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First Steps Towards Exporting Education: Software Engineering Education Delivered Online to Professionals

Kevin D. Wendt
University of Minnesota
wendt@cs.umn.edu

Ken Reily
University of Minnesota
reily@cs.umn.edu

Mats P. E. Heimdahl
University of Minnesota
heimdahl@cs.umn.edu

***Abstract*—Large software organizations seek internal professional staff development beyond traditional corporate training in specific technical skills (i.e., a new programming language or tool). This paper describes the results of one effort of delivery: the offering of a non-credit small, private, online course (SPOC) in software design. Participants spanned those with formal degrees in Computer Science or Software Engineering to those with no formal education in the area. After completing the course, a survey was administered. Intention to enroll in further non-credit SPOC courses was found to be more likely than intention in formal degrees in the area. Additionally, the course content was highly valued by the participants. These findings show a need for further investigation into the value and opportunity of exported education: bringing University expertise out of the traditional classroom and directly into the hands of industry professionals via corporate training-style SPOC offerings.**

I. Introduction

Today's software workforce does not have the requisite education necessary to thrive in their current and future positions [17]. Previous work has been focused on enhancing the efficacy of formal education in software engineering [3], [9], [11], [19]. From teamwork to design skills [**?**], [12], from software testing to problem-based learning [8], [16], researchers are investigating methods of improving the education that students in formal education programs receive. Unfortunately, we find that a significant percentage of the people who end up in positions that would benefit the most from continued education in software engineering hold no formal education in these areas. Further, findings suggest that those in positions requiring skills in software engineering — and that have an interest or a need for continued education — face significant obstacles to attaining it through currently available degree programs. Our limited study indicates that a portion of these professionals will not enroll in the formal education programs to benefit from it. Massive open online courses (MOOCs) have been suggested as a solution, but are only one possible solution that has been met with mixed results [6]. Therefore, we advocate providing alternative methods of skill acquisition to those unable or unwilling to gain them from traditional university education. This paper seeks to open the dialogue and provide early insights into three key questions:

R1. How might delivery by universities compare to delivery by other organizations (i.e., private training consultantcy firms, MOOCs, etc.)
R2. Should universities provide that education directly to professionals?
R3. Can we provide software engineering education online successfully?

A small, private, online course (SPOC) in software design was offered to 40 participants. This paper details insights drawn from the results of surveying these early participants in our proof of concept and suggests improvements to the method to increase scope and validity in the results.

II. Related Work

Much related work in this area applies to the formal education model: Bachelor's and Master's degrees in either Computer Science and Engineering or in Software Engineering.

A gap exists between traditional formal education and the needs of industry [17]. This gap should be filled primarily with industry-relevant education, best provided to those who already have experience [5]. Custom Master's degrees are one successful and necessary avenue for delivering this type of education [1], [4]. However, graduate education delivered in a one-size-fits-all master's degree program will be insufficient to meet the needs of current industry professionals [2] and a more availabe and non-co-located education model is necessary [15].

Skevoulis [18] exemplifies the current trend towards software engineering education delivery. Given a single business' needs, a custom Master's degree program was created and delivered at the business location. Skevoulis outlines four main avenues for academia/industry collaboration: knowledge transfer via employee enrollment in formal degree programs, commercial stewardship of in-class projects for university courses, direct commercial involvement with the university, and cooperative education [18]. Skevoulis states that the custom degree program was built for their partner but hoped it could be reused with little modification for other organizations. This program, however, eventually succumbs to an end of collaboration. While the idea of reusability is key, requiring a full degree program is likely less palatable for the working professional.

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Manisha and Manuja [13] address the problem in a similar fashion. This industry–driven approach focuses on four means of delivering education to students: "training the recruits" by giving additional training to new hires to make the work-ready, "training outsourcing" via in-house training which they note "may not be viable for many small and medium size IT organizations", "establishing corporate universities" which is seeing recent growth [7], and "strong industry-academia collaboration". Manisha and Manuja focus on the final option: how industry can help bolster universities' formal degree offerings by injecting industry knowledge into the classroom. Manisha and Manuja fail to take the next step. We can re-imagine "training outsourcing" by adding to the current outside-consultant dominated space. As a University-provided service, exported education can serve as the "radical change in the ... education system" needed to meet the needs of industry, while also being a long-term solution compared to custom designed master's degree programs which live and die with the company that is partnered with [18].

Previous work has highlighted the need for more education through both formal education and direct education to professionals. None have investigated the direct education method. We believe this must be separately investigated.

