Application Details

Manage Application: Curriculum Innovation Award – 2018

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Description of the Innovation

The innovation described herein is a series of innovations made in developing high-quality learning experiences online at scale. The first two come from the Georgia Tech Online Master of Science in Computer Science program, while the third is the university's first foray into online undergraduate education with an online, MOOC-style version of CS1301: Introduction to Computing. All three of these classes are assembled by Dr. David Joyner, a Senior Research Associate in the College of Computing and the college's Associate Director for Student Experience.

These three innovations together address the challenge of scaling high-quality education. There has traditionally been a significant amount of distrust in the quality of online instruction and assessment. At the same time, the demand for accredited online instruction and assessment is enormous: to meet this demand, we must find ways to offer scalable online courses that are equal to traditional courses.

These innovations tackle three components of on-campus curriculum that have traditionally been difficult to translate to an online environment: project-based learning, engaging and mutable lectures, and rapidly interleaved, immediate assessment and feedback.

Innovation #1: Project-Based Learning Online at Scale

A common criticism of online learning is that while it may be able to replicate assessments like multiple-choice exams, it struggles with truly open-ended project-based learning. Dr. Joyner's CS6460 class was developed in 2015 to address this concern. The class is entirely project-based, with no automated evaluations, no synchronous activities, and no significant video presence. Rather than watch videos and take assessments like a traditional online course, students investigate the literature.

Of specific note are these unique innovations of the course's design:

- **The mini-PhD structure.** Students open the semester researching existing literature on a topic they find interesting. They then complete a 'personal question' reminiscent of a qualifier question in PhD programs. They then write a proposal for what they will complete for the course project, and in the end, present a paper and a presentation covering the project they completed.
- **The mentorship structure.** Throughout these steps, students are partnered with a mentor who evaluates all their course assignments and gives them feedback; in this way, the mentor develops a long-term familiarity with the student's work, and the grading process is a conversation between the two.
- **The self-proposed projects.** Just as no two dissertations are alike, no two student projects are alike. Rather than assigning all students the same project to complete, students in week 7 propose their own project. The project they select may be on one of three tracks: development (creating a new tool), research (investigating a phenomenon), or content (teaching some material).
- **The resubmission policy.** Because assignments are intended to be a conversation between the student and their mentor, we see no need to have formal, final grades: if the student is lacking in a certain area, then they should address that area, and if they do, their grade should be changed to compensate. So, all students are permitted to resubmit any assignment that receives less than an A, and mentors are also free to give students leeway to raise their grade in multiple ways.
- **The participation policy.** Participation in online courses is often inauthentic as students post merely to meet post count requirements. The participation policy for CS6460 gives students

multiple avenues to earn their participation credit: helping on the course forum, completing peer reviews, participating in classmates' projects as testers or survey-takers, etc. Without videos, CS6460 relies on student conversations and interactions to create the class experience, and the participation policy provides multiple ways to support multiple types of students.

CS6460 has been offered in Georgia Tech's online Master of Science in Computer Science program for six semesters. Over 1,000 students have taken the course, and over 30 mentors have been involved in mentoring student projects. End-of-course evaluations over the completed semesters rate the course's overall effectiveness at 4.76 / 5.00, and the instructor's individual effectiveness at 4.92 / 5.00.

Further information about the online version of CS6460: Educational Technology can be seen at the publicly viewable syllabus: http://omscs6460.gatech.edu.

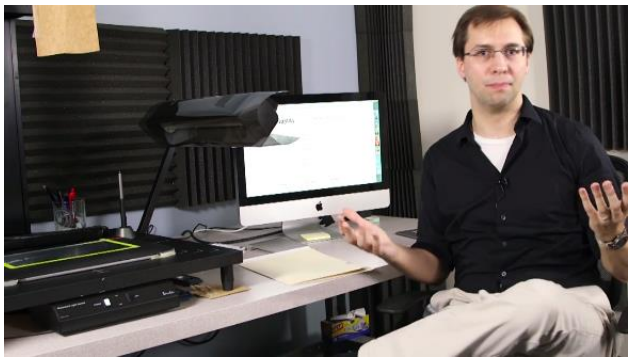
Innovation #2: Dynamic, Revisable Pre-Filmed Lectures

A second common challenge among online instructors is that once a class is filmed, it becomes difficult to main and iterate the way one would do in a traditional class. There is significant pressure to get the initial lectures "right" as they will be reused for several years, and yet this is often an unrealistic goal: the field itself may change, students will give feedback on the course design, and so on. Similarly, many online courses feature a heavily watered-down version of the normal course experience, focusing only on the straightforward lecture with typical slides. The online interface gives incentive to dedicate additional resources to the initial filming.

In 2016, Dr. Joyner developed an online version of CS6750: Human-Computer Interaction. While CS6460: Educational Technology used nearly no video material, CS6750: Human-Computer Interaction invested significant time and energy into developing high-quality, highly maintainable video material. This was done with a focus on authoring short, individually self-sufficient videos averaging 2-3 minutes in length, such that inserting new material, removing material, or revising existing material is far easier.

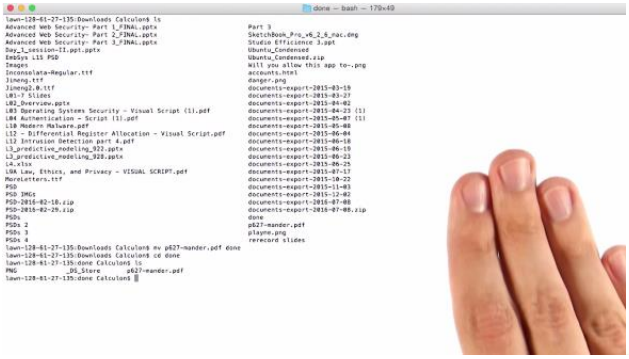
For an example of this curricular innovation, we suggest looking at lesson 2.3 from the course. This lesson is accessible to the public here (though a Udacity account may be required). Human-computer interaction covers interaction in the real world, and so the course is filmed in several locations. Thus, the course was entirely pre-scripted, and the scripts have been made available to students here.

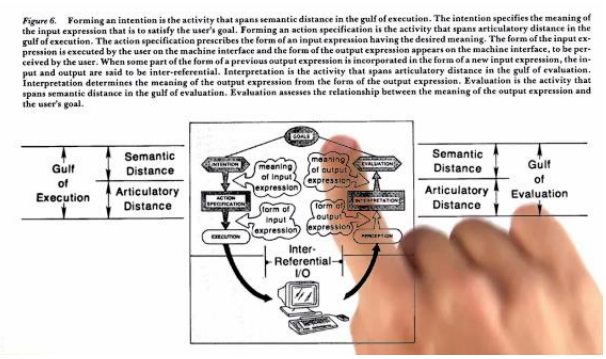
The lesson starts off with an overview of the lesson shot in a typical studio, shown below on the left. From there, the lesson transitions to a studio with a live computer, where the instructor demonstrates the principles being discussed live on camera, shown below on the right.



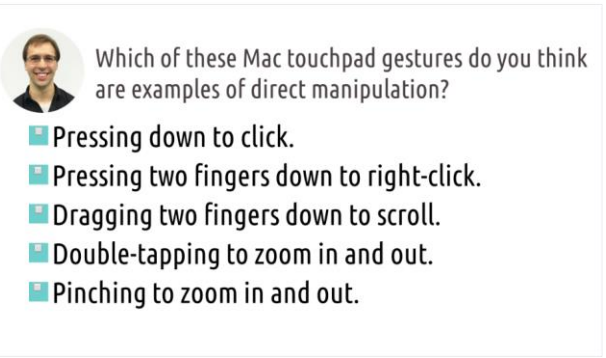
Then, the lesson shifts to a screencapture of the principles that the instructor is demonstrating shown live on screen. The instructor points and motions to things with his hand while describing the different

principles at work, as shown below on the left. Then, the lesson shifts to discussing a paper on the topic, where the paper is shown and highlights, as shown below on the right.





