The Connected Learner:

Engaging Faculty to Connect Computing Students to Peers, Profession and Purpose

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Abstract--The Connected Learner is a re-orientation of undergraduate computing education that focuses on connecting students to peers, the profession, and purpose. The College of Computing and Informatics at UNC Charlotte—comprised of three departments with an undergraduate enrollment of approximately 1,500 students—is a large research institution in an urban setting with a diverse student population. Within this unique context, the project aim is to build a sustainable practice of educational innovation across the undergraduate computing curriculum by increasing faculty awareness of teaching innovations, resources for pedagogical change, and support for teaching practices that engage students. The vision is to create an active learning environment that transforms the student entering the computing undergraduate program from a person with an interest in computing to a person with an affinity identity [1] as a computing professional through these ongoing connections. We employ a systems theory of change for the Connected Learner based on two foundational concepts: flipped classrooms and engagement theory. To achieve related goals of improving student retention and time to graduation, Connected Learner teaching strategies are being integrated across the undergraduate curriculum with an initial focus on introductory gateway courses. Change is occurring via infrastructure supports to sustain learning practices across our college through faculty development initiatives (hiring, training, mentoring, and incentives) that are designed to inform faculty about engagement pedagogies, motivate faculty to adopt these practices, and shift pedagogical attitudes. During the first year of the five-year project, quantitative and qualitative data from students and faculty was collected and analyzed. This data provides a baseline of student attitudes and performance as well as a baseline of faculty attitudes and teaching practices. In this paper, we present the background, context, organizational structure, and research questions for the project. Findings from Year 1 are discussed, including academic outcomes, project milestones, and student attitudes towards new teaching practices. Long-term project goals and expectations are presented.

Keywords--computer science education; pedagogy; faculty development; active learning; student engagement

I. INTRODUCTION

The University of North Carolina at Charlotte (UNCC) is the region's largest urban research university, with more than 27,000 students. The size and demographics at UNCC provides an environment that is typical for many large comprehensive universities and therefore ideal for developing changes in computing education that will transfer to a majority of US institutions. The College of Computing and Informatics (CCI) has piloted a series of innovations in undergraduate computing education: (1) established a pedagogy for peer learning in the classroom based on the concept of "lightweight" teams; (2) established a pilot called the Innovative Computing Project in which business partners propose challenges for student teams within specific core courses; and (3) established courses and service learning opportunities for students to develop skills in communication, leadership, and planning community outreach. The goal of the Connected Learner project is to synthesize, integrate, and apply these three core teaching innovations to all levels of the undergraduate degree with a focus on educating more highly engaged students. The approach toward revolutionizing computer science (CS) education is achieved by changing the teaching culture and practice throughout the College organization. We seek to close the gap between what we value and how we practice within our learning system, which has been noted in STEM education [2], by embedding creative pedagogy and research into the organizational strategic plan. The project vision is to transform the student and faculty attitudes towards education, shifting their attitudes and behaviors away from mere knowledge transmission and lecturing toward a refreshed approach of active and engaging learning environments.

The Connected Learner has an overarching goal of revolutionizing computing education by infusing active teaching and learning strategies across an undergraduate curriculum. The project provides students with multiple concurrent avenues for engagement in computing by offering three kinds of learning communities: peer, community, and professional. Peer learning connects students by scaffolding active learning strategies within courses, and integrating team-based techniques within 'flipped classroom' approaches. Students participate in planning and leading socially relevant activities through service learning computing courses. By engaging with computing professionals in real world challenges, both

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inside and outside the classroom, students develop and hone their professional skills. One of the primary objectives of the Connected Learner project is to identify emerging design patterns (i.e., ideas for active learning in a CS curriculum that address issues of engagement and performance), and gradually increase the percentage of computing courses that incorporate one or more of the core teaching innovations, with an end goal in Year 5 for 90% of computing courses to be 'flipped.' The seed for this change is our early success in achieving active learning using lightweight teams, service learning, and the innovative computing project as described in Section III.