One potential mode of online delivery — that is related to the direct education model we seek to define and research — is the massive open online course, or MOOC. MOOC courses are characterized primarily as "an environment in which students are able to access all course content and resources online, often without cost, and with open enrollment for all." [6] However, while the benefits of MOOCs can include "having been tested before by thou- sands of learners in earlier iterations or sessions" and "many of these courses are available completely free of charge", current MOOC offerings may not exist for the skills industry leaders are seeking. Indeed, unless these MOOCs are pre-existing, the cost will likely reside with the business to create it. If the skills or topics the business needs are not in high-demand, there may be no creator willing to fund the course's creation. Part of that hesitation is the cost of transitioning learning materials to the online format.

Creating a format that is in between the formal education course and a MOOC could be the solution that provides value while lowering cost and providing opportunity to customize content for the specific business' needs.

III. Method

We set out to investigate whether or not a small, private, online course (SPOC) could deliver the software engineering education that was sought. We sought to investigate the benefits of this small directed-education course compared to a formal, classroom-based course, as well as a comparison to other training opportunities at their company. We delivered a course on the topic of software design. The course was designed as an online course with a significant synchronous element. Each week of the 8-week course included online video lectures, asychronous discussion topics, and comprehension check (short, multiple-choice question quizzes) activities, similar to those found in a common MOOC. However, included in each week was a webinar, which was to be attended by all participants simultaneously. In addition to guest lectures from within the company, these webinars included live discussion, deeper discussion of challenging topics, answering of student questions, and other specifically-tailored activities designed to heighten engagement and learning. Participants in the course were employees in the technology group of a large healthcare organization who applied to take part in the course. Topics included software design process and modeling, UML diagramming, software quality attributes, software design patterns, refactoring, and configuration management. Topics were split into similarly sized modules which were consumed 2-3 per week during the 8 week course.

After delivering the course, we hoped to gain insight into our three research questions through the investigation of five subquestions:

- R1.1 How does the participant's perspective of value compare between SPOC courses delivered by university instructional staff compare to corporate training offerings available to the participant?
- R2.1 How does participant interest in non-credit online education delivered by academic staff compare to interest in formal education degree programs?
- R2.2 What is the formal education background of participants in the areas of computer science or software engineering?
- R3.1 What value does the participant place on the educational experience for their business and current role?
- R3.2 What value does the participant place on the educational experience for their own personal development?

The survey was made available in the final week of the 8-week course. Participation in the survey was restricted to those who had completed the work of the previous 7 weeks of the course.

IV. Results/Discussion

Figures 1-7 detail the results. 19 out of the 40 enrolled students responded, giving a 47.5% response rate and a 100% response rate of those who completed the course. Each question had a response rate of 16-17 out of 40, or 40-42.5%. For a voluntary survey, this response rate is quite good. Given that these represent students that completed nearly all of the coursework, these results give some insight into the preferences of those students who completed a similar course. While the sample is small, we can still find implications that are worth investigating further and gain knowledge that can be used to better examine such topics in future work.

A. R1.1: Comparison to other training

The results in Table I are clear. Compared to other training opportunities, that the "course compared favorably" was rated between agree and strongly agree, without a single respondent in disagreement. This indicates that there may be merit in providing directed-education offerings in addition to the

TABLE I
THIS COURSE COMPARED FAVORABLY WITH OTHER TRAINING OPPORTUNITIES AT MY COMPANY.

Classifier	Respondents (%)
Strongly Agree (4):	5 (29.41 %)
Agree (3):	12 (70.59 %)
Disagree (2):	0
Strongly Disagree (1):	0
Average:	3.29

current model of corporate internal development. More must be done to further investigate favorability of other training at the organization to make a more meaningful comparison.

B. R2.1/2.2 - Should we educate?

To reduce the uncertainty, we chose to review the results from the viewpoint that all non-respondents would have responded negatively. For example, if the question were "Which of the following best describes your interest in formal education in a Software Engineering degree program (Bachelor's/Master's degree)?" We could form a conservative number taking all non-respondents as having responded "I have no interest." Even considering this conservative viewpoint, the results provide positive outcomes.

There is a contrast between interest in formal degree programs and further non-credit educational offerings (tables II and III, respectively). While one respondent stated that they intend to enroll in a formal degree program in Software Engineering, nine participants stated an intention on pursuing further non-credit offerings. While this is a small sample size, this difference hints at a crucial separation between formal degrees and individual skill attainment.

TABLE II
WHICH OF THE FOLLOWING BEST DESCRIBES YOUR INTEREST IN FORMAL EDUCATION IN A SOFTWARE ENGINEERING DEGREE PROGRAM (BACHELOR'S/MASTER'S DEGREE)?