After a reflection quiz, the lesson shifts to a shot of the instructor's home, featuring his daughter demonstrating some of the principles discussed in the lesson on her tablet, shown below on the left. Then, students complete another exercise, this time reflecting more objectively on the course material, shown below on the right.



These examples only scratch the surface of the organization of these lessons, which emphasize real examples, a variety of presentation styles to maintain student interest, and frequent opportunities for interaction. Recurrent segments throughout the course build student expectations and solidify principles, like a recurrent "5 Tips" segment that gives five applied, practical suggestions for using that lesson's material.

The goal of maintainability has been realized within the course as well; this year, Dr. Joyner filmed 10 new videos to insert into the course, and was able to do so without fundamentally altering any of the existing material. This presents a major advantage compared to traditional maintenance of 40-minute video lectures, which demand either refilming the entire lesson or awkwardly splicing in new material.

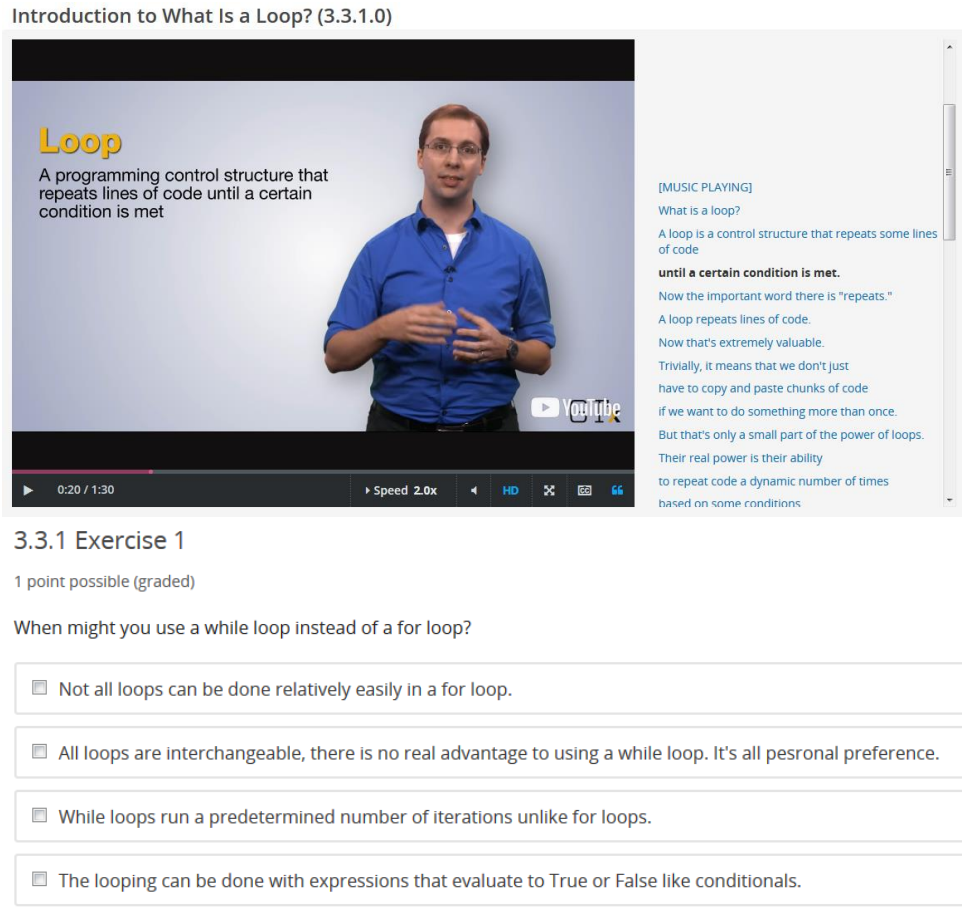
CS6750 Human-Computer Interaction has been offered for four semesters and has been taken by over 800 students. Another 1000 students have enrolled in the class free at Udacity.com. End-of-course evaluations over the completed semesters rate the course's overall effectiveness at 4.80 / 5.00, and the instructor's individual effectiveness at 4.94 / 5.00.

Innovation #3: MOOC-Style CS1 For-Credit Online

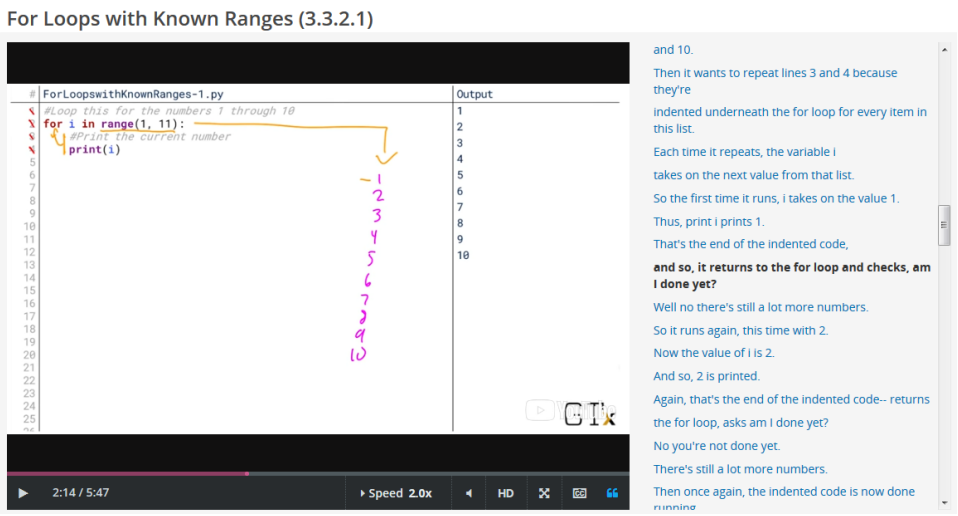
In 2017, Dr. Joyner launched his third course and the College of Computing's first online undergraduate course: CS1301: Introduction to Computing.

This description will use Chapter 3.2 of Dr. Joyner's CS1301x course as an example, which covers the programming concept loops. CS1301x can be accessed with an edX account at bit.ly/CS1301x, and this particular chapter can be found here. Here, the well-designed course materials that embody effective teaching strategies are the lessons that interleave theory, demonstration, practice, and feedback.

As with all chapters, chapter 3.2 begins with shots of the instructor discussing the chapter's general topic, shown below on the left. Interspersed between these videos are conceptual multiple-choice problems, shown on the right.



Then, within the chapters of the lesson, the instructor walks through and hand-annotates code segments in a series of short videos, as shown below on the left. Again, interspersed between these videos are live coding exercises, as shown below on the right. All of these exercises give students live feedback on their progress so that they may decide whether to move forward, rewatch earlier material, or seek help.



Students are also given a sandbox at the end of each lesson loaded with all code shown in the lessons' videos. This allows them to play around with the code they saw and see how different changes affect the output.

As part of the course, students also receive a free textbook built on McGraw-Hill's SmartBook platform. This textbook was authored by David Joyner to be congruent with the course material: its organization and content are the same, and the same examples, visuals, and analogies are present in both the book and the video lectures. This allows students to shift back and forth between video and text to suit their study habits or preferences; anecdotally, many students note that the textbook is great for 'perusing' and recapping, whereas the video lecture is better for initial consumption.