A key outcome anticipated from the Connected Learner project is an increase in the quality of education provided to a diverse population of computing students, evident in improved retention and graduation rates. We will identify how active learning directly addresses some of the faculty concerns about teaching, e.g. students coming to class unprepared and lack of engagement during class. Emerging design patterns from the early-adopting faculty who apply active learning strategies will be further developed and applied by other faculty through our Connected Learner Summer Institute. We expect to observe educational impact on a diverse student population (i.e., first time college students, ethnic diversity, GPA diversity) along with professional impact by increasing and enhancing the talent pool for computing. The innovation from this project is expected to have long-term effects through the establishment of sustainable organizational change and dissemination of replicable education practices that are scalable across a wide variety of computing institutions. Overarching research questions that define the 5-year project include:

1. *What organizational changes (e.g., faculty incentives, new/revised policies) are most effective and efficient at motivating and sustaining any observed shifts in teaching practices?*
2. *Do faculty attitudes and perceptions about teaching change and, if so, how?*
3. *Do students develop computing professional identities and, if so, how?*
4. *Do Connected Learner innovative pedagogies improve student retention and reduce time to graduation?*

Next, we discuss the underlying theoretical foundations that guide the Connected Learner. The practices launched in Year 1 are described, including the core teaching innovations, tools, and the organizational structure supporting the first cohort of faculty champions. We conclude with presentation and discussion of first year outcomes, focusing on student perspectives.

II. THEORY OF CHANGE

A. Organizational Change

At the organizational level, we apply a systems theory of change to our approach to align the college system toward our innovation, building upon educational systems theory and learning organization theory. Steiner [3] describes an educational system as comprised of interconnected core components of faculty, students, content and context. Senge [4] specifies that within an academic setting, the key change agents are department chairs, faculty, and students. The Connected Learner will transform CCI by integrating the four components of learning organizational theory by engaging all levels of change agents, by removing the structures and ideals that tend to isolate them [5], and by moving away from fragmentation, competition, and reactivity within an organizational system. With this systems approach, we organizationally shift to seeing our educational system holistically, rather than compartmentally; that is, the leadership, faculty, and students, comprise an entire community with a unified vision. Although Senge does not prescribe the learning organization as a model, but rather as a vision, he does indicate that within a university setting, department chairs, faculty and students are key change agents [4]. Our organizational innovation is in incorporating incentives for teaching directly within a discipline-based college framework and community, rather than it being externalized (e.g., through a University Center for Teaching and Learning) [32].

The entire system surrounding the faculty will be focused and aligned so that the innovation becomes standard practice and continues beyond the period of NSF funding. The following incentives are provided for faculty to change: reduced teaching load to attend workshops and plan new course materials; summer stipends to develop new teaching materials, travel funds to attend CS education conferences; and teaching awards. The development of learning materials and new course structures is actively supported with a Connected Learner Summer Institute, in which attendance is required by faculty that receive stipends and is also open to any faculty that wish to try one or more teaching innovations presented in the Summer Institute. Additionally, we deploy hiring approaches that focus on innovative teaching, offer faculty teaching retreats, create repositories of teaching practices and pedagogical design patterns, and provide structured faculty mentoring.

B. Educational Change

Retention rates and academic satisfaction have been found to be higher when student identities are developed within similar peer groups [6, 7, 8]. Communities of practice, as defined by Wenger [9], are environments that share a common set of experiences, knowledge base, and common identity with a common purpose, and they have been shown to foster learning [10]. Identity and learning itself is inherently tied up in group membership and participation [11]. The Connected Learner fosters the emergence of affinity groups [1] to facilitate habits of mind and epistemic frames of reference found in communities of practice. Rather than obtain

compartmentalized sets of abstract knowledge via lecture, students learn skills through direct application within controlled environments.

