Using Agile Curriculum Development to Design a Systems Engineering Program Curriculum

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Using Agile Curriculum Development to Design a Graduate Engineering Program for Working Professionals

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Abstract

This project reports on using an Agile Curriculum Development approach to increase the participation of working professionals and their employers in developing and fielding two updated master's programs. Participation was increased by including these stakeholders in marketing assessments of program needs, involving them significantly in program content and delivery design, and collecting feedback on a consistent basis to allow for continuous process improvements. While this approach was seen by all stakeholders, students, faculty, and employers, to be successful, there were future improvements in course delivery that have been identified for our next program offerings.

Introduction

Universities are called upon to service a much wider range of students than they have traditional worked with in the past. A modern urban research institution will see new students with a significant number of advanced placement courses exempting them from most traditional freshman courses. They will also see transfers from community colleges and other universities, students from international institutions, veterans, and students who have been in the workforce for years or often longer. Graduate students are also much more diverse, ranging from full-time locals to international students, often with multiple degrees and work experience, and an increasing number of part-time working professionals looking to advance their careers. Developing degree programs to meet the needs of these different student populations can take months, and tracking inputs from all stakeholders, including students and employers, can be difficult[1]. Using an agile curriculum development process can help address these issues and may result in several benefits, including meaningful face-to-face engagements between faculty, students, and employers, as well as reduced time for curriculum development[2,3,4]. As a process improvement initiative, Agile development began in 2001 as a set of principles used in the development of software. It was then codified and presented as the Agile Manifesto[5]. The first applications of Agile in higher education logically were from computer science and engineering. These first applications in higher education resulted in the Agile-Teaching/Learning Methodology[6] and focused on instructors quickly adapting to students'

abilities and needs, implementing good teaching practices, and student independence in their learning process. Development and use of Agile principles have continued with a particular focus in Science, Technology, Engineering, and Mathematics (STEM), with some applications in non-STEM fields. As the use of Agile has expanded, the incorporation of other related process improvement tools has been seen. The use of continuous process improvement methodologies with Agile has resulted in the development of Extreme Pedagogy[7] which puts an emphasis on learning by continuous doing, learning by continuous collaboration, and learning by continuous testing. One of the curriculum development approaches found to be helpful in this project was the Agile Manifesto for Teaching and Learning[8]. The values of this manifesto included:

> **Adaptability** over prescriptive teaching methods Collaboration over individual accomplishment
> **Achievement** of learning outcomes over student testing and assessment
> **Student-driven inquiry** over classroom lecturing
> **Demonstration and application** over accumulation of information
> **Continuous** improvement over the maintenance of current practices

In a review of research on Agile in higher education, there appears to be a focus on students as the customers of education. Other stakeholders, such as employers, including industry, government, and not-for-profits, appear less frequently. We believe, in particular in graduate education, where the target student population is working professionals, that these students and their employers should have a larger role in the curriculum development process. This project is a result of efforts to increase working professional students and their employers in the curriculum development process by utilizing agile principles in the program development process.

Background

There is an increased interest in reskilling and upskilling programs for working professionals. This is especially true in the defense and aerospace industry, where the rapid change in technology necessitates a focused and continuous effort to retain and retrain the workforce. To support this effort in the Dallas – Arlington – Fort Worth metroplex, the University of Texas at Arlington (UTA), in partnership with the North Central Texas Council of Governments (NCTCOG) proposed an agile curriculum development and implementation project consisting of two focused Master of Science degrees in software engineering and engineering management. These degrees are tailored to match the technical requirements and delivery modalities needed to reach the target population which is comprised mostly of local and regional technical working professionals in the defense and aerospace industry. The project was proposed in May of 2023, with the first offering of the programs scheduled for the fall 2023 semester. The development, delivery, and assessment tasks of this project are scheduled to continue through December 2025. This paper reports on efforts to better understand working professional student and employer needs, and how those efforts impacted the first fielded graduate programs in software engineering and engineering management.

Approach

The project team, comprised of UTA and NCTCOG team members, elected to use an agile

curriculum development approach to improve the applicability of the new programs to working professionals and local industry needs and to reduce the time to develop the programs. Three tasks were identified. The first task was an analysis of regional employer needs to better understand their requirements in developing their working professionals. The second task was to establish a process to identify specific knowledge, skills, and abilities that were needed in the programs. The third task was to develop, deploy, and review the effectiveness of the programs.