440 students have taken CS130x at Georgia Tech for class credit, while 69,000 have registered for and 12,000 have actively participated in the free MOOC on edX. In surveys of these students at Georgia Tech, the course overall effectiveness is rated at 4.88 / 5.00, and the instructor's effectiveness is rated at 4.97 / 5.00.

Description of Innovation Evaluation

Three evaluations are provided covering these innovations: a report of the course satisfaction surveys returned for each offering of each course; a report of student comments on these courses; and a rigorous evaluation of learning outcomes and student experiences specifically from CS1301.

Evaluation #1: Numeric Course Evaluations

All questions were given on a 5-point Likert scale. All surveys were run by Georgia Tech, and results were not provided to instructors until after the final deadline. Numbers shown are interpolated medians.

Course	Semester	Amount Learned	Course Effectiveness	Instructor Clarity	Instructor Respect	Instructor Enthusiasm	Instructor Availability	Instructor Effectiveness
CS6460	Summer ‘17	4.12	4.69	4.82	4.92	4.93	4.88	4.88
CS6750	Summer ‘17	4.41	4.85	4.95	4.96	4.97	4.93	4.94
CS1301	Summer ‘17	4.91	4.86	5.00	5.00	5.00	4.91	4.95
CS6460	Spring ‘17	4.58	4.86	4.93	4.98	4.98	4.97	4.96
CS6750	Spring ‘17	4.45	4.74	4.92	4.96	4.97	4.89	4.95
CS1301	Spring ‘17	4.71	4.89	4.89	4.97	4.96	4.91	4.93
CS6460	Fall ‘16	4.28	4.68	4.85	4.91	4.93	4.85	4.89
CS6750	Fall ‘16	4.53	4.82	4.91	4.95	4.95	4.88	4.92
CS7637	Summer ‘16	4.10	4.46	4.78	4.90	4.92	4.79	4.85
CS6460	Spring ‘16	4.31	4.77	4.93	4.97	4.98	4.89	4.93
CS6460	Fall ‘15	4.36	4.79	4.87	4.95	4.97	4.86	4.93
CS7637	Summer ‘15	4.16	4.60	4.77	4.92	4.96	4.88	4.87

Additionally, the instructor was ranked by the survey software as among the best in school in all of the following categories: Considering everything, the instructor was an effective teacher; Considering everything, this was an effective course; Design project was a meaningful educational experience; Helpfulness of feedback on assignments; Instructor clearly communicated what it would take to succeed in this course; Instructor effectively answered students’ questions; Instructor’s ability to stimulate my interest in the subject matter; Instructor’s availability for consultation; Instructor’s clarity in discussing or presenting course material; Instructor’s level of enthusiasm about teaching the course; Instructor’s respect and concern for students; You learned a great deal in this course; You would like to take another course with this instructor.

More information can be found by seeing the reviews for David Joyner’s classes left at omscentral.com, an independent, student-run class review site for the online Master of Science in Computer Science program at Georgia Tech.

Evaluation #2: Selected Comments

Below are a handful of selected comments from these end-of-course surveys.

- (CS1301, Summer 2017) The best aspect was the responsiveness and overall enthusiasm from the course instructor. It was apparent right off the bat his priority was to make sure each student understood the course material fully. For example, when I did not understand a certain explanation for a coding problem, he explained it two other different ways over office hours. I was initially nervous about taking an online course, but the professor constantly checked the class's online forum throughout the day, so I always received a response (early in the morning or even later in the day). Another example: I was struggling on a coding problem, so right before the test he sent out an email really breaking down the problem, providing explanations for certain aspects, that really helped my understanding and others. He was really able to work at students' basic level of coding knowledge, was down to earth, and very helpful.
- (CS6460, Summer 2017) It is obvious that Dr. Joyner is extremely knowledgeable as well as enthusiastic and engaged. I don't think I've had a course that allows this level of interaction with a professor. I had numerous 1-on-1 conversation with Dr. Joyner and he was great to interact with, he was very helpful and patient with all my questions and concerns.
- (CS6460, Summer 2017) Dr. Joyner is an education machine. I have learned a tremendous amount from him. His communication is unparalleled in the program. He is responsive to questions and obviously cares deeply about students and education. Dr. Joyner inspires me to learn and explore my interests. He is just an unbelievable guy. Thank you Dr. Joyner for all that you do. It is much appreciated sir.
- (CS6750, Summer 2017) Everything he did was his strength. But more specifically I clearly understood his lectures and goals of the course. great, concise communication. At the same time he conveyed importance of and passion for the subject matter.
- (CS6750, Summer 2017) Since this professor is well versed in HCI, he is applying it to the class itself. The fact that he collects data about every aspect of his class shows he really cares and that gets reflected in the quality of the class. Instead of being like most professors who say things like "Yeah, for some reason that question seems to always be a hard one on this test, guess students aren't studying that topic much", David actually looks at the data and evaluates whether the question is the problem. And indeed, David's tests are some of the best I've taken. You obviously need to have internalized the concepts, but the test is not out to trick someone who does have the knowledge to answer the question.
- (CS6460, Spring 2017) Dr. Joyner's greatest strength is the time and effort that he puts in to every class that he instructs. I am very appreciative of his visibility and availability for students. His time and dedication is far above every other instructor that I had in all of OMS. He truly offers students in his courses a gift, not only in his excellent videos, but more so in his genuineness, care and concern for his students' success.
- (CS6460, Spring 2017) Dr. Joyner is the best instructor I have had in my 7 semesters here in the OMSCS (that doesn't mean that the other's haven't also been good). His passion for teaching is very evident in all his actions and the organization of the course. His greatest strength is the manner in which he treats his students.
- (CS6460, Spring 2017) Professor Joyner is my favorite professor in the program because he is extremely knowledgable, but his passion for teaching and developing better ways to teach is self-evident. His courses have transformed the way that I think about education especially online-education.

- (CS6460, Spring 2017) Dr. Joyner made himself completely available to the students. For an online class, I did not realize a teacher could be so available. In fact, Dr. Joyner was definitely more available via Piazza and Slack than any professor I have ever had before, both in undergrad and grad school.
- (CS1301, Spring 2017) Dr. Joyner was very helpful, quick to respond to messages, and always very understanding and accommodating. He made the material easily digestible and taught us it in applicable, interesting ways. I never thought I would be the type to be interested in CS but Dr. Joyner made it happen.
- (CS1301, Spring 2017) So compassionate for his students and always there to help, whatever you need. He was so in tune with students and made immediate responses to feedback, I think its so important to make changes to show your students that you are really taking in their feedback.
- (CS1301, Spring 2017) The instructor was always on top of things. If I had to picture him, I would see him at his computer 24/7 responding to students on Piazza, Slack, through email, etc. It was very impressive how quickly he would get back to us and it was incredibly helpful. I really appreciated that he made us a priority even outside of the "classroom".
- (CS6460, Fall 2015) Dr. Joyner's enthusiasm and passion for the subject was very inspiring. I, along with many students, took this class MERELY because Dr. Joyner was teaching it and showed enthusiasm for it at the end of Summer 2015 KBAI.
- (CS6460, Fall 2015) If all of OMSCS blew up in a catastrophic end-of-all-days firestorm, as long as David Joyner survived it would barely qualify as a loss.
- (CS7637, Summer 2015) Professor Joyner did an exemplary job with this course... not only is everything well organized, but he really goes out of his way. This is the first course I've had where the professor makes weekly announcements, provides suggestions/tips, and responds in a timely manner. He really wants his students to learn/succeed. I wish other professors were like him.