Classifier	Respondents (%)
I have no interest.:	5 (29.41 %)
I have interest, but enrolling is not practical due to the time investment.:	3 (17.65 %)
I have interest, but enrolling is not practical due to the financial investment.:	1 (5.88 %)
I have interest, but enrolling is not practical due to both the time and financial investments.:	5 (29.41 %)
I have interest, but enrolling is not practical due to other reasons.:	2 (11.76 %)
I have interest, and intend on enrolling in a formal degree program.:	1 (5.88 %)

Those with an intention of pursuing further non-credit offerings made up more than a majority (52.9%) of those who responded to the question. However, this is biased by having only respondents who finished the course. If we conservatively assume that all non-respondents have no interest in further non-credit offerings (which contradicts anecdotal expressions made outside of the evaluation vehicles), 22.5% of enrollees in the course expressed interest in further SPOC offerings. This is not an insignificant group of the enrollees. If we include all those who have interest in enrollment, not just intention, we see rates of 88.2% of respondents and a conservative rate of 37.5% of enrollees showing interest in further opportunities of this nature.

TABLE III
WHICH OF THE FOLLOWING BEST DESCRIBES YOUR INTEREST IN FURTHER OPPORTUNITIES IN SOFTWARE ENGINEERING EDUCATION DELIVERY IN A NON-CREDIT ENVIRONMENT?

Classifier	Respondents (%)
I have no interest.:	2 (11.76 %)
I have interest, but enrolling is not practical due to the time investment.:	2 (11.76 %)
I have interest, but enrolling is not practical due to the financial investment.:	1 (5.88 %)
I have interest, but enrolling is not practical due to both the time and financial investments.:	2 (11.76 %)
I have interest, but enrolling is not practical due to other reasons.:	1 (5.88 %)
I have interest, and intend on pursuing further non-credit educational opportunities in Software Engineering, if available:	9 (52.94 %)

A further positive indication, directed-education courses can serve as recruitment and marketing for formal degree programs, rather than seeking to replace them. In our findings, we saw one respondent express an intention of enrolling in a formal degree program. While this may seem low (5.9% of respondents and a conservative 2.5% of enrollees), the importance here is at scale. If programs are rolled out at scale to the meet industry demand[1], this could provide sizable enrollment increases for formal degree programs.

To further investigate the contrast between interest in formal degree programs and non-credit offerings, the respondents lack of interest is of note. While 5 of the respondents noted a lack of interest entirely in formal degree options, only 2 noted such a lack in further non-credit offerings (29.4%/12.5% vs. 11.8%/5.0%, respondent/conservative enrollee percentages respectively). This further indicates that directed-education offerings can be seen as more accessible than formal degree programs.

Respondents were then asked about their formal education background in computer science or software engineering (Table IV). 23.5% of respondents had less than a Bachelor's degree in the field. 52.94% of respondents stated that they possess a Bachelor's degree. 23.5% of respondents state that they held a Master's degree. These results are consistent with previous works [18].

Participants — who already completed a degree in the field — applied to and took a non-credit offering in software design. This may expose a gap in the formal education when these employees matriculated. The particular skills that we offered

[1]Discussions of full scale rollout at the company have included as many as 1000 students enrolling in these offerings.

TABLE IV
WHICH BEST DESCRIBES YOUR FORMAL EDUCATIONAL BACKGROUND IN THE FIELD (COMPUTER SCIENCE/SOFTWARE ENGINEERING/ETC.) BEFORE THIS COURSE?

Classifier	Respondents (%)
No formal training or education (including self-taught and on-the-job learning):	1 (5.88 %)
Some non-academic training or education:	1 (5.88 %)
Certificate (1-year):	1 (5.88 %)
Associate's (2-year) degree or equivalent [Progress towards or awarded]:	1 (5.88 %)
Bachelor's (4-year) degree or equivalent [Progress towards or awarded]:	9 (52.94 %)
Master's (2-year post-baccalaureate) degree or equivalent. [Progress towards or awarded]:	4 (23.53 %)
Ph.D. (Doctorate) degree or equivalent [Progress towards or awarded]:	0

are not being attained/retained by those who completed those programs.

Participants without a degree in either software engineering or, to an extent, computer science, are unlikely to receive any formal software engineering education, education that the employee and their employer believe to be beneficial. The size of group without such a formal degree at a large, developer-focused industry vertical cannot be ignored. Participants in this group would not benefit from gains in formal software engineering education, not matter how great. However, this segment could gain from directed education in these skills, if the offerings are valued as highly as this first pilot.

C. R3.1/R3.2 - Can we deliver it well?

TABLE V
HOW WOULD YOU RATE THIS COURSE OVERALL?