At the student level, the systems theory of change is implemented by the institutional synthesis and transformation of two pedagogical foundations which serve as our core teaching innovations: "flipped classroom" methods [12, 13] and engagement practices [14]. These teaching innovations are deployed primarily through lightweight teams [15], project-based learning [16] and socially relevant computing [18]. Each are described below as applied via the Connected Learner.

III. ACTIVE LEARNING PRACTICES

The flipped classroom, also called "inverted classroom" or "reverse classroom," is a teaching mode that has become increasingly popular as technology facilitates out-of-class learning by enabling students to watch video lectures online. Berrett [13] describes ways in which the flipped classroom actually improves lectures by making them more accessible. In a flipped classroom, the classroom time is no longer spent with a teacher giving a lecture and the students passively listening. Instead, students watch course content videos at home prior to class (i.e., the lecture) and in turn, teacher-student and student-student interactions are implemented in the classroom (i.e., the homework). Early versions of the flipped classroom at the university level were developed and applied by Lage, Platt, and Treglia in an introductory economics course [19]. A comprehensive review of flipped classroom approaches is provided in Bishop and Verleger [12]. Many studies have shown that working with peers in class activities improves overall learning, increases student confidence, and makes computer coding fun [20, 21]. Prior to the Connected Learner launch, five courses were flipped between Fall 2012 and Spring 2015 in the College, with student feedback indicating positive learning outcomes [22].

C. Project-Based Learning

Project-based learning is an active learning technique that engages students in "deep learning"—thinking critically and communicating effectively with peers [32, 33]. "Deep learning is a key strategy by which students extract meaning and understanding from course materials and experiences" [33]. There are two primary ways in which students engage in project-based learning in the CCI undergraduate curriculum: 1) lightweight teams, scattered across multiple courses and 2) innovative computing projects in capstone courses. Lightweight teams [15] are groups of students who work together in class on low-stakes active learning experiences throughout the semester. "Lightweight" refers to the fact that students' grades are not dependent on the performance of team members since activities the teams work on together have little or no effect on assessing individual students. This technique allows students to benefit from in-class peer learning and teaching, practice critical domain-dependent and general communication skills, and avoid the stress typically associated with high-stakes teamwork. Lightweight teams have thus far been implemented in five introductory computing courses across five semesters at UNCC, with students finding the courses engaging and reporting deeper learning [15].

Through Innovative Computing Projects (ICP) in capstone courses, students gain real world experience while external partners benefit from completed work on research and applied projects. Real world challenges are integrated into senior level courses, allowing business partners a unique opportunity for close, ongoing interaction with students. Student teams are provided a specific business challenge, and a business partner acts as a technical advisor/mentor to the team, known as a Subject Matter Expert (SME). We plan to expand ICP into 2000 and 3000 level courses in subsequent years of the Connected Learner Project.

D. Socially Relevant Computing

The Connected Learner leverages a structured framework for student engagement: the STARS Computing Corps. Founded by faculty at UNCC through grants from the National Science Foundation, the STARS Computing Corps [www.starscomputingcorps.org] is a national alliance of universities, industry partners, and community organizations with the mission to broaden participation in computing [23]. The STARS approach is grounded in research showing that service and civic engagement have a positive impact on academic performance, retention, and formation of attitudes and values for all students [14]; students from underrepresented groups particularly benefit from such engagement strategies [24]. Creating supportive communities contributes to strong academic performance for both female computing students [25] and African-American students in STEM [26]. Additionally, having a community of "like" students supports the development of a student's identity and leads to higher student retention rates and greater student satisfaction [6, 8, 25]. At UNCC, STARS is institutionalized as a student organization and through curricular offerings. The STARS Student Organization has approximately 30 student members who meet monthly to plan outreach activities, reflect on recent outreach activities, and to develop their professional skills. The service learning course is offered via two elective courses each semester that aim to develop students' professional skills—teamwork, communication, leadership—through student-led regional engagement. A recent study of UNCC STARS demonstrated that 1) the course attracts a disproportionately higher concentration of women and underrepresented minority students than typical in CCI undergraduate courses and 2) that STARS students had stronger professional identity in computing than a comparison group in the CCI undergraduate population [27]. Undergraduate students engage in projects with K-12 schools, industry, and community partners (such as Girl