Evaluation #3: Learning Outcome Evaluation

As part of evaluating CS1301: Introduction to Computing, Dr. Joyner performed a rigorous evaluation of students' learning outcomes and experiences. The following text is excerpted from Dr. Joyner's submission to Learning @ Scale, currently under peer review, titled "CS1 at Scale: Building and Testing a MOOC-for-Credit".

To test the course, we conducted a pseudo-experiment comparing CS101-Online to CS101-Traditional. Both courses have been available for university students since Spring 2017. Table 1 shows the enrollment patterns in each version during this time.

	Spr. 17	Sum. 17	Fall 17	Spr. 18
Traditional	386	32	329	326
Online	59	27	138	216

TABLE 1. ENROLLMENT IN CS101-TRADITIONAL AND CS101-ONLINE SINCE SPRING 2017.

In all four semesters, students in both CS101-Traditional and CS101-Online have completed a pre-course survey, a pre-test, a post-course survey, and a post-test. For this analysis, we have excluded Summer '17 and Spring '18; in Summer '17, the Traditional class reported a much higher-than-average population of graduate students, limiting the usefulness of comparisons. This decision was made without first analyzing Summer '17 data. Full data on Spring '18 is not yet available at time of writing. It is also worth noting that the Spring '17 Online class was capped at 60 maximum enrollees; no other section of either version

since then has been strongly capped. Based on enrollment patterns alone, it is interesting to note that 100 more students are taking CS101 in Spring '18 than took it in Spring '17.

In Fall 2017, students in the online class were more likely to be older than 20 ($X^2 = 5.037$, $df = 1$, $p < 0.05$), to be 3rd year or later in school ($X^2 = 7.893$, $df = 1$, $p < 0.01$), and to identify as an underrepresented (non-White or Asian) minority ($X^2 = 4.137$, $df = 1$, $p < 0.05$). The distribution of majors differed significantly ($X^2 = 28.741$, $df = 5$, $p < 0.001$), with the Online section preferred by Business and Engineering majors while the Traditional section was preferred by Computing, Science, and Math majors. Online students were more likely to be working ($X^2 = 13.919$, $df = 1$, $p < 0.001$). Prior experience differed between the sections ($X^2 = 21.348$, $df = 5$, $p < 0.001$), but no difference exists in prior expertise, whether defined to include only prior completion of a computer science course ($X^2 = 0.035$, $df = 1$, $p = 0.8525$) or self-taught programmers as well ($X^2 = 0.622$, $df = 1$, $p = 0.4302$). These trends largely held for our initial analysis of Spring 2017 as well.

Performance Data

During the first and last weeks of the semester, students in both sections take the Secondary CS1 (SCS1) knowledge assessment [**Error! Reference source not found.**], a 27-item evaluation of CS1 knowledge. Students receive class credit for completing it, but their score on the assessment is not weighed into their average.

There are two arguments for the type of equivalency that must be present in CS101-Online to make it comparable to CS101-Traditional. Some argue that *outcomes* (post-test scores) must be comparable as the goal of the class is to guarantee a certain level of understanding. Others argue that *change* (post-test minus pre-test) should be comparable as if students enter the class with greater knowledge, they should leave the class with greater knowledge. We tend to adopt the first view, but our analysis covers both.

Table 4 gives the pre-test, post-test, and change (post-test minus pre-test) scores for students in both sections of both semesters. Based on feedback received after Spring 2017, we added a question to the end of the Fall 2017 pre-test and post-test asking students to report whether they put in their best effort on the test; we noted this would not affect their score, but it would influence our data analysis. For Fall 2017, we present results for all students as well as and results from those students who reported high effort.

	Spring 2017		**Fall 2017**	
	Tr.	On.	Tr.	On.
Pre-Test	6.78 (4.06)	7.36 (3.30)	7.22 (4.04)	7.47 (4.43)
	$t = 1.14$, $p = 0.26$		$t = 0.54$, $p = 0.59$	
			7.93 (4.62)	8.28 (4.76)
		High Effort	$t = 0.55$, $p = 0.58$	
Post-Test	9.73 (4.39)	10.78 (4.66)	10.50 (5.01)	11.29 (4.97)

	$t = 1.47$, $p = 0.14$		$t = 1.21$, $p = 0.23$	
		High Effort	12.29 (5.36)	14.84 (4.87)
			$t = 2.54$, $p = 0.01$	
Change	+2.91 (4.66)	+3.07 (4.77)	+4.22 (4.54)	+3.66 (5.03)
	$t = 0.21$, $p = 0.84$		$t = 0.81$, $p = 0.42$	
		High Effort	5.50 (4.81)	5.46 (4.19)
			$t = 0.04$, $p = 0.97$	

TABLE 4. AVERAGE PRE-TEST, POST-TEST, AND CHANGE SCORES IN BOTH SECTIONS AND SEMESTERS. STANDARD DEVIATIONS ARE GIVEN IN PARENTHESES; STATISTICAL TESTS OF EQUALITY ARE GIVEN BELOW VALUES. FOR CHANGE, ONLY STUDENTS THAT COMPLETED BOTH THE PRE-TEST AND POST-TEST ARE INCLUDED. SEE TABLE 2 FOR *N* VALUES.

Altogether, there is no evidence that students in the Online section are disadvantaged compared to the students in the Traditional section. Students in the Online section that reported high effort on the post-test scored better than similar students in the Traditional section on the Fall 2017 post-test with statistical significance. There is an apparent contradiction in this statistic: students reporting high effort across the sections start with equal scores and undergo equal changes, and so one group should not end with a higher score. This contradiction arises from the 28 students who reported high effort on the post-test, but not on the pre-test; their data is excluded from the Change value.

Performance Summary

Overall, we conclude that in contrast to prior studies comparing performance of online and traditional students [**Error! Reference source not found.**], there is no evidence for a difference in learning outcomes between the Traditional and Online section. This conclusion holds for both prior definitions of comparable performance: there is no evidence that students leave the Online class knowing less, nor that they learn less overall. There is some evidence for superior performance in the Online section, but more systematic and consistent evidence to that end would be necessary to conclude Online students achieve greater knowledge.

Attitudinal Data

For transitioning CS101-Online into a MOOC-for-Credit, the most important assertion to make is the equality of learning outcomes. However, merely equaling the same learning outcomes does not necessarily guarantee that the Online course ought to be offered; if, for example, students in the Online course come away with a significantly more negative impression of computer science, it would still be ill-suited to broadcasting to a larger audience for credit.

So, a secondary phase of this analysis focuses on the attitudes of students exiting the Traditional and Online classes. Many of these questions are evaluated using 7-point Likert scales; for these questions, we show the interpolated median and the results of a two-tailed Mann-Whitney *U* Test. is shown. Other questions are nominal; for these, we show the entire distribution is given, and a Chi-square test is used.

Overall Perceptions

We are first interested in overall perceptions of the courses. Toward this end, the post-course survey asks several questions regarding the classes' pace, rigor, quality, and relative value compared to other college

courses. These questions were asked on a 7-point Likert scale. On all questions, 1 represented a strongly negative value ("Way Too Fast", "Way Too Hard", "Not Nearly as Good", "Bad"), 7 a corresponding strongly positive value, and 4 a neutral value. Table 5 shows these comparisons.

