciplinary project between two typically distinct groups, FPST and CMT. The CMT students built a traditional truss project and instead of traditional loading, the FPST students set it aflame while loaded to failure and collected data. Anecdotally, the students expressed great interest in the project although the CMT students did not express similar interest in their coursework (Mosier et al. 2016). This illustration indicates the hands-on learning styles typically associated with technology students.

A similar case study asked student to perform video assignments and report via a survey as to whether a student as teacher approach helped them reinforce their previous coursework. Prerequisite course grades were compared to the post-assignment grade outcomes. Data indicated prerequisite grades were a better predictor of their future outcome than project participation indicated (Mosier, 2016). More recently, the research project expanded to include the college entrance exam and math placement exams (Mosier et al. 2017). This research questioned whether college entrance exams predict success in construction coursework. For the CMT, ARCH and ARCE students studied, once again previous grades indicated a better predictor for future grades. The college entrance exam studied did not act as a better predictor for future success in coursework or grades above passing. The requirement of a minimum college entrance exam score for certain degree programs, like engineering, begs the questions as to whether evaluating students for different personality or learning traits which may indicate the ability for future success even with low college entrance exams.

These previous studies have provided the basic question for the new study; are learning styles correlated with discipline? Felder and Silverman (1988) sought to identify mismatches between learning styles and the teaching styles of engineering faculty through a survey instrument developed from the learning style model from David Kolb (1984). The Felder and Silverman model of learning styles is exemplified by a survey instrument developed called the Index of Learning Styles (ILS) (1988). This instrument will be used as a basis for this study as well. The ILS includes active or reflective, sensing or intuitive, visual or verbal, and sequential or global. The survey instrument builds upon Kolb's learning styles (1984) by adding the sensing/intuition, visual/verbal, and sequentially/globally categories. Felder and Brent (2005) further expand the study and note a "mismatch" in learning versus teaching styles.

A Brief Overview of the Index of Learning Styles:

The Felder and Silverman model learning styles include active or reflective, sensing or intuitive, visual or verbal, and sequential or global. All learners will fall into one of the two styles in each category. For instance, a student could be an active, sensing, visual, sequential learner. To better understand how a student learns, each of the categories needs to be considered individually. Students will show preference on the type of information received and will be considered either sensing or intuitive. Sensing students perceive information better through external sights or sounds. Intuitive students perceive information better internally via insights. Students will also naturally divide between being either visual or verbal, which is how they receive external information. Visual learners prefer pictures or diagrams while verbal learners prefer audible language. These two categories of perception and input reflect the first step in the learning process of receiving information.

The second step of the Felder and Silverman learning process is how the student processes and understands the information they received. First, a student must process the information, and will do so either actively or reflectively. Active learners prefer physical activity or discussion while reflective learners prefer self-analysis. Second, a student will work towards understanding the information, either sequentially or globally. Sequential learning is in steps and global learning is a holistic approach (Felder and Silverman, 1988).

It should be noted that there was previously an additional category placing students into either inductive or deductive means of organization of information. However, Felder later removed this category as it was found that students would say they prefer the deductive approach, but inductive presentation enables students to progress through the reception and processing of information. Felder and Silverman (1988) addressed this originally in that:

> Induction is the natural human learning style.... Most of what we learn on our own (as opposed to in class) originates in a real situation or problem that needs to be addressed

> and solved, not in a general principle; deduction may be part of the solution process but it is never the entire process" (p. 677)

The active or reflective category is derived directly from Kolb's Learning Theory of experiential learning (Felder and Silverman, 1988). Kolb's four-stage cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation is then interconnected with an individual's learning style through the Learning Style Inventory test (Kolb, 1984). Kolb's Learning Style Inventory then provides four basic learning styles: convergent, divergent, assimilation, and accommodation (Kolb, 1984). Each of the learning styles is associated with two of the stages or learning modes in the cycle. Convergent is associated heavily with abstract conceptualization and active experimentation, divergent stresses concrete experience and reflective observation, assimilation relies upon abstract conceptualization and reflective observation, and accommodative emphasizes concrete experience and active experimentation (Kolb, 1984).

