It's Not What You Think: Lessons Learned Developing an Online Software Engineering Program

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***Abstract*—Online education comes in various flavors – skills centered short-duration training, massively open online courses (MOOCs), and more recently, the offering of full online degree programs. In the past 4 years at Arizona State University, the faculty created an online software engineering degree program equivalent to an existing on-campus program, and produced its first graduates in Spring 2017. The challenges in creating this program were significant, but surprisingly the main challenges were not the ones that the faculty anticipated at the outset of the program's development. This paper shares the lessons learned from the development of the online degree program, with an emphasis on the gap between faculty expectations and fears versus the actual issues that needed to be addressed.**

Keywords—online education, project-based learning

I. Introduction

This paper captures lessons learned implementing a 4-year Bachelor of Science (BS) degree in Software Engineering (SE) online at Arizona State University. This is the first BS in SE accredited by ABET that includes a full online mode of delivery. The offering runs concurrent to the same degree as an on-campus offering that has been in existence since 2010. This paper describes the challenges in attempting such an implementation under stressful conditions from several perspectives. While not a scientific study, it is hoped that by sharing the details of the challenges encountered in such a rollout others may consider the full range of impacts to their programs. It is our observation that the main concerns the faculty now have are not the same misgivings they had when informed they had to put the degree program online.

II. Background

The BS in SE degree was first offered at ASU in the Fall of 2010, though its original planning and design started in 2005. Starting in 2013, ASU began offering the BS in SE through ASUOnline. Since its inception, particularly with the online offering, the degree has seen explosive growth while faculty resources have remained the same. The total enrollment of on campus and online programs, plus a Master's degree, was over 1300 students in Fall 2017. ASUOnline enrollments in the BS in SE are expected to grow by 10% annually.

ASU's administration decided to put the Software Engineering degree program online starting in 2013, relatively soon after the degree programs were offered on-campus, and before the program had undergone an initial accreditation evaluation. ASU did this for many of the same reasons as other institutions; the degrees is perceived to not need laboratories or other physical resources, and as these students study computing they should readily accept the delivery modality. Further, of the STEM disciplines, Software Engineering is projected to have very strong job growth [1]. These factors create the perception there is a significant workplace demand for these skills, and a convenient and scalable medium for meeting this demand through online programs.

The BS in SE online degree program at ASU is equal to the on-campus version of the same program in that it offers the same courses and degree plan structure. Specifically, the SE faculty have embraced a project-centric pedagogy [2][3] which is more difficult to scale, thereby adding additional complexity to online development. The only difference between modalities is a narrower set of upper-division electives. The SE faculty recently completed the final year of development and awarded degrees to its first candidates in May 2017. At the completion of the first iteration, the SE faculty had an opportunity to reflect on the evolution of the online program compared against the initial concerns (fears) of creating the program.

To organize the concerns of the faculty, an online Faculty Working Group (FWG) was created in September 2016. The FWG was composed of the Program Chair, a tenure-track faculty member, and a lecturer. The FWG reviewed the evolution of the online program, identifying the concerns presented in section III and analyzing what concerns became reality. The FWG discovered issues that were not originally concerns of the faculty, and in many cases are more significant than the initial fears. The FWG created a strategic plan with specific actions for addressing these issues, which are shared in section IV.

III. Faculty Concerns

The FWG used a survey instrument, interviews, and group meetings with faculty to gather evidence. The process was open-ended and not scientific (meaning the FWG relied on communal knowledge of best practices but was not concerned with scientific validity of the instruments). Table 1 summarizes the initial concerns of the faculty, the initial magnitude of those concerns, and the degree to which the concerns became reality. It also indicates, where the initial magnitude is empty, issues that arose during program development. The FWG did not employ a particular research methodology to conduct its administrative work, so the findings are *ad hoc*, reflecting the FWG's understanding of the concern, magnitude, and reality.

