CTL Innovation in Co-Curricular Education Award Nomination

CS1331 and CS1332 Online and MOOC Courses

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Background

Georgia Tech’s Online Master of Science in Computer Science (OMSCS) degree program was launched in 2014. The MOOC-supported degree program propelled Georgia Tech to the forefront of education in the media because of the cost, format, and success. More than 12,000 students are enrolled in the program with over 5,000 students graduating thus far. In 2018, (Former) Dean Galil wanted to expand his vision of OMSCS into undergraduate 1000-level computer science courses, and he asked Fisayo Omojokun and Mary Hudachek-Buswell to develop a 2-course sequence together. The courses were to have a similar feel, look, programming language, basic format to create a flow of understanding in introductory computer science topics. These two online courses, CS1331 – Introduction to Object–Oriented Programming and CS1332 – Data Structures & Algorithms, were available to Georgia Tech, Atlanta Campus, students in Fall 2019. Once the two online courses were complete, Dean Isbell wanted both courses to be developed for the edX MOOC platform as GTx courses. The courses were retooled for the different platform as well as content, assessments and programming assignments. These two GTx courses were available at the start of 2021.

Fit with Georgia Tech’s Mission and Strategic Plan 2020-2030

Georgia Tech’s mission states that the institute is “committed to developing leaders who advance technology and improve the human condition.” Georgia Tech has 6 focus areas in the 2020 – 2030 strategic plan. Three of these areas are: Amplify Impact, Connect Globally, and Expand Access. The CS1331 – Introduction to Object–Oriented Programming and CS1332 – Data Structures & Algorithms pair of online courses (CS1331/CS1332) embodies the mission and 3 of the focus areas.

1) Amplify Impact as agents of change to generate talent, ideas, and solutions with unmatched impact and scale to help define and address the most critical problems of our time, locally and globally. CS1331/CS1332 online courses allowed us to scale offering computer science education to Georgia Tech students across all majors. The MOOC CS1331/CS1332 courses were designed to scale so that they reach students across the globe.

2) Connect Globally where we build a global learning network to expand our reach and amplify our impact. MOOC CS1331/CS1332 courses have already spread computer science education to six continents. These courses were designed to reach the masses throughout the world.

3) Expand Access to empower people of all backgrounds and stages of life to learn and contribute to technological and human progress. Computer science is the heartbeat of technology and the CS1331/CS1332 online courses at Georgia Tech have opened up availability to students from all majors, not just computer science students. The CS1331/CS1332 MOOC course offerings, via GTx, are free and give students from all over the world the opportunity to be educated in a top 5 ranked computer science program.
Intended Audience

Online CS1331/CS1332 is available to all first-year and above undergraduate Georgia Tech on campus students in any major. Many students in other majors are taking the courses for a minor in computer science or it is required in their major. MOOC CS1331/CS1332 is available to anyone with access to edX across the globe.

Objectives

CS1331 – Introduction to Object–Oriented Programming provides the introduction to techniques and practices for implementing algorithms in the Java programming language. Emphasis on professional software practices. Below are the learning objectives for the course:

- Students should be able to write Java source code given an algorithm or design document as the basis of the implementation. Students should be able to write, test and debug moderate size (many hundreds of lines of code) java programs. They should learn how to use the java API and the associated set of libraries.
- Understand, use, and analyze fundamental programming concepts with a specific focus on how these concepts (variables, conditionals, iteration, recursion, functions, modularity, and input/output) are manifested in java.
- Students will gain an understanding of data structures (arrays, linked lists, trees, hash tables, heaps and graphs) and algorithms (sorting and graph traversal).
- Students will learn the basic concepts of event-driven, graphical user interface programming.
- Apply knowledge of fundamental interface objects (panels, buttons, dialog boxes, and menus)
- Students will learn simple 2-D graphics operations (drawing lines, circles, rectangles)
- Students will learn fundamental concepts of object-oriented programming (classes, objects, data abstraction, inheritance, polymorphism, and dynamic binding).
- Students should be able to start from a written problem statement, determine the nature of the data provided and the results expected, and produce a program that satisfies this specification. The resulting program should be modular, using good abstraction and with limited coupling between program elements.

CS1332 – Data Structures & Algorithms provides an overview of basic data structures and algorithms on those structures. Searching, Sorting, linear, non-linear and randomized structures are covered. Students are expected to understand these structures and algorithms, to implement them in the Java programming language – but not to prove properties about them. Below are the learning objectives for the course:

- Apply knowledge of basic complexity (Big – O) to calculate the runtime or space requirements of an algorithm/data structure given the actual source code or pseudo-code.
Differentiate between the common linear data structures (list, array, set, bag, stack and queue). Student will select and implement the correct structure to use for any given situation.

Differentiate between the common non-linear data structures (disjoint set, hash tables, sparse array, priority queues, trees and graphs). Student will select and implement the correct structure to use for any given situation.

Discuss the fundamental ideas behind randomized data structures (such as skip lists).

Outline the steps for basic algorithms used with data structures such as: hash functions, tree traversals, binary search trees, graph searches, shortest path, tree balancing, union-find, MST and connected components.

Outline the steps for basic text search algorithms and select the best algorithm given a particular situation. These algorithms can include Boyer-Moore and KMP.

Demonstrate improved Java programming skills including ability to use generics, threading and networking classes in the Java API.

Differentiate between various sorting algorithms in terms of their time and space requirements and whether they are on-line or not. Outline the basic steps for common algorithms such as quicksort, mergesort, insertion, selection and radix sorts.

Distinguish between the standard types of algorithms (greedy, backtrack, branch and bound, dynamic programming, randomized).

