How do first-year engineering students develop as self-directed learners?

Boris Taratutin, Taylor Lobe, Jonathan Stolk, Robert Martello
Franklin W. Olin College of Engineering
Needham, MA, USA

Katherine C. Chen, Roberta Herter
California Polytechnic State University at San Luis Obispo
San Luis Obispo, CA, USA

***Abstract*— Although self-direction is among the most critical skills required of today's engineering graduates, the complex processes through which individuals develop the attitudes, beliefs, and skills of lifelong, self-directed learners remains unclear. In this ongoing mixed-methods investigation, we draw on existing motivation and self-regulated learning theories to examine how undergraduate students at two institutions develop as self-directed learners during their first two years of their engineering programs. Preliminary findings indicate that both groups of first-year students make progress as self-directed learners, even after their first semester of college. However, the data indicate marked differences in specific areas of self-directed learner growth at the two institutions. Compared to those at the large public university, students at the small private college report stronger learning goal orientations, help-seeking behaviors, and metacognitive strategy use. We discuss how the learning opportunities and environments may contribute to these differences in learner development.**

Keywords: lifelong learning, self-directed learning, self-regulated learning, goal-orienatation, help-seeking, metacognition

I. INTRODUCTION

A capacity for self-directed learning (SDL) and lifelong learning is widely recognized as a critical outcome for today's engineering graduates [1-5]. Prior research characterizes self-directed learners as those who possess the motivation, or *will*, to engage in learning, as well as an array of behavioral, cognitive, and contextual *skills* that they may readily deploy in the learning environment [6-12]. The processes by which students *become* self-directed learners, and the roles that pedagogy, learning climate, and classroom environment play in these processes, however, remain unclear. This study poses several questions related to SDL development: How do the SDL skills and attitudes of engineering students change during their first two years at college? What causes these changes to occur? What experiences and classroom conditions best promote self-directed learner development? By examining *how* and *why* students progress from teacher-controlled learners to autonomous learners, we hope to inform the design of curricula that better facilitate SDL growth.

II. METHODS

As part of a larger mixed-methods longitudinal investigation that tracks students' SDL development over two years, this study uses qualitative methods to explore shifts in SDL attitudes and skills in the first year of engineering programs, and to gain insight into *why* the shifts occur.

A. Participants and Environments

Participants in this study are first-year undergraduate students enrolled in engineering programs at two institutions: a small private college and a large public university. The *small private college* emphasizes project-based learning and peer collaboration. In their first term, students at the small private college complete a common set of technical courses and one humanities course, all of which are graded as "pass-no credit." First-year students at the large public university complete a one-credit hands-on engineering project along with a range of more traditional introductory courses offered outside of the engineering school. Students at the large public university receive letter grades in all courses.

B. Data Collection and Analysis

At the start and end of their first term of college, participants in this study responded to open-ended survey questions related to their SDL experiences in high school and college, learning goals, and development as learners. An open-coding method was used to select emergent themes and a framework was created to evaluate individuals' developmental level for SDL-relevant behaviors (effort regulation, time management, help-seeking), cognitions (metacognitive skills and awareness), motivations (extrinsic to intrinsic), and goal orientations. The emergent themes and SDL evaluation framework draw heavily on self-determination, achievement goal, and self-regulated learning theories [8-25].

III. PRELIMINARY RESULTS & DISSCUSSON

After only one academic term, engineering undergraduates at both institutions showed signs of SDL skill and attitude development. The qualitative data indicates shifts in students' behavioral self-regulatory strategies at both schools, as well as increased learning goal orientation, metacognitive strategy use, and help-seeking strategy use at the small private school.

A. Similarities Across Institutions

The start of college prompted significant behavioral strategy development at both schools. As one male student from the small private college describes, "*With so much on my plate being on three extra-curricular teams and taking a full course load, I have so little time that I have gotten much better*

at time management... The primary driving force behind this change has been the sheer decrease in the amount of free time I have during the semester. With so much going on all the time and fun activities always going on that I could participate in, I need to really manage my time in order to learn through all of my classes and teams." Similarly, many students from the large public university spoke about improving their time management skills, and they contrasted the college environment with that of high school. As a male student comments, "*I have learned that procrastination is the enemy. In high school it's docile and easy to flirt with, without any repercussions. With the speed of the quarter system, it is a luxury that we can no longer afford. This has taught me to, in general, manage my time in a more sane fashion and procrastinate less.*" Students attribute their behavioral shifts to the increased challenge of the schoolwork and the availability of interesting new opportunities. Time and effort management, two important behavioral self-regulatory strategies [26-29], emerge at both schools and appear to be prompted by an increase in learning activities and workload, combined with feelings of being overwhelmed.