2377-570X/17 $31.00 © 2017 IEEE
DOI 10.1109/CSEET.2017.45

TABLE I. FACULTY CONCERNS

	Concern	Initial	Actual
1	The applied, project-centric essence of the existing SE program would be sacrificed.	High	Low
2	Course shells will lack presentation consistency and user experience in the Learning Management System.		High
3	Faculty will be allowed the proper amount of time to create high quality course shells.	High	Low
4	Faculty will be allowed the proper amount of time required to maintain course shells.		High
5	A lack of technical infrastructure and support personnel. For example, green screen room access.	High	Low
6	The 7.5 week session will limit the ability to provide meaningful formative and summative feedback.		High
7	The ability to assess several degree program outcomes, such as Design, Teamwork, & Critical Thinking, will be difficult in an online environment.	High	Low
8	How will faculty meaningfully interact with online students? How will students interact with each other?	Medium	High
9	A suspicion there will be a high number of Academic Integrity issues, many of which are simply not detectable in the online format and timeline.	High	Low
10	The 7.5 weeks for online Software Engineering students (compared to the 15 week schedule for on-campus) will be a barrier to student learning.	Low	High
11	A significant implementation focused on instruction will not count toward tenure evaluation.	High	High
12	The faculty were concerned about the administration's support for the online program.		Medium

We acknowledge the informality of the results and the potential for confounding factors in the concerns. Nonetheless they are an accurate summary of faculty fears at program conception and what issues turned out to be the most severe.

The FWG found that the major concern (1st row) voiced by the faculty was essentially, "can we provide high-quality software engineering instruction online"? As a corollary to this, the major decision initially facing the faculty was whether they could deliver quality instruction using the project-based pedagogy [3] and program design [2] they used in on-campus classrooms. The project-based approach was an expression of faculty values, and as such the decision boiled down to whether those values could be implemented equally as well online as on-campus [4], or if an alternative implementation, but equivalent with respect to program outcomes, could be defined.

The next 3 concerns are related to course shell development. The program was rolled out one year at a time, so those faculty teaching in the lower divisions were the first asked to develop online course shells[1]. The first concern relates to the lack of uniform best practices – how many videos to record? what length? how does one lay out the course shell? The FWG used an informal survey of the faculty that garnered 22 responses (instructors completed a survey for each course). The survey was an *ad hoc* non-validated instrument to gather faculty input on issues like online course organization; media types used; and desired refresh frequency. Relevant to this discussion, Fig. 1 shows the results for a question asking faculty to grade their own course shells. No current instructor gave a grade of "A" to an online course shell (Fig. 1).

[1] A course "shell" is the term used for the clonable Blackboard course used as a container for media, notes, readings, or other course resources, laid out in a week-by-week format.

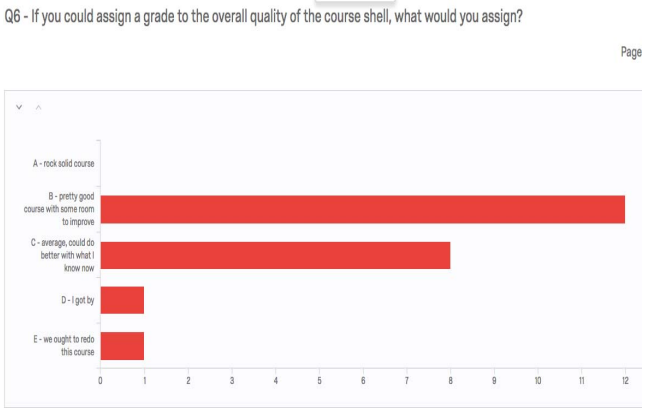

Fig. 1. Faculty perceptions of online course shell quality

The faculty did not identify the second concern initially, though in retrospect it seems obvious. Only after having a number of course shells did student course evaluations point out the frustration in different navigational schemes in different courses. This concern is currently being addressed through local instructional design support and the creation of exemplar course shells for faculty guidance.

