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Engineering Students' Development as Lifelong Learners

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Abstract

It is widely accepted that one goal of higher education is to instill in students the need for and the practice of lifelong learning. Given its importance, it is surprising that there is a paucity of methods to assess this outcome in students. Two recently developed assessment instruments purport to measure various facets of this outcome in college students. We used these instruments to assess differences between engineering students at a large, public university in the western United States. Engineering students from the first through senior year of study in a variety of disciplines were surveyed using both instruments. The sample (n=356) also included a fair representation by females and minority groups. Analysis of variance was used to assess for differences between the various subgroups of students. The results based on the survey for measuring lifelong learning skills showed that there were several differences between student populations. In comparing between racial or ethnic groups, Asians self-reported lower abilities with "application of knowledge and skills," and "adaptable learning strategies." When students were compared based on their year of study, a significant difference was found between the first-year and senior students, and between second-year and senior students, with the seniors reporting higher abilities in "adaptable learning strategies." The results based on the survey for measuring autonomy of learning showed significant differences between Asian students and other racial or ethnic groups, with Asian students consistently self-reporting weaker scores on both subscales of "independence of learning" and "study habits". Finally, male students held a higher self-belief in independence of learning compared with female students.

Introduction

It is widely accepted that one goal of higher education is to instill in students the need for and the practice of lifelong learning. All major stakeholders of higher education – graduates, employers, faculty and accrediting agencies – agree that this outcome is critically important given the rapid pace of change of society, especially in engineering and technology. Our graduates must adapt to this change to remain productive contributors. Indeed, it can be argued that much – or even most – of what an engineering graduate needs to know several years after obtaining his or her degree will not have been learned in school but will need to be acquired through independent learning outside of formal instructional settings.

Given the importance of lifelong learning, it is surprising that there is a dearth of instruments to measure it. Two recently developed assessment instruments[1,2] purport to measure various facets of this outcome in college students. Our goal in this work is to use these instruments to assess differences in engineering students at a large, public university in the western United States.

Background

Lifelong learning is a relatively new construct in higher education[1] and, though currently widely used, its definition is rather vague and imprecise. Some researchers equate lifelong learning with characteristics that lifelong learners possess, such as self-directed learning, autonomous learning, motivation to learn, and perceived competence.[1,2] Even using these well developed psychological traits, however, the available instruments to assess them have rather severe shortcomings.

One instrument to directly measure lifelong learning was constructed by Deakin Crick and colleagues called the Effective Lifelong Learning Inventory.[3,4] This 72-item survey was designed for a target audience ranging from young children to adults and, as a result, is laborious to complete because of its length, vagueness of some questions, and openness to multiple interpretations of others.[1]

Other instruments that measure associated traits exist, but each has problems that make it inadequate for use with college undergraduates. As Macaskill & Taylor[2] described, the Self-directed Learning Readiness Scale[5] has severe problems with its construct validity and other shortcomings, and the Self-directed Learning Readiness Scale for Nursing Education[6] is long and designed for a specific population. A widely studied and used instrument, the Motivated Strategies for Learning Questionnaire[7] (MSLQ), for measuring aspects of motivation for learning among college students seems appropriate but, in our opinion, is rather long and may not be compatible with some pedagogies and modern teaching practices.

The instruments under study are appealing in that both are based on educational psychology research, psychometrically sound, and brief, taking less than 10 minutes to complete both. Macaskill and Taylor's 12-item instrument[2] aims to measure two subscales – independence of learning and study habits – that characterize an autonomous learner, which arguably forms the act of being a lifelong learner. Kirby et al.[1] claims to directly measure lifelong learning as conceptualized through five traits: goal setting, applying appropriate knowledge and skills, engaging in self-direction and self-evaluation, locating information, and adapting learning strategies to different conditions. This instrument contains 14 questions. We previously reported some preliminary results using these instruments.[8] The results reported here are more reliable and have higher statistical power due to the much larger sample size.