Felder and Brent (2005) provide what type of faculty instruction works best with the four learning styles by Kolb: convergent, divergent, assimilation, and accommodation. Teaching to a convergent learner, the instructor should act as a coach. Teaching to a divergent learner, the instructor should act as a motivator. Teaching to an assimilation learner, the instructor should act as the expert. Teaching to an accommodation learner, the instructor should ask open-ended questions and utilize problem-based learning (Felder and Brent, 2005).

For engineering disciplines, the typical teaching pedagogy only fulfills the needs of the assimilation learner. Felder and Brent (2005), recommend that the most effective teaching style, according to Kolb's model, is to teach around the cycle by motivating new topics, presenting basic information on a given topic, practice within the topic, and provide means of applying the topic.

Felder and Silverman (1988) built upon Kolb's learning styles by adding the sensing/intuition, visual/verbal, and sequentially/globally categories. This enables educators to have a holistic approach of students learning styles. Each of the four categories of student learning described by Felder and Silverman (1988) correspond with a teaching style. The category of student perception will rely on the content the teacher relays. The content will be either concrete or abstract. The presentation of the content will be either visual or verbal. Faculty relies heavily upon student participation being either active or passive, which corresponds to the students learning being active or reflective in processing information. Finally, the faculty will have their own perspective of if material should be presented sequentially or globally.

Further, there is a mismatch in learning and teaching style. According to Ruutmann and Kipper (2013), most engineering students fall under the active, sensing, visual, and sequential. However, most engineering educators use teaching methods best received by intuitive, verbal, passive (or reflective), and sequential learners (Ruutmann & Kipper, 2013). Since the original paper from Felder and Silverman (1988), a variety of studies have been performed, both international and in the United States. Felder and Brent (2005) subsequently provided a review of the papers and survey results. An adapted table from their paper is presented herein. Only the U.S. engineering data is included.

Population	A	S	Vs	Sq	N	Reference
Iowa State Univer.	63%	67%	85%	58%	129	Constant (1997)
Michigan Tech.	56%	63%	74%	53%	83	Paterson (1999)
Ryerson Univ. 2000	53%	66%	86%	72%	87	Zywno & Walen (2001)
Ryerson Univ. 2001	60%	66%	89%	59%	119	Zywno (2002)
Ryerson Univ. 2002	63%	63%	89%	58%	132	Zywno (2003)
Tulane, 2nd.	62%	60%	88%	48%	245	Livesay et al. (2002)
Tulane, 1st.	56%	46%	83%	56%	192	Dee et al. (2003)
Univ. of Michigan	67%	57%	69%	71%	143	Montgomery (1995)
U.S. Engr. Student Average	60%	61%	83%	59%	1130	Total (N)

Table 1 Reported Learning Style Preferences in Engineering
(Adapted from Felder and Brent, 2005)

The abbreviations for Tables 1 and 2 are “A” = Active, “S” = Sensing, “Vs” = Visual, “Sq” = Sequential, where “N” is the number of participants.

Discussion:

For the programs studied, junior level Architecture, Architectural Engineering, Construction Management, and Fire Protection and Safety students have all completed Engineering Statics coursework. All of the students had previously completed coursework in Calculus, Physics and Engineering Statics. These courses are not considered to be experiential learning courses, but are more typically taught in a lecture format. Both Physics and Engineering Statics have an associated laboratory or recitation section. The students in the junior level cohort were identified by post-requisite courses in which they were currently enrolled. This group of students was chosen based on their similarities in early, sophomore level courses. The students also share similarities in their overlap with coursework in drawings due to the relationship with the construction industry.