Scouts, Citizen Schools, Black Data Processors Association, Boys and Girls Clubs, refugee communities) to inform, excite, and prepare students for entry and success in college computing programs and careers. Among undergraduate student participants, STARS has shown a positive effect on student success factors of self-efficacy, commitment to computing, grade point average, the perception of computing as socially relevant, and retention [23, 28].

IV. YEAR 1: PROJECT LAUNCH AND OBJECTIVES

The Connected Learner project entails a mixed agenda of both research and practical implementation. One of the primary objectives for Year 1 of the project was to formally establish and build the Connected Learner community of faculty champions. Effective organizational change is a large undertaking; research shows that bottom-up change is more successful than top-down, forced change [29]. With that strategy in mind, we see faculty as change agents, for they are in a unique position between students and the organization. We are cautious, however, of respecting the tradition of academic freedom that is a core principle "for unfettered teaching and research in institutions of higher education" [30]. Therefore, we are building the Connected Learner community of faculty champions through voluntary participation, stipend incentives, and workshops, resources, and support for faculty interested in transforming their classrooms.

The second primary objective for Year 1 of the project was the collection of baseline data from both faculty and students. At the faculty level, a survey of pedagogical climate was administered during the Spring 2016 semester. A follow-up faculty survey will be administered in Year 3 of the project to gauge change in faculty attitudes and teaching practices. At the student level, course surveys were administered to students enrolled in courses taught by self-identified Connected Learner faculty in both the Fall 2015 and Spring 2016 semesters. The student surveys measured student attitudes and perceptions of active learning techniques. In Year 2 of the project, we will deploy another wave of student surveys that will be coupled with their academic records so that we can explore linkages between students' flipped classroom experiences and academic performance, retention, and graduation. Student surveys will be administered every semester so that changes can be observed and assessed annually for the duration of the 5-year project.

V. YEAR 1: PROJECT OUTCOMES

A. Faculty

1) Connected Learner Community – Faculty Champions

In Year 1 of the Connected Learner project, the inaugural cohort of faculty champions was formed. This inaugural cohort of faculty serve as the founding change agents who have begun infusing the undergraduate curriculum with core teaching innovations. These faculty champions first convened in a workshop in Summer 2015 as the project began and subsequently collaborated in seminar discussions throughout the academic year. The seminar discussions were an opportunity to collectively discuss teaching strategies, identify barriers and seek solutions, and begin building a repository of teaching strategies and resources that will eventually be disseminated within the College, the UNCC campus, and with faculty peers at other institutions across the country. In the Fall 2015 semester, the community comprised approximately 15 members; that number grew to approximately 25 members in Spring 2016.

2) Baseline Survey of Pedagogical Climate

We conducted a faculty survey of pedagogical climate during the Spring 2016 semester. The College's entire roster of faculty (N = 99), ranging from adjunct instructors to tenured professors, was contacted by email invitation to participate in an online survey. As CCI's upper administration is supportive of the Connected Learner project, the Dean publicly announced the survey and its importance at a faculty meeting prior to the email invitation being sent. This message was further reinforced by all three Department Chairs.