Methodology

Participants

A total of 356 engineering students attending a large, public university in the western United States completed the surveys. The students were recruited from two time periods between May and September 2012. The first was during the spring quarter of a three-quarter academic year from multiple sections of three courses: Introduction to Thermodynamics, Dynamics, and Thermal Systems Design. The second period was early in the fall quarter. The students were enrolled in multiple sections of five courses: Statics, Thermodynamics II, Semiconductor Device Electronics, Polymer Electronics Lab, Programmable Logic and Microprocessor-Based Systems Design. Approximately 20 participants were excluded from the final analyses due to either incomplete surveys or small number of respondents in the demographic group, leaving a final sample size of n = 356. Table 1 provides the demographic characteristics of the participants.

Table 1: Demographic characteristics of the sample (n = 193).

	n	%
1. Quarter of survey		
Spring 2012	180	50.6
Fall 2012	176	49.4
2. Gender		
Male	296	83.1
Female	60	16.9
3. Race/ethnicity		
White	258	72.5
Asian	60	16.9
Hispanic	38	10.7
4. Year of study		
First year	61	17.1
Sophomore (2nd year)	65	18.3
Junior (3rd year)	116	32.6
Senior (4th or higher year)	114	32.0
5. Major		
Mechanical	168	47.2
Civil & Environmental	44	12.4
Biomedical	43	12.1
Electrical	32	9.0
Computer Engineering	18	5.1
General	15	4.2
Industrial	11	3.1
Aerospace	9	2.5
Agricultural	6	1.7
Other	8	4.2

Procedure

The two instruments were combined into a single survey (Figure 1). The upper section of the survey is the lifelong learning scale (LLS) of Kirby et al.,[1] while the lower section is the autonomous learner scale (ALS) of Macaskill & Taylor.[2] For the ALS, items A-G form the "independence of learning" subscale, while items H-L form the "study habits" subscale. Each subscale of the LLS was formed from the following sets of questions:

Goal setting: Questions 1, 6, 7, 9, 14

Applying appropriate knowledge and skills: Questions 5, 10, 12

Engaging in self-direction and self-reflection: Questions 8, 13
Locating information: Question 11
Adapting learning strategies to different conditions: Questions 2, 3, 4

Circle your answers to these questions using these guidelines for 1 to 5.

1-Strongly agree	2-Agree	3-Neutral	4-Disagree	5-Strongly Disagree

1. I prefer to have others plan my learning	1	2	3	4	5
2. I prefer problems for which there is only one solution	1	2	3	4	5
3. I can deal with the unexpected and solve problems as they arise	1	2	3	4	5
4. I feel uncomfortable under conditions of uncertainty	1	2	3	4	5
5. I am able to impose meaning upon what others see as disorder	1	2	3	4	5
6. I seldom think about my own learning and how to improve it	1	2	3	4	5
7. I feel I am a self-directed learner	1	2	3	4	5
8. I feel others are in a better position than I am to evaluate my success as a student	1	2	3	4	5
9. I love learning for its own sake	1	2	3	4	5
10. I try to relate academic learning to practical issues	1	2	3	4	5
11. I often find it difficult to locate information when I need it	1	2	3	4	5
12. When I approach new material, I try to relate it to what I already know	1	2	3	4	5
13. It is my responsibility to make sense of what I learn at school	1	2	3	4	5
14. When I learn something new I try to focus on the details rather than on the 'big picture'	1	2	3	4	5

Circle your answers to these questions using these guidelines for 1 to 5.

1-Very like me	2-Like me	3-Neutral	4-Not like me	5-Not at all like me

A. I enjoy new learning experiences	1	2	3	4	5
B. I am open to new ways of doing familiar things	1	2	3	4	5
C. I enjoy a challenge	1	2	3	4	5
D. I enjoy finding information about new topics on my own	1	2	3	4	5
E. Even when tasks are difficult I try to stick with them	1	2	3	4	5
F. I tend to be motivated to work by assessment deadlines	1	2	3	4	5
G. I take responsibility for my learning experiences	1	2	3	4	5
H. My time management is good	1	2	3	4	5
I. I am good at meeting deadlines	1	2	3	4	5
J. I plan my time for study effectively	1	2	3	4	5
K. I frequently find excuses for not getting down to work	1	2	3	4	5
L. I am happy working on my own	1	2	3	4	5

Figure 1: Combined surveys of Kirby et al.[1] (upper section) and Macaskill & Taylor[2] (lower section). Note that questions about demographics are not shown.