In Spring 2017, students in both courses perceived their version as slightly too fast and slightly too hard. Students in the Online section, however, had a significantly more positive view on the course according to both questions. In Fall 2017, students in the Online version still perceived their version as higher-quality, but also perceived its pace and rigor as more appropriate. We hypothesize this is due to changes made between the semesters that allocated more calendar time to challenging topics and less to easier topics.

	Spring 2017		Fall 2017	
	Tr.	On.	Tr.	On.
Course Pace	4.30	4.20	4.23	4.07
	$Z = 0.66$, $p = 0.51$		$Z = 2.18$, $p = 0.03$	
Course Difficulty	4.63	4.54	4.62	4.11
	$Z = 0.23$, $p = 0.81$		$Z = 4.27$, $p < 0.01$	
Quality vs. Other Courses	4.93	5.96	5.37	6.07
	$Z = -4.61$, $p < 0.01$		$Z = -4.61$, $p < 0.01$	
Overall Quality	5.20	6.13	5.58	6.35
	$Z = -4.70$, $p < 0.01$		$Z = -5.09$, $p < 0.01$	

TABLE 5. STUDENT PERCEPTIONS OF THEIR COURSE'S PACE, DIFFICULTY, AND QUALITY BOTH ON ITS OWN AND AS COMPARED TO OTHER COURSES. FOR PACE AND RIGOR, 4 REPRESENTS "ABOUT RIGHT", WHILE HIGHER AND LOWER REPRESENT TOO FAST/HARD OR TOO SLOW/EASY. FOR QUALITY, HIGHER SCORES REPRESENT HIGHER PERCEPTION OF QUALITY.

Given the equal results on performance measures we reflect positively on students' perceptions of pace and rigor moving closer to the midpoint of the scale. Computer science is often regarded as a hard, unwelcoming topic, and we embrace students perceiving it as more manageable while keeping the learning outcomes comparable.

Specific Components

Second, we are interested in perceptions of the value of individual pieces of the different classes. We identified six components that are used in both versions: lectures, recitations, textbook, assignments, tests, and a forum. For each component, we asked students to agree or disagree on a 7-point Likert scale with the statement: "The [component] was valuable in helping me learn the material." Table 6 presents our results for each of these components.

	Spring 2017		Fall 2017	
	Tr.	On.	Tr.	On.
Lectures	5.34	6.34	5.73	6.60
	$Z = -4.50$, $p < 0.01$		$Z = -4.74$, $p < 0.01$	
Recitation	4.84	4.11	5.16	4.03
	$Z = 1.90$, $p = 0.06$		$Z = 4.62$, $p < 0.01$	
Textbook	4.95	4.22	4.43	4.10

	$Z = 1.07$, $p = 0.28$		$Z = 0.60$, $p = 0.55$	
Assignments	6.26	6.73	6.36	6.75
	$Z = -2.16$, $p < 0.05$		$Z = -2.90$, $p < 0.01$	
Tests	5.04	5.12	5.39	6.08
	$Z = -0.07$, $p = 0.94$		$Z = -3.88$, $p < 0.01$	
Forum	5.24	6.03	5.27	6.00
	$Z = -3.57$, $p < 0.01$		$Z = -2.49$, $p = 0.01$	

TABLE 6. STUDENT PERCEPTIONS OF THE VALUE OF EACH OF SIX COMPONENTS COMMON TO BOTH THE ONLINE AND TRADITIONAL VERSIONS. NUMBERS SHOWN ARE INTERPOLATED MEDIANS.

In Spring 2017, three statistically significant differences were observed: Online students valued the Lectures, Assignments, and Forums more highly than Traditional students. Although Traditional students valued the Recitation and Textbook more highly, in neither case was the difference statistically significant.

In Fall 2017, two more differences were observed (in addition to replicating the original three differences). Traditional students valued Recitations more, while Online students valued Tests more. This new observation regarding Recitation value likely comes from the increased sample size in Fall 2017; however, we hypothesize that the increased value attached to tests is due to improvements made to the Online course tests between the semesters.

It is not clear to what extent these differences are inherent between online and traditional classes and to what extent they are attributed to these specific implementations; however, we argue that these implementations aim to take advantage of opportunities in teaching online at scale. Although these differences may not be automatic when transitioning to online at scale, they are uniquely possible.

Attitudinal Summary

The attitudinal surveys give a positive picture of students' perceptions of the Online version: they rate it as higher quality overall, perceive its pace and rigor as slightly more appropriate, and have a greater appreciation of certain individual components. There is no evidence that they are uncertain about where to seek help, countering the idea that online students are isolated and that online learning should only be used by highly self-regulated learners. Interestingly, students in the Online version also report spending significantly less time per week on course material.

We attempted to evaluate attitudes and behaviors in other ways without success. First, we surveyed students regarding their likelihood to switch to CS as their major or add a CS minor. We saw a small increase in students planning to pursue CS minors and no change in intent to pursue CS majors. However, observed that likelihood to switch majors or add a minor is a product of many factors beyond appreciation of the subject, and so it would be inaccurate to attribute these changes to the course experience on its own.

We also evaluated Online student attendance of the help desk and recitations. Both were found to be dramatically lower than the Traditional class. 70% of Online students attended two or fewer recitations (45% attended none), while 89% of Traditional students attended 3 or more. 84% of Online students never visited the help desk, while 70% of Traditional students did at least once. These findings are notable because these components are among the only parts of CS101-Online that are not massively scalable. Their low usage suggests they are not partially responsible for the positive results associated with the Online class, and so removing them should not threaten the CS101-MOOC.

Description of Adoption Potential

The three innovations described herein touch a wide variety of elements of online course delivery. As such, the takeaways are far-reaching in their adoption potential. Dr. Joyner has already overseen the adoption of many principles he developed in other classes; as General Course Manager and now Associate Director of Student Experience in the program, his stated role is to support individual classes with improving the student experience in part by transferring lessons learned in his and other classes.

The following design guidelines cover the way these innovations may adapted, as well as the places in which this adaptation may apply.

Applications of CS6460: Educational Technology

- **Project-Based Learning Online.** CS6460: Educational Technology demonstrates that with proper staffing, there is no significant reason why project-based learning cannot function online. In many ways, the 24/7 classroom offered by Piazza is actually *more* conducive to the types of discussion and feedback that go into project-based learning as the opportunities for conversation are continuous rather than isolated to synchronous blocks. Peer review thrives in an online environment where students can have as much time as desired to investigate their classmates' work without being boxed by the requirements of a synchronous lecture. The ability to offer the class without significant synchronous time also supports students' individual investigations as part of the core class process. For all these reasons, a major place where the lessons of this innovation may be adopted is through the creation of future project-based online courses.
- **Mentorship.** A notable component of Georgia Tech's online programs is the different demographics: students tend to be older and more experienced. For this reason, the students present in the program have significantly different perspectives on student work. The mentorship model, where TAs function as mentors rather than simply graders and question-answerers, in the online program thrives in many ways specifically because it takes advantage of these components: it increases the amount of student-student interaction, as well as facilitates more organic student-student interaction. This model may work on-campus as well: there is no reason the functional role of on-campus TAs cannot be adapted to fit this mentorship model. In practice, however, it is likely these unique and varied perspectives in the online student body that makes mentorship here *so* effective.