Analysis

The first task, the analysis of regional employer needs, was done by a survey using an external research group supplemented by information on existing programs provided by the university data analytics team.
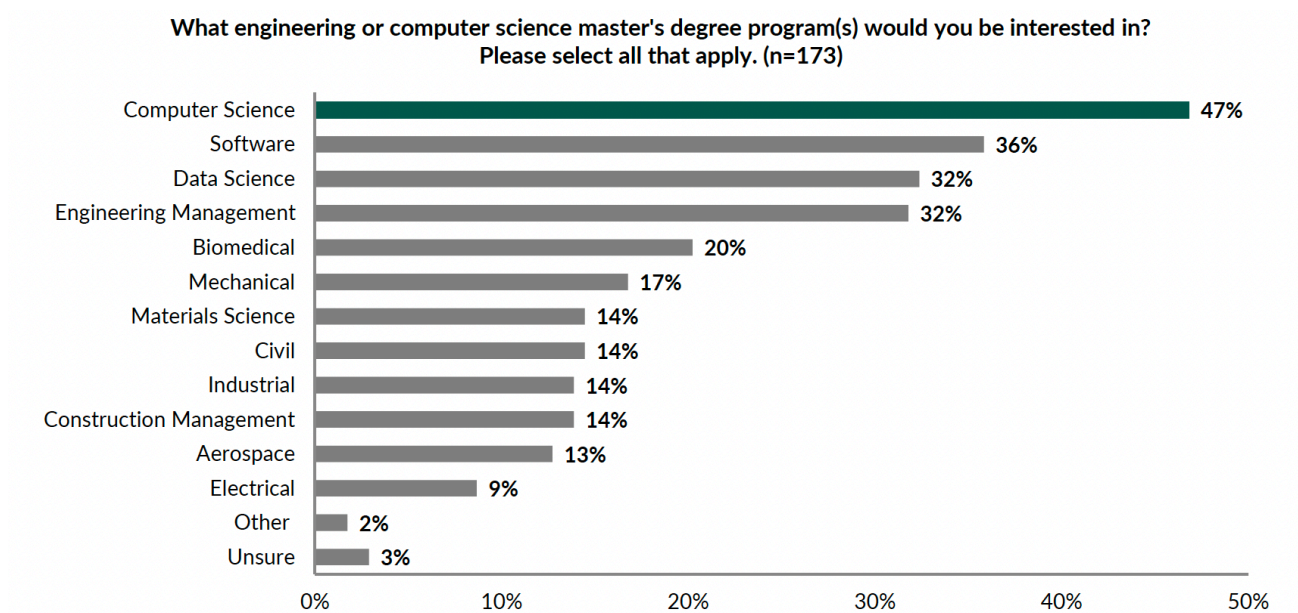
Survey Results

The survey was completed by 253 stakeholders, including current students, graduates who were employed and represented companies in the Dallas – Arlington – Fort Worth metroplex, and community members who were familiar with the university. Most stakeholders were from technical fields, primarily engineering and computer science.

Type of Program

Survey results showed that most stakeholders (68%) indicated they were interested in a master's degree program, and a bit more than half (52%) indicated they were interested in a certificate program (participants had the option of selecting either or both options). Of interest was that current students and alumni were more interested in master's programs, while community members were more interested in certificate programs.