To our knowledge, there is no existing survey instrument for college-level, computer science faculty that measures pedagogical climate. Therefore, we used established measures of teacher attitudes and experiences from peer-reviewed research journals (such as the *Journal of Applied Psychology* and *Teaching and Teacher Education*) to create our own faculty survey of pedagogical climate[1]. The survey thus asked a series of attitudinal questions regarding teaching experiences (e.g., "In general, the students in my courses seem tuned in."), approaches to instruction (e.g., "Teachers should provide students with the opportunity to develop and build upon their own understanding of computing concepts."), and the usage and perceived effectiveness of various teaching techniques (e.g., lecture, clicker quizzes, in-class activities). In an effort to gauge "pain points" that often act as barriers to the willingness of faculty to change their teaching practices, we asked faculty to indicate their level of agreement with several statements culled from anecdotal evidence of faculty resistance (e.g., "Coming up with course activities and content is too hard.", "Course materials change too fast and can't be reused.", and "Changing the way I teach one of my recurring courses is too much work."). We also asked faculty open-ended questions such as "How do you define student engagement?" and "What other issues make teaching difficult for you?" to elicit other factors that may not be captured with the quantitative items. The results from this faculty survey administered in Year 1 provide baseline data of CCI's pedagogical climate. For example, preliminary results

[1] Three members of the research team are organizational scientists with extensive experience in survey methodology and psychometrics.

indicate that CCI faculty believe active learning techniques are effective, but somewhat difficult to implement, with time frequently cited as the primary barrier. While further analyses of the Year 1 baseline data will continue, comprehensive interpretation of results will be on hold until Year 3 of the project, when a second faculty survey will be administered to gauge change.

3) Connected Learner Summer Institute

In Summer 2016, we held our inaugural Connected Learner Summer Institute. The Summer Institute was comprised of a series of workshops and "how-to" sessions for faculty transforming their courses to incorporate active learning pedagogies. While the Summer Institute was open to all CCI faculty, a subset of faculty—new to the Connected Learner community—were funded to revamp one of their Fall 2016 courses with active learning techniques. Strategically, this cohort of funded faculty teach courses in core courses of the CCI undergraduate curriculum. In addition to funding and training, this cohort receives ongoing mentoring and support. When the second Connected Learner Summer Institute is held in 2017, the current cohort will serve as mentors to the next cohort. This approach slowly expands the number of faculty champions in CCI so that we reach our goal of 90% faculty participation in Year 5.

B. Students

During Fall 2015, an end-of course survey was administered to a sample of CCI students. The sampled students were those in courses taught by our initial cohort of Connected Learner faculty champions. These are faculty members who have self-identified and expressed an interest in active learning pedagogies and being an integral part of Connected Learner initiatives. At present, we have approximately 20 faculty in this cohort who represent all three of CCI's departments and all levels of CCI's curriculum, from first year undergraduate students to doctoral students. The degree of implementation of active learning techniques in their courses varies. For example, some faculty are in the early stages of "flipping" their courses—they may still primarily lecture, but have begun to implement clicker quizzes to break up the lecture. Other faculty have completely transformed their courses—creating their own course content videos for students to watch outside of class with total emphasis on activities and teamwork during class time.

As the population of our study is comprised of CCI students in active learning courses, we used homogenous purposive sampling to collect data. The student survey was thus conducted across 12 courses with responses from a total of 373 students. Of the sample, 38% of respondents were enrolled in 1000-level courses, 18% in 2000-level, 34% in 3000-level, and 10% in 4000-level. The majority of the sample was male (74.5%) and white (approximately 66%). Asian students comprised 15% of the sample, African American/Black students comprised 11%, and Hispanic/Latinx comprised 7% of the sample. A majority of the student respondents (approximately 66%) had taken at least one prior CCI course that used some degree of active learning techniques, so the pedagogical approach was not completely new to them. The survey was advertised to students during class time in their respective courses. Two members of the research team visited each course to announce the survey in the context of the Connected Learner project, its purpose, and the need for their critical feedback. While students were sent a direct link to the survey via email, some of the participating faculty gave students time during class to voluntarily complete the survey. The survey was designed to gather student perceptions about the flipped classroom and to provide formative evaluation. The survey was developed from the NASA Task Load Index (TLX), which is designed to measure work-load [31] Following contextual prompts, items included perceptions of workload such as "How rushed was the pace of this course," and "I felt I was able to learn more at my own pace?" Adapted items were designed to gauge perceptions of learning activities; for example "Explaining things to others helped me learn," and "Learning from other students is just as good as learning from the professor." Course materials, such as online video tutorials, were also assessed.