Applications of CS6750: Human-Computer Interaction

- **Producing Maintainable Material.** The most significant guideline from CS6750 that may be adopted to other online classes is the notion of creating maintainable video material. This carries with it several components: videos must be authored to be as individually self-sufficient as possible, but there also ought to be sufficient context-switches and adjustments to the course look and feel that when adjustments are necessary, they fade into the "noise" rather than stand out as an obvious place where subsequent changes occurred. Through this process, online courses may preserve the benefits of pre-production (high-quality lecture material, resource reuse, freed up time to invest into in-semester activities rather than lectures) while recreating some of the benefits of live lecturing (frequent adjustments and revisions, insertion of live or recent examples, incorporating student feedback into course structure).
- **Establishing a Cadence.** Among the things lost in the transition to an online medium is the cadence that comes naturally with a weekly class meeting schedule. One innovation that has already be transferred to other courses in the OMSCS program is the idea of establishing this cadence in other ways. In Dr. Joyner's classes, this comes from weekly announcements with

reminders about what is coming up in the next week, as well as a weekly assignment routine to keep students actively invested. Both of these components are entirely content-agnostic: any online class may adapt these principles to its own delivery.

Applications of CS1301: Introduction to Computing

- **Rapidly Interleaved Assessment.** CS1301 is built fundamentally around a model of extremely rapid, frequently interleaved assessment. Students complete exercises after roughly every 3 minutes of video material, and these exercises are largely substantive, including live coding rather than just multiple choice-style questions asked by PRS devices. This is difficult to do in an on-campus, synchronous lecture where students inherently must watch the lecture at the same pace. Online, however, as they pursue their own paces, this rapid assessment offers a way to take advantage of the online medium. Any online course may adapt this method whereby authentic assessments are interleaved with the course material to offer students the chance to constantly evaluate their own understanding and adjust their pace accordingly rather than be forced to move on due to the demands of a synchronous lecture.
- **Immediate Feedback.** A component of this rapidly interleaved assessment is the presence of immediate feedback; every exercise in the CS1301 course is equipped with an autograder that tests student code with dynamically-generated test cases and provides live, immediate feedback. This feedback mechanism, however, is not inherent to online courses; offline courses have used immediate, automated feedback for years. What is notable about this model is the scope: CS1301 offers 300 problems all with these immediate autograders, giving students constant feedback on their progress rather than intermittent feedback at the point of major homework milestones. This structure could be easily adapted to use as the standard homework approach for a traditional class, and in fact, even these exact assignments could be offered to traditional students as-is.
- **Reinvestment of Time.** Although this spans across all courses, this is particularly relevant as it applies to the innovations of CS1301: Introduction to Computing. The most readily transferrable lesson here is that time saved through pre-production of lecture material, assignments, autograders, etc. ought to be reinvested into the actual student experience. Due to the time saved by these components, 100% of both instructor and TA time in CS1301 is invested into those components that cannot be preprepared: helping students live. Every student in CS1301 this semester is required to meet with TAs for a minimum of two hours to improve their understanding even further. Each week, Dr. Joyner individually reaches out to any student falling behind the course's regular schedule, and regularly answers questions via Piazza, chat, and email within minutes at any hour of the day. These have been noted as evidence that Dr. Joyner and the TAs are individually invested, but instead, this is a sign of an adaptable lesson from these courses: when material is pre-produced, there is significantly *more* time to invest into interaction with students during the semester. Rather than online education lowering the amount of student-instructor interaction, it may increase it by expanding the amount of time the instructor is available to individual students.

Georgia Tech College of Computing

Zvi Galil, *The John P. Imlay Jr. Dean of Computing*

To whom it may concern,

This letter is to nominate David Joyner for the Center for Teaching & Learning's Curriculum Innovation Award.

In January 2017, David launched an online version of CS1301, the Introduction to Computing class taken by computer science, industrial systems and engineering, business, and several other majors across campus. The course was offered to on-campus students for course credit.

Historically, most online options like this have been inferior to the traditional in-person course, but David's CS1301 offering has proven to be the best that online education can offer. The course is built around almost 500 videos averaging 2 minutes in length each, rapidly interleaved with over 1,000 live practice problems. Students have the flexibility to pace themselves as they move through the material, pausing and seeking help when they're confused rather than getting lost as the course moves on without them. The course design is a master class in how to create a course that takes advantages of the opportunities of teaching online.

One year later, the results of the course have been spectacular. A rigorous evaluation showed that students in the online course learned just as much as students in the traditional course. On top of that, they reported that the student experience in the online course was far better than traditional courses they had taken. They reported learning as much material as the traditional section, but in significantly less time per week with lower stress. And despite being an online course, many of them reported that they felt David was more attentive and invested in their success than any of their other instructors, sending weekly reminders to students who fell behind the recommended pace and typically answering questions on the course forum within minutes.

Perhaps most remarkably, the course was built to also function as a MOOC. To date, almost 70,000 students have enrolled in an identical public offering of the course on edX. This stands in contrast to years of failures in online education. Most prior experiments comparing MOOCs or other online offerings to in-person experiences found that the online alternatives were far worse, but David's CS1301 course has succeeded where many others have failed.

This is just the latest online curricular innovation David has released. In 2014, he co-created the OMSCS version CS7637: Knowledge-Based AI with Ashok Goel, and in 2015, they together completed the OMSCS programs' first rigorous evaluation of learning in the program, which was published in the International Journal of Scholarship of Teaching and Learning. In 2015, he created the OMSCS version of CS6460: Educational Technology, an experiment in teaching a heavily project-based class with almost no video material which has gone on to be one of

students' favorite courses in the program and generated numerous student-written peer-reviewed publications. In 2016, he created the OMSCS version of CS6750: Human-Computer Interaction, an experiment in filming a video-based class across many locations with an eye towards maintainability.

For the last four years, David has been at the forefront of innovative online curriculum development, with his successful experiment with an online version of CS1301 in 2017 standing out as among the most impactful educational technology initiatives in recent college history.

Sincerely,

Zvi Galil

Ashok K. Goel
Professor, School of Interactive Computing
Director, Human-Centered Computing
Georgia Institute of Technology
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Email:ashok.goel@cc.gatech.edu
URL: http://home.cc.gatech.edu/dil/3

January 29, 2017

Director, Center for Teaching and Learning
Georgia Institute of Technology

Dear Director Weinsheimer,

I am truly pleased to write this letter of recommendation in support of Dr. David Joyner's nomination for the Curriculum Innovation Award. David obtained his 2015 Georgia Tech Ph.D. in Human-Centered Computing under my supervision. Even before he graduated, he and I co-developed the popular OMSCS 7637 online course on Knowledge-Based Artificial Intelligence. Thus, I know David and his work very well. To put it simply, David is exceptional!

Let me briefly share a little about David's Ph.D. work before I turn to his more recent achievements in online education. His dissertation focused on learning science and technology, and was titled "Metacognitive Tutoring for Inquiry-Driven Modeling". It won the 2015 College of Computing Outstanding Ph.D. Dissertation Award, and represented Georgia Tech in the competition for the 2016 ACM Distinguished Dissertation Award. David's Ph.D. work has directly led us to collaboration with Smithsonian Institution and an NSF BigData grant worth more than a million dollars (>$1M). Several students in my laboratory continue to build on David's work: his Ph.D. dissertation has made a difference.

Since graduating from our doctoral program, David has focused mostly on online education. Here is only a partial list of his many recent accomplishments:

- Created three online courses (two graduate, one undergraduate) as an instructor; supported creation of six more as the primary course developer.
- Authored an interactive book on introductory programming published by McGraw-Hill, a leading global publisher.