The third concern addresses faculty workload and the ability to develop quality courses, and similarly the fourth concern identifies there was no mechanism for updating shells with new technical content. While course content development and maintenance is a task all faculty share no matter the discipline, in a software engineering program the issue is more severe due to the rapidly evolving research body of knowledge and also the fast pace of technology change. The issue is acute given the time needed to create multimedia content, and create resources and asynchronous labs. When refreshing, new content must be integrated piecemeal into pre-existing course shells. Given the quick pace and isolated nature of initial development, most shells were not developed in a modular fashion. Initially course development time was a significant concern due to the connection to concerns 11 and 12, and is discussed below. Course refresh was not originally a major concern as faculty were merely trying to get through the initial development. However, it soon became apparent that program changes, faculty attrition, and changing technology would mean courses needed refreshing on a frequent schedule. The FWG pushed the issue with administration, and a new course refresh policy has recently been adopted.

The fifth concern is related to the previous two, and is situated to a specific university environment. The SE faculty are located at a separate campus from the rest of the department faculty, which is also distinct from the location of ASUOnline. Each is about 25 miles from the SE faculty campus, making it impractical to resolve technical issues quickly, or utilize recording studios at those locations. This concern has been actively addressed and is relatively minor now. Green screen facilities now exist on the SE faculty campus, local instructional and media support personnel are staffed on the campus, and additional recording and collaboration tools have been made available to the faculty.

The next five concerns deal with course delivery. Concerns 6 and 7 focus on assessment; 6 on course-level assessment of student work, and 7 on program-level assessment. Formative and summative assessment turns out to be significantly impacted by the 7.5-week timeline. While the scale of the grading exercise was understood, the ability to assess student work and turnaround quality feedback that students can use to inform their next tasks fast enough has proven near impossible. This remains a significant issue for the faculty today, and we are trying innovative ways to address it, from peer grading, to graduate mentorship, to TA training, to interleaved module delivery in online courses. At the program level, the faculty were concerned that higher-level abstract activities related to analysis and design would be difficult to assess, and deeper qualitative assessment through observation of project-based activities would be near impossible. This has not turned out to be the case, though student learning of higher-level abstract concepts (see concern 10) has proven challenging.

Concern 8 focuses on interaction, both faculty-student and student-student with the obvious concerns about frequency and richness of the interactions. This concern turned into reality initially, with most faculty relying on asynchronous discussion boards and email. Discussion boards turned out to be a very inconsistent tool for managing or directing conversations. Some threads could be very positive, with students providing peer support in a positive way. But some threads could become overwhelmingly negative, with students reinforcing negative attitudes and spreading them to peers. ASUOnline did offer best practices on discussion board management, but these did not prove to be very helpful. This concern has required significant effort to address on the part of the faculty and the administration. First, more emphasis was placed on synchronous communication (office hours). College administration supported the purchase of videoconferencing licenses for each SE faculty and for each SE course. Second, graduate mentors were used to more actively monitor discussion boards, email, and hold office hours. Third, the online students started a Slack community that has taken a strong hold; this kind of peer-to-peer interaction has resulted in a significant improvement in student-to-student interaction. Faculty also participate in the Slack discussions, but these channels are entirely moderated and organized by students. Finally, SE faculty have made a concerted effort to promote engagement opportunities outside the classroom, such as "coding clubs" and hackathons, for online students.

Academic Integrity (Concern 9) is a rising issue in higher education, particularly in online education. The faculty feared in an online environment the inability to observe student behavior would lead to an inability to detect cheating on labs and exams. ASUOnline has invested in tool support, initially ProctorU and subsequently RPNow. These have largely proven, with some challenges, to be effective tools for remote exam proctoring. Cheating on labs, particularly programming labs, is a challenging issue for both on-campus and online environments. We do not have complete evidence comparing the rates in on-campus vs. online, though more academic integrity cases have been referred to the Dean's office in the online program. Consistent with some recent literature [5][6], cheating in online environments is often easier to detect due to the patterns that arise and the relative objectivity of evaluators when they do not see the students in person on a frequent basis.