The survey primarily consisted of several Likert-type items on a 5-point rating scale, with 5 = strongly agree. Items inquired about how students' current "flipped" course compared to their past lecture-based courses, their experiences working in pairs/groups, and their overall learning in the course. Item means are presented in Table 1. The majority of students skew towards positive perceptions, with means consistently above 3.00 and with low standard deviations, indicating consistency in ratings. Student reported highest ratings for working in pairs or groups. Additionally, students were asked to rate the helpfulness (5 = extremely helpful) of various teaching strategies, such as lecture, online videos, in-class teams, clicker quizzes, and industry partner projects (a "not used" option was provided). Item means are presented in Table 2. Teams, pairs, groups, and labs were among the highest ratings. Strong ratings for lecture and for individual homework and assignments were also found, which may be attributed to students' familiarity and comfort with traditional teaching techniques.

Lastly, three open-ended items inquired as to their likes, dislikes, and suggestions. The comments appear very mixed. Many students liked the flipped classroom: "I like that the majority of the class we are doing the activity instead of hearing a lecture" and "I enjoyed the outside lecture and in

TABLE 1. Student survey results for statements related to flipped classroom and peer learning

Survey Item	Mean	SD
How Flipped Courses Compared to Past Lecture-Based Courses		
I felt I was more able to learn at my own pace (compared to previous courses).	3.21	1.11
I was more able to recognize when I didn't understand something (compared to previous courses).	3.29	1.16
I looked at extra information beyond the provided material (compared to previous courses).	3.39	1.18
I felt that I learned more during class time (compared to previous courses).	2.76	1.21
I felt that I learned more outside of class time (compared to previous courses).	3.46	1.09
Experiences Working in Pairs or Groups		
Learning from other students is just as good as learning from the teacher.	3.38	1.22
Working with a partner(s) during lab/class activities generally helped me to understand the code/concepts better.	3.66	1.13
I generally helped my partner(s) to understand the code/concepts better when we were working on lab/class assignments.	3.76	.98
Other students helped me to understand the right answers while we were discussing quiz questions/assignments.	3.58	1.06
I helped other students to understand the right answers while we were discussing quiz questions/assignments.	3.57	1.04
Explaining things to other students helped me to understand them better.	3.77	.99
Overall Learning in the Flipped Course		
I have gained knowledge of how to work effectively in teams in this course.	3.35	1.06
My understanding of computing concepts has advanced in this course.	3.66	1.11
I have developed my communication skills in this course.	3.23	1.09
I am confident in my ability to apply knowledge and skills acquired in this course.	3.44	1.16
I felt adequately prepared for this course.	3.34	1.19

class discussion." However, many students dislike the flipped classroom: "I don't like flipped courses and I don't like group projects" and "I would rather take the quizzes online on moodle before class. Why waste time taking quizzes in class for a flipped classroom." Several of the suggestions also reflected mixed attitudes: "Go back to a traditional lecture and homework style class" versus "More videos in class and in class activities. In class activities encourage working together, asking questions and paying attention." We suspect these contrary views may be related to students' expectations and how well (or if) the instructor explains the active learning approach to students at the start of the semester. Students are well-ingrained with traditional teaching practices and their expectations align with a lecture-based approach. However, anecdotal evidence from our Connected Learner faculty suggests that negative student attitudes towards flipped classrooms are buffered when instructors take time to clearly explain the flipped structure and why it is being used. Further investigation is needed to understand these conflicting student attitudes.