- Supervised systematic improvements to low-performing online classes, from improving teaching assistant teams to redeveloping core material.
- Supervised integration of multiple third-party vendors with online programs, including edX, Udacity, McGraw-Hill, Vocareum, Verificient, and Peer Feedback.
- Developed a workflow for identifying strong candidates for teaching assistant positions to streamline TA hiring in a large online program.
- Assembled training materials to on-board those teaching assistants as well as new instructors on best practice and practical skills.
- Performed ground-breaking research on motivational factors of online teaching assistants, work that has been praised in the learning at scale community.
- Performed and published a systematic comparison of online and residential sections of an undergraduate class.
- Consistently achieved extremely high CIOS ratings. (4.92 / 5.00 all-time average for instructor effectiveness)
- Received several awards including the CoC Outstanding Instructor award, Lockheed Excellence in Teaching award, and the Dissertation Award I noted earlier.

These accomplishments speak for themselves. However, let me try to put them in context. In my opinion, David is one of the foremost scholars of online education at Georgia Tech and perhaps in the country. However, he is more than just an education researcher: he is also Georgia Tech's foremost practitioner of online education. It is this combination of practice and research that makes David so special, precious, and almost unique.

In summary, I enthusiastically support David's nomination for the Curriculum Innovation Award. He is exceptional. We are - I am - very proud of him and his many accomplishments. Thank you.

Yours sincerely,

Ashok K. Goel

Ashok Goel is a Professor of Computer Science in the School of Interactive Computing at Georgia Institute of Technology in Atlanta, USA. He is the Director of the School's Ph.D. Program in Human-Centered Computing and the Design & Intelligence Laboratory. He is also a Co-Director of the Institute's Center for Biologically Inspired Design, a Fellow of the Brooke Byers Institute for Sustainable Systems, and the President of the Board of Directors of The Biomimicry Institute. For thirty years, Ashok has been conducting research into artificial intelligence, cognitive science and human-centered computing, with a focus on computational design, modeling and creativity. He is the Editor-in-Chief of AAAI's AI Magazine, and an Associate Editor of IEEE's Intelligent Systems, Cognitive Systems' Advances in Cognitive Systems Journal, and Design Research Society's Design Science Journal. He is also the primary architect of Jill Watson, a virtual teaching assistant for answering questions in online education (https://www.youtube.com/watch?v=WbCguICyfTA).

Pamela K Buffington
Georgia Institute of Technology
pam@gatech.edu
Jan 30, 2018

Dear Evaluator:

I am writing to strongly recommend David Joyner for the Curriculum Innovation Award at Georgia Tech. As the Associate Director of Academic Technology for OIT and the Director of Faculty and External Engagement for C21U it has been my distinct pleasure to work closely with David over the past few years. During this time we worked together to create CS1301, GT's first undergraduate computing course that is wholly online, as well as multiple courses in the Online Masters of Science in Computer Science (OMSCS). David has an unrivaled passion in delivering superb quality and innovative CS courses to all students and has always gone above and beyond in everything he does. He is driven to provide a highly interactive experience for students of all levels in multiple technologies and methods to best meet the students' needs continually ensuring that all their questions and concerns are answered promptly.

While developing CS1301 David worked incredibly hard ensuring that the course design would meet the needs of students at a variety of levels. He personally developed more than 400 videos to present the course content in manageable chunks. In addition to this, he worked with McGraw Hill Education to create an online interactive textbook. He researched vendors to enable students access to an online programming environment without needing to install anything on a local computer which also enables immediate feedback for the students to effectively learn from their mistakes in real time. Finally, he integrated this programming environment with his online proctored exam process.

David Joyner is an amazing innovator who takes time to research and understand the field, listen and understand any improvements his students offer and using research techniques to ensure that his innovation is effective and supported by quality data that is then reviewed by peers.

I can not imagine a more qualified and passionate candidate for this award. David is a delight to work with and is a prime example of innovation at Georgia Tech.

If you would like additional information about David, you can telephone me at (678) 992-9205

Sincerely,

Pamela K Buffington

Associate Director of Academic Technology :: Office of Information Technology
Director Faculty & External Engagement :: Center for 21st Century Universities

Angela Smiley
11311 NE 128th St.
Kirkland, WA
98034
D202

To whom it may concern,

I've learned from Dr. Joyner in various capacities (sometimes student, sometimes TA) for about three years. You wouldn't think that's a long time, but yet I feel I know him very well. That's because - like many students in the OMSCS - after having him as head TA in CS7637, I decided to follow him around and take any other classes he offered.

In creating my program, Georgia Tech took on a great risk in hopes of a great reward. The risk is that any lapse in instructional quality will stain Georgia Tech's reputation as a top 10 CS school; the reward will come when the innovations pioneered in the laboratory of OMSCS can be distilled for use on the main campus and in the world at large. In the last year, no single instructor has contributed more to its instructional quality - and to gleaning best practices - than has Dr. David Joyner.

He began by taking over as the instructor for CS7637 during the Summer 2015 term, when the usual instructor was unavailable. That offering of CS7637 set an enrollment record for the program, so simply volunteering to teach it was a great service. Dr. Joyner went beyond that, though, by successfully addressing some challenges which had resisted solution in previous semesters. (E.g., motivating greater use of visual methods and rewarding experimentation in the early projects.) Several students remarked that despite the 300+ enrollment it had the feel of an intimate seminar due to Dr. Joyner's omnipresence in class discussions.

Genuine excellence as an instructor requires not just the highly visible work of teaching in class but also the almost-invisible work of mentoring individuals and working behind the scenes to strengthen the institution. Dr. Joyner has embraced all these tasks, not just the glorious ones. He has consistently found time to offer guidance to his students outside the formal bounds of the classroom, particularly to those researching more effective ways of guiding a class and fighting plagiarism (two areas that feed back into the quality of education for all). He was also the leader in selecting and mentoring TAs from the OMSCS program itself. This helps to further the financial stability of the program and to free up on-campus TAs for on-campus classes, but more importantly, expanding the pool of TA candidates raises the bar for their performance and directly improves the student experience in *all* classes, not just his own.

In addition to his great work in KBAI, Dr. Joyner pioneered the OMSCS offering of CS 6460: Educational Technology. This was no mean feat: the on-campus counterpart revolves around in-classroom discussion, and relies heavily on individualized attention and feedback. In short, it

offers the kind of experience that few professors could replicate (or would even think to replicate) in another setting.

Dr. Joyner's reimagining of the course is one of the most popular offerings in the program, and it's already an indispensable part of the degree for students who have an interest in learning to do research. I know that I, personally, could never have been admitted to a Ph.D program or joined a lab without the experience I gained here. And other students agree; I think this comment from a course review sums it up well:

"The instructor is Dr. David Joyner, of KBAI fame, and he is extremely active on Piazza, keeping the class lively and engaged, which is no mean feat since we are all doing different projects. The final coursework is not done, so I can't comment here how it will all end, but so far it is a joy to be part of this particular environment. It is different from other courses."
(https://omscentral.com/reviews/6460)

Dr. Joyner didn't stop with EdTech; he created another acclaimed "OMSCS edition" - of CS6750, our Human-Computer Interaction class here at Tech. Some quotes from the rave student reviews on https://omscentral.com/reviews/6750:

"The lecture materials were excellent. Communication with the professor is great. The assignments were thought provoking and interesting. One of the best courses in the program."
"The Piazza for this course was the most active and interesting of the courses I've taken."
"Favorite OMSCS class so far."
"I think everyone that designs computerized products should take this course."

Pause for a moment and look at that last comment. Over and over again I've heard OMSCS students across specializations echo that sentiment - that everyone who's involved in design (or wants to be) should take Dr. Joyner's course.