Types of Masters Programs

The master's program options provided to stakeholders in the survey were based on existing and proposed engineering and software offerings by regional universities. The software and engineering management programs were selected to be updated and tailored for working professionals because they were both popular among stakeholders and were programs that would be developed with minimal prerequisites to be viable for the largest number of defense and aerospace working professionals. There was also interest expressed in specific certificates in artificial intelligence, cyber security, and data science. While there has been an overall increase in interest in stand-alone certificates in many disciplines, employers in many engineering firms still appear to prefer degree programs first and certificates as a complementary skill set. There was reported interest found during follow-up meetings with employers in certificates for their working professionals when they could be earned in conjunction with a graduate degree program (Figure 1).
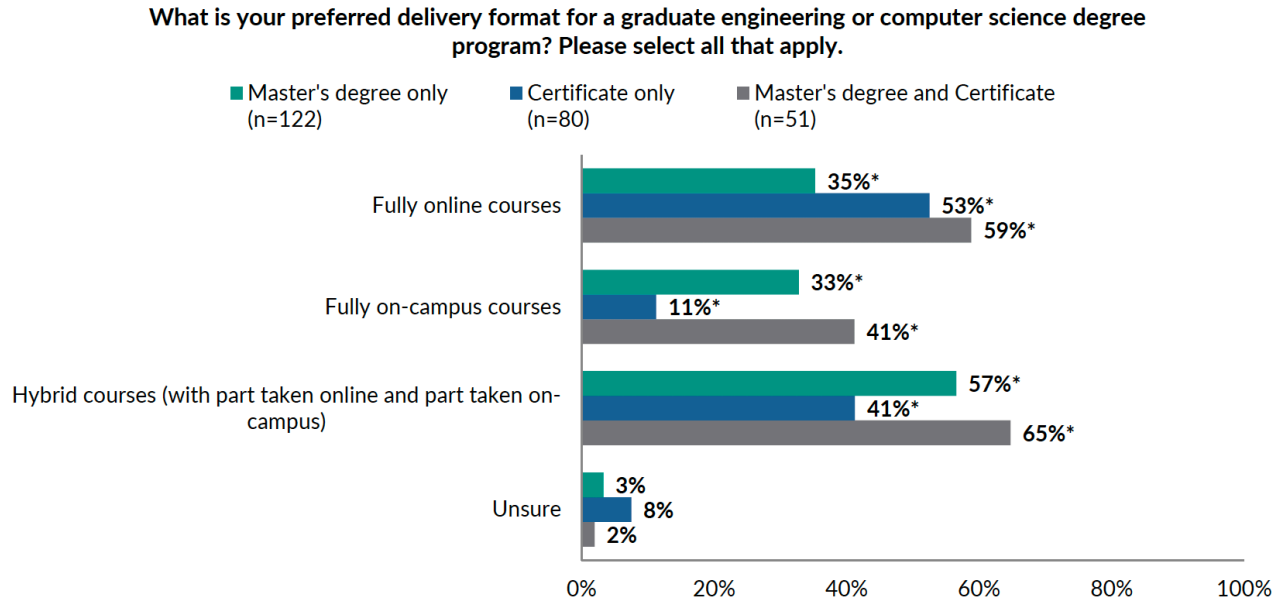
What engineering or computer science master's degree program(s) would you be interested in? Please select all that apply. (n=173)

Program	Percentage
Computer Science	47%
Software	36%
Data Science	32%
Engineering Management	32%
Biomedical	20%
Mechanical	17%
Materials Science	14%
Civil	14%
Industrial	14%
Construction Management	14%
Aerospace	13%
Electrical	9%
Other	2%
Unsure	3%

Figure 1. What Program are you Interested in?

Delivery Format

Stakeholders who were interested in masters programs preferred a hybrid format over fully online or fully on-campus courses (Figure 2). Further discussions with employers during online and face-to-face recruiting events, and with working professionals during open house events on campus did show a much greater interest in fully online courses but with an option of being able to talk directly with instructors as needed. Online courses with the option of attending classes (recording sessions) when possible was often voiced as the preferred option.

When stakeholders were asked about online delivery formats there was a preference for asynchronous over synchronous or hybrid delivery. One common input from working professionals was the need for flexibility due to work requirements.

Of interest was also the limited discussion on the need to customize programs to individual needs. A standard cohort curriculum was seen as valuable with the assumption the knowledge, skills, and abilities in the program were seen as valuable for both immediate applicants in the workplace as well as future career growth.

What is your preferred delivery format for a graduate engineering or computer science degree program? Please select all that apply.

■ Master's degree only (n=122)   ■ Certificate only (n=80)   ■ Master's degree and Certificate (n=51)

Fully online courses
- 35%*
- 53%*
- 59%*

Fully on-campus courses
- 33%*
- 11%*
- 41%*

Hybrid courses (with part taken online and part taken on-campus)
- 57%*
- 41%*
- 65%*

Unsure
- 3%
- 8%
- 2%

0%   20%   40%   60%   80%   100%

Figure 2. What Delivery Format are you Interested in?