Classifier	Respondents (%)
Outstanding (7):	1 (5.88 %)
Very good (6):	11 (64.71 %)
Good (5):	5 (29.41 %)
Fair (4):	0
Poor (3):	0
Very poor (2):	0
Exceptionally poor (1):	0
Average:	5.76

Tables V, VI, and VII regard participant perception of value. The results are highly favorable. In fact, only one response on a single question was on the lower half of the respective scale. Without comparable data for other courses the students have completed, it is difficult to make definitive comparisons. However, the positive results do not disprove — and may suggest — that the answer to the key question of "Can we?" deliver this type of education using SPOC offerings is "yes".

V. FUTURE WORK

There are non-insignificant threats to the validity of these findings. The results are small in scale at only 40 total

TABLE VI
I LEARNED SOMETHING WHICH I CONSIDER VALUABLE TO MY PERSONAL DEVELOPMENT.

Classifier	Respondents (%)
Strongly Agree (4):	8 (47.06 %)
Agree (3):	9 (52.94 %)
Disagree (2):	0
Strongly Disagree (1):	0
Average:	3.47

TABLE VII
I LEARNED SOMETHING WHICH I CONSIDER VALUABLE TO THE BUSINESS IN MY CURRENT ROLE.

Classifier	Respondents (%)
Strongly Agree (4):	6 (35.29 %)
Agree (3):	10 (58.82 %)
Disagree (2):	1 (5.88 %)
Strongly Disagree (1):	0
Average:	3.29

participants in the course and 19 survey respondents. The self-selection into the class could skew the results. There is more to be done to further and more accurately investigate these questions.

There are necessary changes to the survey itself. The survey was completed as a Moodle "feedback" module [14]. This restricted the level of detail we can measure. For example, we cannot see if those who marked "No interest" for formal education also marked "No interest" for similar offerings. While that is the hypothesis, the data available cannot be analyzed in this way. Second, the Likert scale should have been used, rather than the sans-neutral scale that was used. Third, without the use of both pre- and post-surveys, little can be said of the direct impact of this delivery on the interest in formal education and non-credit offerings. Knowing that there is interest in non-credit offerings is good; showing that the delivery entices even higher interest is better. Similarly, there was no published data found regarding the value of other corporate training. Without this data, there can be no direct comparison between the value of content delivered by accredited university staff and other methods of training using consultants.

With such a small sample, it is difficult to claim that those without a formal degree background have a higher need or higher interest in further opportunities, but that is an aspect which can be better answered by a larger study. There is also a possibility that interest in these courses by those already holding formal degrees can be used to identify gaps in current programs.

Lastly, questions of generalization remain. Many previous efforts to met industry demands were attempted by using custom master's degrees tailored to a single company. This limited their broader application and longevity. Future work can directly investigate the long-term viability of a more accessible and general education in software engineering skills.

In order to better assess the full population's interest is such directed-education offerings, we intend to execute a survey on

a larger scale, to all those employees who may be offered such a course in the future and in multiple, large technology companies. This will avoid the self-selection bias by only querying the interest of those who applied to take the course, who clearly have interest in the type of education. More importantly, qualitative methodology must also be employed to better identify differences in interest not only for the comparisons previously surveyed, but also to elicit differences not yet studied. For example, we have not contrasted the small, private, tailored offering of this pilot with the possibility of a more generic MOOC offering. Along with that question, we must also properly frame the work to compare the financial impact to the company. Lastly, while only participants in our course could respond to our survey, another viewpoint which can be researched is that of the managers who support and sponsor these participants. Both qualitative and quantitative study can be implemented to better assess research questions R1 and R2.

VI. Conclusion

After delivering a small, private, online course in software design, data collected via a survey give a positive impression of the experience and value for the participants. Interest in further offerings of this type was found to be higher than interest in formal degree offerings in the same content area. We have only scratched the surface of our research questions. Delivery by University staff was favorably compared to other training undertaken by the respondents. However, the more general conclusion is that University-staffing is objectively preferable to that provided by outside consultants not affiliated with a University. We get an indication that we should consider providing direct to professionals. We do not get a full picture of whether this should be in addition to or in leiu of formal education (though the authors believe it should be in addition to). Lastly, we see an indication that the education was perceived as a favorable experience. However, we do not provide an objective assessment of the learning in the course, nor do we make a proper comparison of this format to the possibility of creating a more general and asynchronous style of delivery as a MOOC.

Our current work provides an indication that more such research is necessary to aid in the answering of the three key questions: can software engineering be effectively offered via direct online courses to professionals, should it be offered, and how well are universities positioned to deliver such courses? We believe that there is enough evidence here to say “Maybe, yes?” and to look deeper. With more evidence, we hope to convince higher education institutions to “export their education”, out of the classrooms and ivory towers and directly to the employees that need it.

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