Shaping Good Old-Fashioned Students: A Work-In-Progress

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Abstract

The modern engineering student must practice lifelong and self-directed learning competences throughout their instructor-guided learning in college. Public secondary education has failed to equip most graduates with the learning skills needed for success in higher education and beyond. Engineering education has a history of innovation in instruction. Yet, practicing engineers need the tools common to lifelong learners across generations and cultures. The common learning traits and skills of previous generations create a framework for developing lifelong learning competencies through careful structuring of learning activities in all levels of engineering classes. The framework described in this paper can help engineering instructors evaluate learning activities to help students become self-directed and lifelong learners.

Keywords

Lifelong learning, self-directed learning, autodidact

Introduction and Background

Incoming engineering students, particularly post-pandemic, are struggling more than ever to take responsibility for their educational outcomes. Public schools in an effort to create compliant citizens and equitable learning outcomes have largely failed to shape graduates capable of critical thinking and ongoing learning beyond simple regurgitation [1–4]. Yet, professional societies list lifelong learning as a necessary trait and outcome for engineering professionals [5,6]. Engineering programs are faced with a challenging problem: taking under-prepared incoming students and creating self-directing lifelong learners.

Through the efforts of ASEE and increased interest in improving the classroom experience, instructors have explored teaching innovations including active learning, flipped classrooms, adaptive homework, and even the possibilities of AI-powered personalized learning. Yet even with the most progressive classroom pedagogies, many students seem to fail to grasp and retain information beyond simple short-term recall. In many cases, students are left without any meaningful increase in the understanding required by and assumed in future courses [7]. Such students must retake courses, change majors, dropout or painfully scrape by.

Perhaps, the issue is not the ability of instructors to teach, but the ability of students to learn for themselves. What if some teaching innovations create short-term gains but undermine the ability of students to learn new concepts for themselves? Engineering students may receive teaching on lifelong learning, a lecture here or there in the curriculum, but do students practice lifelong learning? What do the skills and attitudes of self-directed and lifelong learners look like? Can engineering educators design activities, both in and out of the classroom, that not only reinforce the course content, but also provide students the opportunity to practice lifelong learning skills in a low-risk environment?

Lifelong Learning Sources

ABET and the ASCE Body of Knowledge identifies lifelong learning as an important outcome in both the cognitive and affective domains [5,6]. The pathway to the outcome requires both "undergraduate education and mentoring experience" [5]. At the college level, the BOK recommends "independent study projects and open-ended problems" [5]. Practicing engineers should pursue "continuing education, professional practice experience, and active involvement in professional societies, community service, coaching, mentoring, and other learning and growth activities" [5]. Many of these activities provide a context for self-directed and lifelong learning, but do they develop the skills of lifelong learning? Or do they continue dependence on others through various professional development seminars rather than creating an internal desire to seek additional understanding?

Expert learners themselves hold the keys to lifelong learning. An anecdotal survey of doctorate-holding engineering faculty members tells a clear story. Many faculty members came through weed-out based engineering programs that effectively kept only those students who already possessed the cognitive and affective characteristics of lifelong learners. In many cases, instructors, either through incompetence or preoccupation with other priorities, were the least valuable resource for learning. These instructors provided a resource framework (textbooks, homework, projects, etc.) and evaluated mastery (midterm and final exams), but the actual learning was left to the students. Poor instructors should not be tolerated, but for high achieving students, the instructor did not matter. Successful students knew they needed to read the textbook, take notes in class to clarify the textbook content, practice the homework, discuss concepts and problems with fellow students, and generally take ownership of their learning. Independent study activities turn to dissertations as expert learners devour academic literature and synthesize ideas and experiments into new knowledge.

The great historic innovators of the past also provide insight into lifelong learning. Isaac Newton's classical education in Greek, Latin, and mathematics, formed the foundation for self-directed learning from the writings of Descartes, Galileo, and Kepler. The English hymnist Isaac Watt's *Improvement of the Mind*[8] formed the foundation of Michael Faraday's voracious reading and self-education during his seven year teenage apprenticeship.