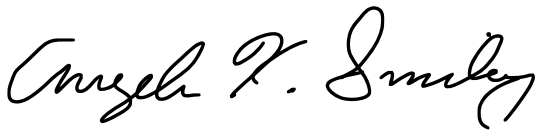
Why such a strong endorsement for a class that isn't (officially) required? HCI shows the same care, engagement and attention to detail as EdTech, but it's otherwise very different: rather than building a support system for research, HCI is laser-focused on giving students a toolbox they can take with them into their career - and use whenever there's an opportunity to evaluate and improve designs. For anyone who works in software, these opportunities are key; they often make the difference between life and death for a product. Of the many courses I took during OMSCS, it was the most immediately applicable to my work in software, and with each passing year I'm more glad to have taken it.

Most recently Dr. Joyner has pioneered yet another sort of online course: Georgia Tech's Introduction to Computing Using Python on EdX (1301x). This MOOC began its life targeted to Georgia Tech undergraduates, but it was quickly discovered by other students in other programs. Online Master's in Analytics students, in particular, have come to rely on it as a crash course in programming for those who don't have a CS background… and over and over again, I've heard them cite it as their exemplar of "online teaching done right." They comment

on the interactive textbook and other technological innovation, but most of all, they point to Dr. Joyner's unrivaled teaching and course design skills.

More than anything else, CS1301x showcases Dr. Joyner's rare combination of technological aptitude, pedagogical brilliance, and dedication to continued improvement for even the most successful courses. Lacking one of those qualities, one might not know about the latest research in cognitive tutors; or one might add them to the course, but without a clear argument for how they will affect it. Dr. Joyner is the rare instructor who includes new technology, insists that it materially improve the student experience, *and* has the wherewithal to make it so. These three qualities combined in one person make him a rare gem.

Sincerely,



Angela Smiley

To whom it may concern:

I wish to nominate Dr. David Joyner for the Curriculum Innovation award.

I am a former student of Dr. David Joyner's edX CS1301x Intro to Computing with Python. Through the MOOC, Dr. Joyner has made unparalleled contributions to Georgia Tech's undergraduate computer science community. With the growing popularity of learning computer science comes issues with overcrowding in traditional classroom settings, and Dr. Joyner's course is the most viable solution to this problem.

Aside from sustainability, it is also an innovative solution that seeks to challenge how computer science concepts are currently taught and delivered to students. More specifically, Dr. Joyner's course is innovative in that it addresses and practically applies many educational technology research methodologies such as instructional scaffolding and transfer. As a student, it was immediately obvious how much thought Dr. Joyner put into building the course to increase students' engagement and understanding of Python.

As I am almost halfway through college, Dr. Joyner's CS1301x course remains as the coolest course I have taken at Georgia Tech. In view of his distinguished career and dedication to bettering education on an infrastructural level, it is only the most appropriate to award the Curriculum Innovation award to Dr. David Joyner.

Sincerely,

Nina Qin

Georgia Tech Class of 2020

Industrial Engineering

December 4, 2017

To whom it may concern,

I am delighted to recommend Dr. David Joyner for the Center for Teaching & Learning Curriculum Innovation award. I have had the opportunity to work with Dr. Joyner both as a student in three of his courses, as well as in his role handling the teaching assistants for the Online Master of Science in Computer Science (OMSCS) program at the Georgia Institute of Technology.

I took three courses from him:

- CS6460 Educational Technology (Spring 2016)
- CS7637 Knowledge Based Artificial Intelligence (Summer 2016)
- CS6750 Human Computer Interface (Fall 2016)

My experience working with Dr. Joyner has been exemplary. In addition to being an extremely intelligent instructor, he is also remarkably talented at communicating and working with students. His courses, without a doubt, are the best executed courses that I had the privilege of taking in the OMS program – which is high praise indeed given the very good instruction provided by the program.

One thing that stands out for me with his classes is that while taking them there is a sense that nothing is overwhelming – the flow of his courses is brisk but uniform, his expectations are clearly laid out, his feedback clear and lucid. When issues arose during the execution of the classes, he quickly adapted to the changing circumstances in a way that demonstrated strong professionalism, flexibility, and a dedication to providing the best instruction possible. When the courses were done and I looked back at what I had learned, I was astounded at the sheer amount of information that I not only learned but retained. I have certainly had classes in which just as much material was presented, but in a less well-structured fashion, which I found leads to poorer retention. Thus, I found his courses to be highly valuable. I have recommended, and continue to recommend his courses to students in the OMS program.

Working with him in my capacity as a teaching assistant, I have found him to be easy to work with, highly approachable, diligent, and ultimately concerned about the well-being of the program TAs as well as the students in the program.

One final observation on the value of him as an instructor: the Educational Technology class helped me realize the sheer joy that I found in doing research, in explaining concepts and materials from my own field to others, and ultimately encouraged me to continue on to pursue my PhD, which I am now doing at the University of British Columbia. His Human Computer Interface class inspired, albeit indirectly, my research direction in semantic file systems. No other instructor in the program did more to encouraging me to pursue further education than Dr. Joyner.

Thus, without reservations, I am happy to recommend him and his work to you as worthy of receiving your recognition for the amazing contributions he has made to Georgia Tech and to the entire USG system.

Regards,

William Anthony Mason

To Whom it may concern:

It has been an honor to have prized guidance from Dr. Joyner, without which graduating from as rigorous curriculum as OMSCS from Georgia Tech would have been very difficult. I am not the only one who was personally touched and encouraged to achieve academic excellence by Dr. Joyner nor I believe will be the last one. He has a unique way of discovering best in a student through innovative and methodological structure followed by imparting innovative learning experiences including meaningful and rewarding student's engagement.

The inventive learning experiences provided by Dr. Joyner to name few but not limited to are: "peer feedback"; "exemplary paper"; "reflection paper development"; "qualitative contributions and engagement with fellow students"; "personalized & interactive welcoming students in online environment"; one-on-one mentor-mentee relationship; developing research interest in students; giving full degree of freedom for development of open-ended advance technology ideation and its realization through methodological and incremental framework; leading, mentoring and guiding army of TAs to impart best academic practice to huge student base of OMSCS while maintaining grading consistency; taking advantage of cutting-edge technologies to develop curriculum, assert ingenuity of each & every students, enforcement of student integrity; interfacing with external world of academics such as journals, seminar and others to further student's development; and many others.

I had taken 3 classes under him starting with "Knowledge-Based Artificial Intelligence" in summer 2015, which was a turning point in my career, academic, and life. The novelty of this class was to impart best learning experience of a very difficult and subjective class of giving the landscape of advanced technology like AI and by asserting student's understating of the science behind the subject beyond imparted in the classroom. Second one was Educational Technology, where I was encouraged and closely mentored to developed "Electronic Learning record". This research paper defined the framework for developing standards with which an individual learner of all categories including life-long can express his/her formal, informal and non-formal learning in a standardized and credible manner to a wide variety of stakeholders for personal, economic, education and training development. This paper was selected for further development as part of my 3rd class directly under the guidance of Dr. Joyner. This is where I was exposed to his deep subject matter expertise in research and paper development, which not only shaped the direction of paper but also shaped my thinking process in general for time to come.

The student community of Georgia Tech is very proud to have Professor Joyner as their guide, mentor, and philosopher. With growing popularity & demand of OMSCS along with complexity & challenge of keeping up with advanced technology, we always look forward to supporting his noble cause at every opportunity.

Best regards,

Susanta K Routray

908-433-5622

Senior Software Developer, AT&T Lab