Concern 10 was not initially a major concern of the faculty. There was some concern that students could not absorb the course material in half the time, even though they took half (or less) courses (the typical online student takes 2, maybe 3 courses per 7.5-week session). This has turned out to be a significant concern, which we believe ties to concerns 6, 7, and 9. The fast pace of a full semester course in a 7.5-week session makes it easy to focus on technology skills at the expense of higher-level, durable learning. The ability to learn these transferrable concepts requires discovery, iteration, reflection, and active learning. But the 7.5-week pace combined with online students that typically have jobs or other significant outside responsibilities results in a "just get this week's work done" mentality of the students. In some ways this has been the biggest threat to the program values expressed in Concern 1.

The last three concerns express the fears the faculty had about undertaking a significant new online development in the given context, and whether the administration understood the full dimensions of the faculty concerns here. Concern 10 deals more with the particular makeup and transition the SE faculty were undertaking at the time. This is a particularly sensitive topic due to the nature of tenure in academia and the perceived role of junior faculty. We address it in the next subsection. Concern 11 is more practical, indicating the faculty had no information about how certain established processes would work in the online context. These concerns are more institutional and so are discussed below in section B.

A. Online development and the tenure process

The online BS in SE was developed during a period of immaturity of ASUOnline, as well as a period of great change for the program (integration into a new college). Course offerings were developed on the backs of the existing workloads of faculty, who at the same time were expected to dramatically increase research productivity while many junior professors were late in the tenure evaluation stream.

The faculty responsible for the BS in SE originally operated in a teaching-centric college, where the expectations for research, teaching excellence, and workload distribution were more inline with expectations of faculty at smaller, regional universities that emphasize a teaching mission. The faculty prioritized teaching over research, and as such, felt conflicted about a new research mission while at the same time being asked to introduce a new online program.

Another concern arose from the lack of anecdotal perspectives on the mission and effort of online education. For example, the College had previously developed two online degree programs. In one case teaching-track faculty developed the program, and in the other case research-track (already tenured) faculty developed the program. At a highly active research university, junior faculty will be more focused on establishing their research programs in advance of tenure evaluation. This does not mean junior faculty are not concerned with excellent teaching, but the incentive system in research universities discourages extra effort in teaching and service activities, which is exactly what online education

requires. As is the case with on-campus courses, new course development at the undergraduate level in core curricular areas is most "efficient" when performed by teaching faculty or by those faculty with the protection of tenure. This is certainly the case of online development, which is more intensive and less forgiving than on-campus development. But the Software Engineering faculty at the time consisted mainly of junior tenure-track faculty members.

Finally, we note that the time commitment to design online course shells was further exacerbated by the faculty's lack of prior experience designing online classes, and ASUOnline's turnover of instructional designers, learning management systems, policies and personnel.

B. Faculty concerns regarding institution support

ASU is a semester-based institution, yet ASUOnline requires the same courses to be taught in 7.5 weeks. This presents problems for developing and conducting courses, and it stresses the support processes that surround resourcing the educational mission. There are several instances of ASU processes that do not map well to the online model.

1. Faculty workload expectations were confusing, constantly changing, and considered by most faculty to grossly misrepresent the work required to deliver quality education online [7].
2. The reimbursement process has evolved over time and was poorly communicated. The result has been stressful for faculty, administrators, and staff.
3. The Faculty Annual Review process did not account for the online model, resulting in evaluations where faculty were tied to evaluations of course offerings that they did not actually teach. Further, evaluation of faculty performance in online requires special consideration of online-only factors [8].
4. TA/Grader support policies and hiring processes were defined in terms of a traditional semester model. This resulted in situations where assignments could not be completed in a timely fashion as new sessions started.

The FWG investigation into the these process issues showed the faculty and support staff shared many of the same issues. Administrative support staff had no more preparation or feeling of a shared community of best practices than the faculty. They also felt "on their own" in terms of adding support for online instruction on top of their existing responsibilities. There was no administrative evaluation or process reengineering activity that occurred at the time. In a way, institutional inertia resulted in staff attempting to move tasks along same as they did before. As the first iteration of the BS in SE was completed, staff as well as faculty began to see best practices evolving, and started championing efforts to the upper administration to put more adaptive processes in place.

A second dimension to this problem deals with the nature of revenue generated by online programs. At ASU, the tuition model and revenue stream from online education is distinct from on-campus education. At a program level, it creates a "color of money" issue that impacts administrative processes. This is niether a good nor a bad thing, just a reality; but it does create administrative overhead when allocating resources to online development and instruction.