At the time of this writing, a second wave of the survey was recently administered to students enrolled in CCI courses taught by Connected Learner faculty during the Spring 2016 semester. As several of the Connected Learner faculty have heavier teaching loads in the spring, the second student sample is drawn from 19 courses. The second wave of data is currently being analyzed independently as well as comparatively with the first wave to see if patterns of change are emerging.

TABLE 2. Student survey results for statements related to teaching strategies

Survey Item	Mean	SD	Survey Item	Mean	SD
Lecture	3.34	1.11	Video collaboration/commentary	3.46	.97
Textbook/reading materials	3.62	.97	In-class teams	3.81	1.05
Individual homework/assignments	3.83	.87	Paired (2 people) programming or paired in-class activities	3.89	.94
Labs or pre-labs	3.95	1.01	Group (3 or more people) out-of-class assignments	3.79	1.10
Online forums/discussions	3.07	1.04	Small group discussions/activities in class	3.63	1.03
Journals/blogs	3.25	1.00	Industry partner projects	3.38	1.02
Social media (e.g., Twitter, etc.)	3.05	.95	Guest speakers	3.38	1.02
Quizzes/clickers	3.56	.99	Sketchbooks	3.26	1.04
Online instructional videos	3.79	.92			

VII. DISCUSSION

We have achieved two key milestones in Year 1 through the establishment of a community of faculty champions who are scholars of engagement learning practices and have implemented core teaching strategies in introductory level CS courses. These faculty champions are not only deploying these core teaching strategies, but documenting how these strategies play out within specific classroom activities and levels of student experience. Further, these champions explore the implementation phase and bring valuable lessons learned to the cohort. These lessons learned are being captured in design patterns which will be disseminated widely to CCI faculty and beyond. Within CCI, the design patterns emerge from the faculty that are champions of the Connected Learner approach and are used as a vehicle to engage faculty that participate in the Summer Institute. We see encouraging evidence that interest in these practices is spreading, as we had increasing number of faculty participants in the workshops and seminars. We believe there is a buzz around the practices and the project overall, as we share insights regularly in faculty meetings across the College and Departments. By infusing these practices within the introductory CS courses, we are shifting the computing teaching zeitgeist from that of gatekeeping to one of admission and inclusion. We hypothesize that creating opportunities for engagement throughout the educational process enhances the evolution of professional identification, identity, and self-confidence of students. First year student survey results demonstrate that students believe that working together is conducive to learning and that they value active learning strategies (e.g., clicker quizzes, group activities) applied within the courses. Student feedback has been mixed, however, a clear indication that—like faculty—students share the expectation that the classroom experience is predominantly lecture. We will continue to observe and examine the nuances of student perceptions to determine patterns within their perspective and within academic performance. We believe that open discussion about active teaching practices will raise student understanding and offset expectations of passive learning. We suspect that these core teaching practices will serve to civilize the computing discipline, making the field more clearly connected to humanity, by engaging students in active learning between peers and faculty that is situated within socially relevant contexts.

VIII. CONCLUSION AND FUTURE DIRECTIONS

Innovation and governance for the undergraduate curriculum occurs through a college undergraduate curriculum committee, along with committees at the department level. In addition to proposing and approving curriculum changes, these committees monitor student learning outcomes in key courses, as well as assess the effect of new teaching approaches, such as the flipped classroom and lightweight teams. Our strengths are in developing, delivering, and evaluating novel instructional approaches that enable students to learn challenging computing content in relevant and meaningful ways. We anticipate revolutionizing the entire undergraduate experience across three departments by integrating and scaling individual innovative teaching practices across our curriculum, to have a positive effect on faculty (e.g., quality of teaching, integration of pedagogy with research), on students (e.g., quality education experiences, connections), and on the organization (e.g., building capacity for innovation). The innovation of active and engaged learning within the classroom experience is

expected to have a long-term effect through sustainable organizational change and dissemination of replicable education practices, via design patterns, that are scalable across a wide variety of computing institutions and curriculums.

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