Transforming First Year of ET Programs

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Challenge

The first year of the university level education is very important to ET students. Typically, the first year is filled with general education classes, classes reviewing topics learned in high schools, or various introductory courses related to the major disciplines in a college where freshmen are admitted. For ET students, the first year experience may vary depending on where the ET program is housed. Required common core courses leave little room to introduce a solid skill development in the first year. Some universities have introduced group learning environment to keep students interested. However, solid skill development beyond introductory level activities does not occur. Similarly, 120-credit limit further limits the discipline specific hands on experiences students may gain during the first year and the hours available to deliver lectures per course. Courses that introduced hands-on activities at the freshmen level are gone. The retention rates are in the decline. A lost first year limits students’ opportunity to gain very important skills that are required by the discipline, causing ET programs unfavorable impact. Yet in many countries, bachelor’s degree in engineering requires five years of studying to complete 140 to 150 credit-hours of learning. In some countries like Germany and Switzerland, students complete an apprenticeship before entering to universities.

Going from 140 credit hours to 120 sounds like a cost effective solution. The intentions behind these changes are good, including modernization of the course content, increase the interdisciplinary nature, more team work, real-world problem solving, industrial experiences, better communication skills, etc. Unfortunately, my observations and many other faculty members who have gone through this process over the past several years are that we are producing less skillful students with a distorted idea about the discipline they came to learn. The challenge is to engrave the most important skill set in students’ mind early in the learning process so that advanced, theoretical concepts can be introduced over time, even after the graduation.

Changing student demographics brings another challenge to this situation. Incoming freshmen possess less and less prior knowledge related to technical areas. They spend less and less time playing outside with other neighborhood kids. Even if they do, computer games dominate the play period. Computer games and wireless social interactions further change the nature of problem solving and team work skills. Many traditional industrial arts program are no longer perceived as “cool” things to do. Students see traditional lecture based learning as a boring experience. Yet, most of university lectures rely on traditional lecture based delivery. However, students entering to ET programs wish to gain hands on experience, immerse in the discipline to compete in the global job markets. Challenge is to guide students to achieve mastery of some fundamental skill set needed by their discipline within a reasonable time frame.

Several recent funding opportunity announcements (FOA) of the United State Labor Department (US DOL) focus on re-inventing traditional apprenticeship programs to train US citizens to be placed in the high-tech jobs that are currently filled through H1-B visas. According to the US DOL, in the fiscal year 2013, 77% of H1-B visa were issued for technology occupations with computer-related skills. The remaining 23% included ET related jobs such as electrical engineers, electronic (including power
electronics, except computer) engineers, engineering managers, mechanical engineers, operations managers, and industrial engineers. Why cannot US companies find skilled workers in the US labor market? One answer to the above question is that most labs in engineering and engineering technology are done in a simulation environment. For example, power electronics system design is a highly desirable skill. Yet, many university programs opt to simulation because to provide proper design and prototyping requires specialized equipment and systematic training. In some cases, it is required to work with high voltage, which requires skilled instructors nearby. Educating an applied engineer demands higher investment than educating a philosopher. There is little money or time allocated in the traditional academic program environment to the above. On the other hand, it is very difficult to train someone through a typical co-op or internship. The best solution is to integrate systematic, hands-on learning of such highly desirable skills in the university environment. Organizations such as German American Chamber of Commerce is introducing German apprenticeship to American companies (http://www.gaccmidwest.org/skilled-workforce/ ). We need to introduce a model that encompass characteristics of proven methods like German apprentices into applied engineering education.

Change

So, what can be done to change the situation? I would like to focus on two key components of higher education: 1) minimize the dependency of instructor’s teaching ability in the delivery of instructional material where learner-oriented cooperative learning environment is promoted, which I call Cluster Learning (CL) and 2) integrate a novel apprenticeship-like program to the freshmen year of ET programs, which I call Discipline Specific Skill Acquisition for Freshmen (DSSA).