Nathaniel Bowditch provides an excellent example of a successful autodidactic. Born in 1773 to an alcoholic father and left without his mother from an early age, Nathaniel Bowditch was indentured from ages 12 to 23. Yet, he revolutionized naval astronomical navigation, wrote the *American Practical Navigator* (in continuous revision and publication from 1802 to present) and was invited to serve as mathematics chair at Harvard, University of Virginia, and West Point (he declined in each case). A lifetime of self-directed study laid the foundation for his success. Entering indentured servitude at 12 years old with only the fundamentals of reading and arithmetic, he worked through the small library of his master teaching himself algebra and geometry. Later mentors secured the young Nathanial Bowditch access to the Kirwan Library (captured by Yankee privateers in 1780 and stewarded by the Philosophical Library Company of Salem, Massachusetts). "Bowditch's method of study was direct and thorough. He sat down to the books and – with interruption for working, eating, and sleeping – read straight through them" [9]. Nathaniel kept "Commonplace Books" on various topics that contained his own thoughts, notes from his reading, and handwritten copies of large sections of borrowed books. He was frequently found working mathematical problems on his slate tablet. He eventually taught

himself Latin to read Newton's *Principia* and French to translate Laplace's *Mecanique Celeste*. As a seaman, Bowditch taught his crews his method for calculating longitude from lunars with an unaffected sincerity and unbridled enthusiasm. Mentorship, reading, notetaking, practice, and peer-instruction, all the elements of Bowditch's lifelong learning, make up the core skills of lifelong learners in every age.

Reformist educators have argued for a return to a classical model of education [10,11]. The classical model emphasizes scaffolded learning from the grammar stage to dialectic stage to rhetoric stage. Innovative new ideas and designs are built on logic and critical thinking which in turn depends on observation and a grasp of fundamental knowledge. In most cases, these skills are developed through memorization, discussion, and writing. These traditional means of learning represent "the democracy of the dead"; how dare progressives think they know best by virtue of being alive at this moment [12]. In too many cases, the American educational system, in jettisoning classical learning pedagogies for the new, the faddish, and the innovative, have "removed the organ" of lifelong learning "and demanded the function" [13].

Lifelong Learning Framework

This review of educators and autodidacts provides a foundation for developing a framework for the practices of lifelong learning. Lifelong learners have a passion for learning, for increasing their understanding of the world as it is. Lifelong learners read books beyond their understanding to increase their understanding. Lifelong learners take notes on books they read, lectures they attend, and thoughts they think. Lifelong learners internalize their understanding through practice by solving problems, discussing ideas with others, and writing. As "iron sharpens iron" (Proverbs 27:17 [14]), lifelong learners depend on peers to sharpen and refine their thinking. Likewise, "wisdom is with the aged" (Job 12:12 [14]) and lifelong learners have mentors to scaffold their learning and ensure mastery of foundational concepts so they can tackle more complex challenges.

So how can engineering educators develop good old fashioned lifelong learners out of their underequipped engineering undergraduate students? By guiding them through the practices of lifelong learners. Students need mentors (like engineering faculty) to scaffold their learning and resource their education. Students need peer instruction, discussion, and group work with other students. Students need to practice solving problems [15], and evaluate the accuracy of their work [16–19]. Students should be held accountable for taking notes from their reading and lectures. Students should read the best textbooks and be taught to do so [20]. When students are helped to pursue these activities during college, where the cost of failure is low, where engaged faculty can help patch holes left by developing learning skills, and where committed fellow learners are easy to find, engineering students can develop the skills of lifelong learning.

Future Work

This work-in-progress paper has attempted to identify the practices of lifelong learners and a framework for developing them. The need is clear: engineers must be lifelong learners and most incoming engineering students are ill-equipped for self-directed learning. The goal of this work is to continue to define the common characteristics of lifelong learners and innovative engineers and then reform the traditional pedagogies, particularly for outside the classroom, to teach, practice and reinforce the habits of lifelong learners.

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