Faculty presented each of these groups with an ILS survey instrument to complete. Of the 131 enrolled in these courses, 102 surveys were returned for a participation rate of 77.8%. Students who did not complete the survey and/or did not complete the pre-requisite coursework were not considered or included in the participation rate. In addition to the ILS, students were asked to provide an identifier that could easily be correlated with their grade in the prerequisite course. Further, students were asked to identify their major, gender and minority affiliation. These additional markers were requested but not required.

The survey is comprised of 44 questions each having only two possible responses. With a written survey, the student can self-score or the survey can be scored by others. The survey is also available online and available for free to anyone wishing to take it. Using the responses, a score is determined on a continuum scale as illustrated in Figure 1. Each student’s ILS score included a measure on a scale in each category; i.e. intuitive versus sensing. The score is associates a student with the strength in each of the categories.

INTUITIVE	11	9	7	5	3	1	1	3	5	7	9	11	SENSING
VERBAL	11	9	7	5	3	1	1	3	5	7	9	11	VISUAL
REFLECTIVE	11	9	7	5	3	1	1	3	5	7	9	11	ACTIVE

Figure 1 Index of Learning Style Scale

Given the scale nature of the above independent variables, the data was transformed to a scale of 1 to 12. For each of the categories, the learning style associated most with teaching methods by Ruutmann and Kipper, were designated at the high end of the scale. Scores between 7 and 12 score were associated with reflective, intuitive, verbal, and sequential learning styles. Scores between 1 and 6 are associated with active, sensing, visual, and global learning styles.

Using the same basic format as presented in Table 1, the results for the various majors were identified. Average grades for required Calculus, Physics and Statics courses are also included. A grade of "A" is set to 4.0 as would be in a typical 4.0 grade scale.

Population	A	S	Vs	Sq	N	Average Grade
ARCH	60.7%	39.3%	92.9%	50.0%	28	2.86
ARCE	81.8%	90.9%	90.9%	63.6%	11	3.10
Mixed ARCH/ARCE	66.7%	53.8%	92.3%	53.8%	39	2.94
CMT	75.0%	91.7%	97.2%	83.3%	36	2.76
FPST	63.0%	88.9%	92.6%	70.4%	27	2.83
Overall Results - University	68.6%	76.5%	94.1%	68.6%	102	2.84

Table 2 Reported Learning Style Preferences – Oklahoma State University,

The purpose of this research was to determine how much a student's grade in an engineering statics class could be explained by their Index of Learning Style scores. The students were enrolled in a class that required an Engineering Statics course as a pre-requisite. Only the highest passing grade of each of the prerequisite course was evaluated. Upon obtaining the ILS scores from each student, their highest grade in the Engineering Statics course was also obtained. Students who withdrew from the engineering statics were not considered. However, only the final attempt grades were used for the study.

The overall average grades for the Calculus, Physics and Engineering Statics courses are shown. As these courses are all prerequisite courses, a "C" or better is required to move into the next course. The overall average grade is not telling. However, the Calculus and Engineering Statics have much higher averages at 2.94 and 3.03 respectively. This points to a possible issue with the Physics course, with an average of 2.56.

Comparing the results of this study to the previous studies, the Engineering and Technology students do have some differences and similarities to other engineering students. As the students studied all have a general association with construction careers, it is not surprising that they are slightly more visually oriented than other engineers. The Engineering and Technology students are average 11.2% more visually oriented, for all majors scores are in the 90% plus range. However, when focusing on the Architecture students, the sensing category is much lower, indicating that the Architecture students are much more intuitive in their learning styles.

By removing the Architecture students, the Engineering and Technology students can be compared to other university engineering programs shown in Table 1. The Oklahoma State University Engineering and Technology students are much more sensing than students in other universities or the Architecture students. An interesting note shows is the difference between the Architecture Students and Architectural Engineering students is the largest, at over 50% difference in sensing versus intuitive. These students are in many of the same courses and classes, so this information can be very useful to the faculty for these courses.