Identifying Specific Knowledge, Skills, and Abilities

One key element of Agile Curriculum Development is direct contact with the stakeholders, working professionals who may enroll in the program, and the employers who support these professionals. The UTA and NCTCOG team implemented a three-level structure to interact with these stakeholders. This structure included the following groups:

The Dallas-Fort Worth Regional Aerospace Consortium

This professional organization has existed in the region well prior to this project. It was included as an advisory board for this effort based on its long-standing work in the North Central Texas region and its focus on this key industry. While it functioned like traditional academic industrial advisory boards, its composition of senior business executives and managers that were industry focused gave it much greater insight into industry requirements for both current and future growth. There was also a focus on developing the current professional workforce rather than developing future employees. The UTA and NCTCOG team members meet with this consortium on a semiannual basis to review progress and receive feedback on curriculum design efforts.

Agile Curriculum Program Committee

Much of the work on the project, especially in the first year, was done in during the semimonthly meetings with the Agile Curriculum Program Committee. This committee included engineering managers and directors for regional defense and aerospace companies, as well as UTA and NCTCOG team members. Depending on specific topics addressed individual department chairs and faculty would be included in meetings, as well as some university administrative leaders, to ensure the programs could be fielded within our current operating procedures.

There were several examples of why this close work with industry was critical, including how focused on cyber security the software engineering program should be, what, if any, certifications should be included in the curriculum, and specifics on modalities for program delivery.

The initial surveys on employer needs did highlight the need for an increased focus on cyber security, however during the committee meetings, employers clarified that what they needed was a better awareness of cyber security fundamentals and issues among their general engineering workforces. They did not need more degreed cyber security specialists. This result was an increased focus on cyber security in the existing software engineering courses instead of a new cyber security-focused graduate program.

A similar discussion occurred related to certifications. There are numerous certifications that their software engineering needed for specific applications, but these were highly dependent on the specific customer, such as the Department of Defense or a commercial company. The committee preferred the academic programs focus on fundamentals required of all technical professionals and let the company focus on training for specific certifications to meet individual customer needs.

A discussion on modalities centered on start times for classes after work and accounting for the notable commute time in the metroplex, as well as the advantages of 8-week versus 14-week course delivery schedules.

These discussions were much more detailed than traditional industrial advisory board meetings held to support academic programs and provided the faculty with valuable insights on employer needs.

The recruiting and retention programs at the University of Southeast Texas fall into three categories: those at the University level, those of the College of Engineering, and those conducted by the Department of Mechanical Engineering.

Agile Curriculum Design Teams

Much of the work in updating and revising the individual course materials was managed by individual faculty teams working in conjunction with industry representatives. Each course in the program was updated by the corresponding teams with a focus of providing the working professionals with knowledge, skills, and abilities that were relevant immediately and provided a foundation for future career growth. Many industry representatives were able to provide specific case study materials as well as serve a subject matter experts for faculty. Several are serving as both guest lectures and, in some cases, adjuncts for the programs.

Program Development, Deployment, and Review

The revised Master's of Software Engineering and Engineering Management programs were delivered, and the first cohorts have completed the program. While the use of an Agile Curriculum Development Process with a focus on increasing student and employer involvement was found to be

beneficial, we also found that there has been a need for continual work to revise the process. The revised curriculums did better match the requirements for the working professionals and their employers. Some additional updates have been made as faculty learn to work directly with our expanded stakeholders.

Conclusions

There have been some limitations found. Most notable is the need for improved direct contact with the companies to help advertise and market the programs. General marketing and updates to the university websites, as well as virtual and live open house events, have brought in a smaller population of students, and direct events with companies have been much more effective at reaching potential students. When these events are supported directly by corporate training and the engineering leadership teams. The original hybrid delivery format using 8-week course delivery schedules was also found to only be limited in effectiveness. A fully online asynchronous 14-week course delivery schedule was found to be more effective, although this was not what was reported during the initial stakeholder surveys. Finally, the hiring of a single, well-qualified recruiter/advisor has been valuable. Working professionals prefer to have a single point of contact on the program rather than being required to contact numerous university offices for questions on applying, registering, and financing their programs.

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