As mentioned previously, the survey took less than 10 minutes to complete on paper, and was administered either at the beginning or end of a normal class meeting, as was convenient for the class instructor who granted access to his or her class. The purpose of the assessment – to measure students' learning strategies and habits – was explained to the students prior to its administration. Only volunteers completed the survey and no remuneration or extra credit was provided for participation.

Results

Lifelong learner characteristics

Comparisons on each of the five subscales (or traits) for the LLS with study population characteristics found only a few significant differences, which are shown in Table 2. A series of one-way analyses of variance (anova) were carried out to determine how the characteristics of a lifelong learner are related to gender, race/ethnicity, class and major. When there were more than two groups being compared and the overall anova p-value was significant ($p < 0.01$ indicating at least one group had a significantly different mean), post-hoc pairwise comparisons of means were carried out using Tukey's method, controlling the family-wise error rate at 0.05. Note that a Bonferroni adjustment was used on the overall anova p-value, since there are five comparisons being made (one for each characteristic), to protect the Type I error rate. The "Mean (std dev)" values in Table 2 represent the means and standard deviations for each trait and for each population group, and correspond to the summed values of all survey questions for that trait. Note that reverse-worded questions were reverse coded before the analyses. A lower mean score indicates a higher self-rated propensity for that trait.

Table 2: Significant differences between study population groups for each subscale of LLS.

Trait of lifelong learner	Mean (std dev)	Mean (std dev)	p-value*
Goal setting	Mechanical: 12.39 (2.66)	Civ. & Env.: 13.89 (2.28)	0.0096
Applying knowledge & skills	Whites: 5.82 (1.68)	Asians: 6.62 (2.47)	0.0107
Adaptable learning strategies	Whites: 8.81 (1.86)	Asians: 9.58 (1.67)	0.0021
	Senior: 8.59 (1.98)	First-year: 9.28 (1.60) Sophomore: 9.65 (2.09)	0.0004
	Mechanical: 8.70 (1.95)	Biomedical: 9.72 (1.88)	0.0006

* Indicates a significant difference in means in overall anova; $p < 0.01$.

Between the majors, significant differences were found between mechanical engineers and civil & environmental engineers in their self-perceived goal setting ability, and between mechanical engineers and biomedical engineers in their ability to adapt learning strategies to different conditions. Between race/ethnicity groups, significant differences were found between Whites and Asians, with Whites having stronger perceived ability to adapt learning strategies to different conditions, and with Whites having a perceived ability to apply appropriate knowledge and skills in their studies that was at the limit of significance. Finally, significant differences were found between the first-year and senior students and between sophomore and senior students, with senior students exhibiting stronger self-beliefs in their ability to adapt learning strategies to different conditions. There was no dependence of any trait on the students' gender. It is worth emphasizing that no significant difference was found for the lifelong learning traits of self-direction and -evaluation and locating information between any subgroups in our study population.

Autonomous learner characteristics

Comparisons on each of the two subscales (or traits) for the ALS with study population characteristics found only a few significant differences, which are shown in Table 3. A series of one-way analyses of variance were carried out to determine how the characteristics of an autonomous learner are related to gender, race/ethnicity, class and major. When there were more than two groups being compared and the overall anova p-value was significant ($p < 0.025$ indicating at least one group had a significantly different mean), post-hoc pairwise comparisons of means were carried out using Tukey's method, controlling the family-wise error rate at 0.05. Note that a Bonferroni adjustment was used on the overall anova p-value, since there are two comparisons being made (one for each characteristic), to protect the Type I error rate. The "Mean (std dev)" values represent the means and standard deviations for each trait and for each population group, and correspond to the summed values of all survey questions for that trait. Note that reverse-worded questions were reverse coded before the analyses. A lower mean score indicates a higher self-rated propensity for that trait.

Table 3: Significant differences between study population groups for each subscale of ALS.