B. Differences Between Institutions

Student responses reflected an emergence of different goal orientations, help-seeking skills, and metacognitive awareness at the two schools.

1) Goal Orientation

Prior education research shows that goal orientations can have a significant impact on self-regulated learning outcomes [e.g.,13,20,30,31]. Students at the large public university reported primarily performance-oriented goals. For example, one male student from the large public university expressed a goal of "*getting an A*" in his math class. Another male student reported, "*The main goal that I set for myself last quarter in calc 4 was to complete all the homework*." In contrast, students at the small private college tended to report learning-oriented goals that ranged from course-specific learning to broader, long-term competency development. One female student set a course-level learning goal as follows: "*For a particular project in a design class, I set goals to get better at coding and to have a better understanding of motors*." Another female student focused on larger competency goals to develop design and creativity skills, and to explore unfamiliar topics: "*In [design class], my learning goals were primarily design based. I wanted to improve my ability to solve design issues creatively, effectively, and practically*." The more learning-oriented goals set by the small private college students appear to be linked to the classroom environments at that institution. Non-graded, heavily project-based first-semester experiences at the small private college encourage (and sometimes require) students to set their own goals, pursue their own interests, and focus on learning, collaboration, and exploration of personal interests over performance, competition, and instructor constraints.

2) Help Seeking

Help-seeking is a resource management strategy that is important to self-direction [12,23,28,32]. At the large public university, students rarely mention going to others for help; while at the small private college, help seeking seems to be a regular practice. One female student describes the situation in this manner, "*Prior to that semester, I was pretty confident that I could learn a lot by studying by myself. However, through this semester, I learned that I will have to find as much help as I can, rather than struggle and waste time while trying to figure something out. I learned to rely on others more to learn bette*r." Students at the small private college seem to have internalized the importance of help seeking and collaboration as useful strategies that can enhance their learning. They report that both in-class environments (e.g., project-based courses) and out-of-class academic culture influence the development of their help-seeking behaviors. Although the impetus to seek help is typically a desire to reduce stresses on their time, the learning-oriented environment at the college may help students gain comfort in engaging others in finding solutions to problems.

3) Metacogniton

Metacognition, a key component of SDL that interacts with motivations and behaviors [26,28,33], appears to develop differently at the two schools. Students at the small private college show a marked improvement in their metacognitive skills after the first semester. One male student described discovering new insights about his own learning process in his first semester, "*I've discovered that I am certainly not an auditory learner, preferring instead to learn by doing or experiencing. I would much rather carry out an experiment or simulation than listen to lectures or write out problems*." In contrast, students at the large public university engaged in less reflection overall - and those who did, focused their reflection more on their behaviors than their learning. A male student's response illustrates this: "*A moment of self-realization really was a large turning point in my outlook towards each class. I thought of myself in the future, and didn't want to look back and regret any decisions I had made regarding my education. Also, my GPA the first quarter was not something to brag about, and that really made me change the way I was approaching my college curriculum*." Although this student is taking responsibility for his learning and linking actions to outcomes – signs of SDL development – he remains focused on extrinsic goals such as achieving good grades and avoiding feelings of guilt.

IV. CONCLUDING REMARKS

As early as the first academic term, engineering students at the two institutions appear to develop a range of SDL-relevant goals, behaviors, and cognitive strategies. Students link their SDL attitudes and skills directly to their *learning experiences* and *learning environments* – a promising finding for instructors who seek to design SDL-supportive courses and programs. In the words of students, key factors include the level of *exposure* to self-directed activities (e.g., open-ended projects), the amount of *choice* to set one's own goals and pursue one's interests, the available *resources* and *support* (professors, peer mentors, course assistants, course scaffolding), and the *academic culture* of the school.

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