Figure below is based on learning related research. There are some critique about this model. But, those who have involved in skill development based education knows the benefits of the bottom part of the pyramid. Further, it clearly depicts the weakness of instructor centered learning. The learners seeking careers in ET prefer the activities in the bottom part of the pyramid. The proposed learning environment will create learning around the bottom part of the pyramid.

![Learning Pyramid](source: National Training Laboratories, Bethel, Maine)

Figure 1 Learning pyramid highlights the hands-on learning [1]

Changing Learning Environment through Cluster Learning (CL)
Traditional classrooms and lecture halls are designed for instructor-centered learning. The first thing we must change is the physical layout of the classroom to motivate more productive learning. Cooperative learning, between groups, has been studied extensively. Since in-class time is shrinking, the cooperative learning concept can be modified to engage student at home and in class. Basic characteristics of Cluster Learning are given below. Figure 2 illustrates the classroom setup.

1. Learners are grouped into small groups, 4-5 students.
2. Learners are required to complete pre-class activities posted on Blackboard or Canvas. Rewards must be given when a learner complete these activities.
3. In class, the learners are assigned to a group. When learners arrive in the class, they access the learning objectives of the day and watch pre-recorded lessons. Then the learners solve problems by themselves. When one learning objective is completed, the learners watch the next presentation and so on. The computer-based learning system monitors the progress of each student. The Instructor and advanced learners who complete learning tasks early, are available to help slower learners. The computer-based monitoring will help the instructor to provide individual feedback.
4. At the end several concepts, each group is connected with another to solve more global challenges as in cooperative learning.
5. Instructor is able to monitor the progress of each group in classroom settings or the level of mastery, using specific software. In lab environment, students’ mastery level can be monitored using tools such as TekSmartLab by Tektronix Company. In classroom, learning platforms designed for enhanced, self-phased learning brings new meaning to learning.

**Figure 2 Alternative classroom setup for Cluster Learning**

Based on the published research, the following learner benefits can be gained through cooperative group activities [2]:

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1. Develop a better understanding of what is being learned through discussion of multiple perspectives
2. Receive interpersonal feedback about performance
3. Motivation to take risks through others support
4. Develop new attitudes about the subject matter
5. Experience individual’s role in a group environment
6. Emulate high performing peers in the group

Alternative cooperative learning environment is shown figure 3 below. Here, electrical power generation, transmission and distribution is simulated by a computer simulation and a display relate each are projected on a wall. The groups, one for generation, one for transmission, and one for distribution, are formed. When consumers’ consumption profiles are changed at the consumer end, alarms will appear in the every segment of the power system. The groups’ responsibility is to clear the alarms while applying prior learning, before circuit breakers trip, causing black outs.

![Cooperative learning in electrical power system simulation](image)

**Figure 3** Cooperative learning in electrical power system simulation

Similar approaches have been experimented in manufacturing related courses at Purdue University Northwest.

**Discipline Specific Skill Acquisition (DSSA) for Freshmen Students**

DSSA is an apprenticeship-like a program. In a typical apprenticeship, a youth, an apprentice, is admitted to a program runs at a company, typically the under the oversight of a trade union, to learn a trade-related skill set that will be useful to perform his or her future job. The apprentice then works under the supervision of a skilled craftsmen and get paid. There are many literature available discussing
the pros and cons of such an approach. This methodology seems to work well in industrial age jobs and may not be suitable for information age jobs. For example, an electrician technician who works with electric motors in an industrial age job is required to troubleshoot a panel full of electromechanical relays and a reading ladder logic diagrams. The learned skill set requires little change because the underlying technology does not change much. However, the information age and the recent development of enabling technologies, such as power electronics and internet of things, make the electrician’s job in the information age demands a whole new set of skills with ability to adopt newer technologies. For example, an electrician in the information age needs to master troubleshooting microprocessor based programs with many codes, power electronics-based motor drives, and communication networks used for interfacing. The biggest challenge comes when employees are required to change jobs more frequently in the information age than in the industrial age. A graduate of a traditional apprentice program has very little chance of getting into a 4-year university program. But the lifelong learning is a must in this information age.