IV. Strategies for Success

Given the rate of growth of the program, issues requiring solutions in the near term, the attrition of faculty, and a desire to improve quality of the program, the FWG developed some strategies for success that we share in this section. The FWG organized these strategies around three issue dimensions: *Scalability, Quality,* and *Process*, presented in this section. Some of these strategies are in progress, others are under consideration by the faculty and upper administration.

A. Scalability

Online programs are now popular as a way to expand the traditional brick-and-mortar campus [9][10] with cost-effective, revenue-generating, scalable programs that provide otherwise unavailable learning opportunities for students. The ASUOnline offering of the BS in SE is growing at a rapid pace. The SE faculty are focused on strategies such as the following.

- Expand grading and mentoring support. Online sections are large and require fast turnaround in a 7.5 week course. Students need around-the-clock mentorship online, which cannot be the sole responsibility of an instructor. Graduate and undergraduate mentors, plus TAs and graders should be heavily resourced online.
- Expand instructional design and content production support. Faculty should not spend time assembling content, post-editing video/media, and managing content assets. Further, that support should be trained in domain-specific concerns of software engineering – for example project-based pedagogies and the reliance on software tools. Teaching Software Engineering online is not the same as teaching a Humanities course.
- Invest in licenses and support for automated code plagiarism and formative assessment tools. Provide funds for computing-specific tools supporting online.
- Create a faculty workload policy that represents the work needed to create & maintain quality course shells.

B. Quality

The FWG suggested a number of ideas to address quality. First, they noted that every suggestion under Scalability will also improve Quality. Additionally:

1. Faculty review processes (tenure and periodic evaluations) should reward innovation in online education instead of encouraging a "do the minimal" culture that penalizes faculty for spending time.
2. Foster a connection to the institution for online students. For example, bring some students to campus each session to meet faculty and on-campus students; promote online profiles in newsletters and websites, or connect online students with alumni in their city.

3. Create a social presence for online students in Software Engineering. Ensure faculty post rich profiles describing their research and teaching interests.
4. Adopt an Agile approach to teaching and learning [11][12], where the instructional mission of the program is a collective responsibility of the faculty. Modularize course content and delivery and maintain a constant workstream for course updates.
5. Provide more faculty professional development opportunities for online instruction. At present these opportunities are limited and not valued, yet they contribute to online instruction quality [13].

C. *Processes*

1. Coordinate communication between faculty on best practices, workload models, and support tools across all online programs.
2. Define a consistent workload policy and identify a faculty input mechanism for it.
3. Unify student support services, like advising /tutoring.
4. Have support staff participate in yearly kickoff and end-of-year faculty workshops, with process issues a specific agenda item for these events.

V. DISCUSSION

There are significant challenges putting a degree program online, but in many cases, the real challenges were not the challenges the faculty initially feared. This paper shares the faculty's reflections with the community, as we feel there are many lessons learned that more and more programs will need to address in the near future. Recent reports and papers show that several of the concerns raised by the faculty are showing up at other institutions [8][10][13].

Though a body of knowledge exists on online teaching and learning [14][15][16][17], researchers [18] are discovering that different aspects of online learning need to be explored in more detail within specific contexts for specific types of learners. Means, Bakin, and Murphy [18] state that solid empirical research on implementations of online learning is limited, and is lagging behind technological innovations that act as game-changers. They have specifically identified a need for moving away from broad claims about the benefits of online education, and focus on rigorous research performed in specific contexts, to test the aspects that provide additional advantages to students. Software engineering, given its highly technical nature, engineering foundations, and perceptions of "quick-win" technology skills development, is such a specific context.

This paper presented lessons learned from a case study in putting a software engineering degree program online, and proposes some ideas for moving similar efforts forward. The most import theme around all of these ideas is to create a community culture around online education. Strong institutional support and faculty experience will lead to improved instruction. As with software engineering, instruction quality starts with a culture that values quality, and promoting this culture is more important than any specific practice.

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