Trait of autonomous learner	Mean (std dev)	Mean (std dev)	p-value*
Independence of learning	Males: 15.40 (2.99)	Females: 16.47 (3.22)	0.0136
	Whites: 15.45 (2.92) Hispanics: 14.92 (2.10)	Asians: 16.58 (3.86)	0.0122
Study habits	Whites: 11.93 (3.61)	Asians: 13.53 (3.53)	0.0079

* Indicates a significant difference in means in overall anova; $p < 0.025$.

Asians held significantly lower self-beliefs in the autonomous learner trait of independence of learning compared with the other two race/ethnicity groups (though there was no difference between Whites and Hispanics). Asians also self-perceived to have poorer study habits in comparison to Whites. Male students held a higher self-belief in independence of learning compared with female students. No differences for either trait were found between the students' year of study or between the majors.

Discussion

The differences between Asians and other race/ethnicity groups was somewhat consistent between the two instruments, with Asian students believing that they have weaker abilities in two of the five LLS subscales (applying appropriate knowledge and skills and adapting learning strategies to different conditions) and both of the ALS subscales (independence of learning and study habits). In fact, although the differences were not statistically significant from Whites or Hispanics (and therefore not shown), Asian students had the lowest self-ratings in two of the other three subscales of the LLS. These findings may be interpreted based on recent findings about the effects of the "model minority stereotype" on Asian-American engineering students.[9] That study found that although Asian-American students' academic records were not significantly different from other racial/ethnic groups, the stereotype influences some Asian-American students' judgement of their self-worth resulting in lower self-evaluations.

Although this study was cross-sectional in time rather than longitudinal, we nonetheless interpreted the differences found between the students' year of study as resulting from the time spent in school. The finding from the LLS that students gained in their abilities from the first or sophomore years to the senior year in the adaptable learning strategies trait is a welcomed one (Table 2), although it is disappointing that students did not develop in all lifelong learning or autonomous learner traits. It can be argued that adaptable learning strategies, along with applying appropriate knowledge and skills, are more practiced and emphasized in most engineering curricula than the other lifelong learning traits. The fact that the other four lifelong learning traits showed no significant gains throughout a student's academic career may indicate that either these traits were well developed before students enter college or, sadly, they are not being developed during college.

The fact that no significant differences were found for the students' year-of-study for either subscale of the ALS is surprising in light of the LLS results. It may be that "adaptable learning strategies" (Questions 2, 3 and 4 in Figure 1) as a construct in the LLS is not captured well in the ALS. This is supported by the inter-instrument comparison, which showed that this subscale had only a weak correlation ($r = 0.254$) with the ALS (Table 4).

We are somewhat surprised at the two significant differences between the majors since we had expected to find none. More work is needed to understand these differences including studies with larger populations of students from various engineering majors.

The only difference found between male and female engineering students was for the autonomous learner trait of independence of learning. This finding was surprising since these two subgroups showed no significant difference for any of the five lifelong learning scales (although we note that the trait of adaptable learning strategies was nearly significantly different at a p-value of 0.0118). That females rated themselves as less able than males at being independent learners (Table 3) is consistent with a previous study[10] which found that female chemical engineering students had lower self-assessments than males for solving basic engineering problems, problems that required creativity, and computer problems. The authors of that study concluded that the female students lacked self-confidence in these abilities, rather than having an actual deficiency in these skills relative to the males.

Conclusions

Students vary in their abilities as lifelong or autonomous learners, as expected. While we hope that their educational experience will help them to make gains in these abilities, the results found here are mixed. Asian students were found to have weaker self-beliefs in several lifelong or autonomous learner traits. This was the most significant finding from this study. Males and females appear to differ only on one autonomous learner trait, with females self-reporting a lower ability in independence of learning. Happily, we found that engineering students make significant gains in a trait that is emphasized in most engineering curricula, adaptable learning strategies. This finding suggests that, perhaps, emphasis and effort should be put into developing curricula that focus on the remaining lifelong learning traits to help students develop them. What is perhaps somewhat surprising is that there are not more differences between student subgroups for more lifelong learning traits.

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