DSSA pulls out the beneficial characteristics from a traditional and integrated into new well-choreographed learning environment where an apprentice has an opportunity to gain a four-year degree. Inputs from all stakeholders are considered during the skill identification process.

![Figure 4 DSSA is integrated into the freshmen year of college education](image)

**Figure 4 DSSA is integrated into the freshmen year of college education**

**Figure 5** below depicts possible time schedules for DSSA offering. During the dedicated time slots on Mondays, Tuesdays, Wednesdays, and Fridays, learners will be in specially designed lab areas. On Thursdays, lectures are offered. The lectures should explain the related theories related to the ongoing hands-on activities. The time period for a given activity such as EET 1 is flexible. Learners are encouraged to complete within the scheduled time, but the most important metric is the mastery level. If a learner completes a task at an acceptable mastery level, he or she may start the next activity. As
discussed later, activities are built on a previous skills and pulled out from an instructional analysis of the curriculum. For example, EET 2 includes and advanced level performance of EET 1.

**Figure 5 Proposed schedule for the first year**

**Identifying Skills for DSSA**

The following can be performed to identify the skills for the freshmen year. It is better to perform this activity for entire EET curriculum. Every course offered today has course objectives and every lecture may have three-to-four learning objectives. Some instructors may need some help from an experienced instruction developer. The advantage of performing an instructional analysis curriculum wide is to reduce the redundancies and increase the precision and the quality of the skills.

1. Perform curriculum wide instructional analysis to identify subordinate skills and entry level knowledge.

2. Identify the entry level skills that must be mastered in order to perform higher level skills effortlessly.
3. Define the level of mastery.

4. Describe the evaluation criteria for each skill.

For example, recently, an instructional analysis was completed for electrical and power area by partnering with an area electric utility, power grid device manufacturers, advanced meter network manufacturers, and a global consortium on smart grids. Similarly, the skill sets could be identified for any discipline. The findings are entered into a table similar to the one Figure 6. Typically the skills that fall into prior-knowledge column can be developed as DSSA activity. This first step can even be used to modernize curriculums. A detail paper will be published at the ASEE 2017 conference.

<table>
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<th>Major Skills</th>
<th>Subordinate Skills level I</th>
<th>Subordinate Skills level II</th>
<th>Subordinate Skills level III</th>
<th>Subordinate Skills level IV</th>
<th>Prior knowledge</th>
<th>Delivery Method</th>
<th>Expected performance level</th>
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<td>1.1.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6. Skill analysis record table

Extended Benefits of DSSA

1. Extend the program to high schools with some modifications
2. Open the programs to traditional apprentices at companies
3. Possible new path for traditional apprentices to college education
4. Employ retired experts as instructors
5. Free up professors’ time after the launch
6. Open up opportunities for senior level capstone projects or internships in industry
7. Underutilized university facilities will have anew use

Resources

The above initiatives need investments in terms of facilities, equipment, and trainers or guides. It is also necessary to formulate assessment methods that can be linked to traditional grade scales. The training staff may consist of experts from different segments of the society such as retirees, experts from industry, and from faculty.

Challenges and Conclusions

The major challenge that we have to overcome is conventional credit allocation. Since DSSA is launched after a complete instructional analysis of a program, many of the hands on activities distributed over many courses over four years are now concentrated in the first year. In some universities, badges are used to identify the level of performance. Accepting transfer students will become problematic. ABET accreditation becomes another issue. In the last ETLI meeting, ABET administrators asked the ET leadership to differentiate ET from Engineering. Perhaps an approach like this may reveal a new identity for ET disciplines. I think the above challenges can be overcome with creative thinking. We must remember that “credit” was created at one point in time. To launch a program like this, there should be strategic initiative by the institution with some allocated funds.
References