Similarly, when comparing this group of Engineering and Technology students to other university engineering programs, there is an almost 30% difference in learning styles. It indicates that this group of Engineering and Technology students are much more sensing than intuitive, with over 90% sensing as compared to 61% from other programs. An additional difference is the Sequential learning nature of this group of students. By removing the Architecture students provides additional insights into the Engineering and Technology students. As a group the Engineering and Technology students are much more sequential in learning styles than their counterparts at other universities. This also is very useful information for faculty to incorporate into the classroom.

Both Calculus (math) and Engineering Statics frequently have a sequential pedagogy (Dollar and Steif, 2004) where the coursework is presented in a sequential or logical incremental progression (Felder and Brent 2005). Math can be taught using the Eureka! Method (Hadamard, 1945), or a more global method or using understanding of related material to understand newly presented material, however ultimately one concept builds on the previous concept. Global learners can more readily apply this new knowledge to unrelated problems (Felder and Brent 2005). An initial Physics class may be a survey course, which introduces the student to a wide variety of Physics topics. This might explain why sequential learners overall scored lower in the Physics course than they did in the post-requisite course of Engineering Statics.

The post-requisite courses varied for the students surveyed. The post-requisite courses were identified by cohort, all having taken the same prerequisite courses in Calculus, Physics and Engineering Statics. As the four programs are different in focus, the post-requisite for Engineering Statics also varied. For ARCH and ARCE students, the survey was administered in their Timber Design course, which does not require Strength of Materials as a prerequisite. The CMT students were surveyed in a Construction Estimating course which runs concurrently with their Strength of Materials course, indicating the same cohort of students. The FPST students were surveyed in their course, Structural Designs for Structure and Life Safety. Although the coursework and teaching styles may have been different, the questions for all of the students were the same. The survey questions focused solely on individual preferences in learning styles.

Other considerations may include the fact Engineering and Technology majors have traditionally had a large gender gap with women in engineering making up about 20% in 2012 (Pawley et al. 2016 and Yoder, 2013). This is mirrored by the current study with 22 of 102 students surveyed being female or 21.6%. Delving deeper into the majors, the majority of the female students surveyed are in Architecture and Architectural Engineering with 53.6% and 45.5% respectively or 20 of the 39 of the respondents from the two majors. Of this group of junior level students there was only 1 female student in CMT and 1 in FPST.

The female students surveyed from Architecture and Architectural Engineering majors, scored similarly to their overall majors. This is not surprising as these respondents make up approximately 50% surveyed from those majors. These female students scored 65% sensing and 60% sequential learning styles. When comparing to the Engineering and Technology groups, it is apparent that the female students vary greatly from the overall respondent group. As more women enter these fields, this is an opportunity for engineering educators to review curriculum for these other learning styles.

Conclusion:

Students' scores on their ILS were analyzed and compared to their initial math, physics and engineering statics courses. The ILS score of intuitive/sensing and sequential/global learning styles were found to be significant. When reviewing the course content for engineering statics, a sequential learner coincides with the methodology and technical content of engineering statics.

This differs compared with what Ruutman and Kipper (2013) have indicated on the type of teaching methods typically associated with faculty in engineering. The coefficients confirm the mismatch between teaching and learning in the reflective/active scores and how students process the information.

Given the limited size of the data set in this research, future research in this area should include replicating this study with similar core engineering science courses as well as comparing ILS scores and grade achievements in the various engineering, architecture, and engineering technology disciplines. A multiple regression analysis should also be performed to provide a more concise relationship between the course grades and learning style attributes.

Student learning is an important aspect of higher education. Student learning is what ties many elements of higher education together. Students, faculty, employers, and accreditors all want the same thing – students who learn and develop while in college. Students who understand of their own learning style such can ensure they are giving themselves the best advantage when learning the different content. Similarly, faculty are impacted by student learning in that they need to understand how students learn so that they can modify their teaching style accordingly.

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