Great code has its foundation built upon Object–Oriented Programming, Data Structures, and Algorithms. One must have a deep understanding of how objects work, data structures operate and the efficiency of algorithms. Implementing algorithmic techniques that build solid classes & objects, and efficiently manipulate data structures is the essence of both courses. Students will understand data abstraction, inheritance, polymorphism, and dynamic binding. Students will be able to differentiate between linear, nonlinear, hierarchical and probabilistic data structures. An important aspect of the CS1332 course is that students will learn to analyze the performance of data structures and their operations.

**Pedagogical Approach**

When tasked with developing the CS1331/CS1332 online courses, we approached the videos and slides from the viewpoint of what did the students need to see, if the lectures were not live. All content came from our notes and examples. The courses’ design uses a diverse content experience with captioned videos, designed textual content readings, knowledge–check quizzes, diagramming in exploratory labs, programming the elementary objects and data structures in assignments, and in-depth exams. The content was grouped into modules where the students were lead through the learning process. The courses present the content in a modality that best fits the type of material being taught.

All content from the GT online courses was reconfigured for the CS1331/CS1332 MOOC edX platform. This included developing a self-contained programming environment that was independent of software or IDE installed on a machine and could be run through the web page. Additionally, all quiz/content questions were reworked to fit edX’s delivery method. We also worked on making the textual content more visually appealing.
The CS1331/CS1332 courses use various strategies to engage the learner.

1) The content is broken up into small page presentations to make digital reading easier.
2) The video content is closed captioned to assist the learner with understanding the audio content.
3) Video length is kept short to keep the learner’s attention and facilitate continual reflection.
4) After a small fragment of content is presented, it is followed by knowledge check questions to help the learner gauge their level of understanding.
5) Active programming assignments are presented to the learner after a concept has been fully explained.
6) All the different types of learning components are alternated throughout the modules to help keep the student engaged. For example, videos, readings, questions, laboratory, programming are all alternated within the modules.

**Impact**

The impact of the CS1331/CS1332 online courses for GT students is seen in the scalability that the online course holds. Prior to the online course, CS1331/CS1332 on campus courses did not meet the demand because we were limited by faculty and space. Furthermore, the College of Computing had limited accommodations for non-CS students who (a) wished to minor in the field or (b) had the course as part of their majors’ curriculum. With the online courses, we now have the flexibility to address these limitations with the primary cost being the need to hire more TAs for recitations and grading. Before the launch of the online courses, enrollment in the courses was capped at 1200 annually in each course. Since the launch, we are accommodating 1800 in each course annually. Essentially, we increased enrollment in the courses by 50%.

The impact of the CS1331/CS1332 MOOC courses for students worldwide has completely taken us by surprise. In 2021, over 25000 students in 154 different countries have taken the courses; refer to Table 1 for a listing of some of the countries. We also have a geographic distribution, Figure 1, which really tells the story of where our MOOC students are located. We have found some other interesting information regarding the students who take these MOOC courses. The median age of our MOOC students is 28, with approximately 40% of the CS1331 students are under the age of 25. However, in the CS1332 course, approximately 37% are under the age of 25. In looking at the education demographic, 44% of students in CS1331 hold a bachelor’s degree. Whereas, 51% of students in CS1332 hold a bachelor’s degree.

| Table 1. Country Locations with 10 or more CS1331/CS1332 MOOC Students |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| India           | South Korea     | Indonesia       | Poland          | Uzbekistan      |
| United States of America | Mexico  | Saudi Arabia    | Spain           | Lebanon         |
| Canada          | Nigeria         | South Africa    | Spain           | Albania         |
| Pakistan        | Morocco         | Algeria         | Ethiopia        | Greece          |
| Egypt           | Kenya           | Ghana           | Israel          | Peru            |
| United Kingdom  | Taiwan          | United Arab     | Palestine, State| Azerbaijan      |
| Vietnam         | Hong Kong       | Emirates        | of Sweden       | Chile           |
|                 | Japan           | Colombia        | Tunisia         | Iraq            |
Singapore
Turkey
Germany
Bangladesh
Brazil
China
Nepal
France
Australia
Philippines
Russia
Netherlands
Malaysia
Thailand
Sri Lanka
Italy
Romania
Argentina
Jordan
Switzerland
Finland
Ireland
Ukraine
Bulgaria
Dominican
Republic
Kazakhstan
Portugal
Serbia

Figure 1. Visual geographic distribution of MOOC students where the darker the country, the more students are enrolled.

Evaluation

The CS1331/CS1332 MOOC courses were launched in January, 2021. In November 2021, both courses received Class Central’s “Top 100 Most Popular Free Online Courses of 2021.” Details here: https://www.classcentral.com/report/most-popular-courses-2022/ One student review of the course on Class Central stated, “This is an excellent course that reinforces the concepts with a variety of activities after each lecture. Some online courses just give you the concepts and have a brief activity after each lecture, but this course has a solid set of activities (coding, comprehension questions, analysis labs) that really help to grasp and remember the subjects taught. Besides, the video and written lectures are excellent, detailed and clear with lots of examples.” We will continue to monitor the enrollments in these MOOC courses, evaluate the courses annually.

The CS1331/CS1332 online courses offered for Georgia Tech students have several measures in place in order to evaluate the effectiveness of the course. We examined the grade distributions from the online course with its in-person campus course. Over the last 7 semesters in the CS1332 course, the grade distribution averages were within 2 percentage points of each other. We also use C'IOS scores to evaluate, and in some cases the online course rated effectiveness 2/10ths of a point higher than the campus course. We also conduct pre and post surveys of the students to learn what was helpful and what was not.
Colleagues:

I am extremely pleased to write a letter in support of Drs. Mary Hudachek-Buswell and Fisayo Omojokun for the Innovation in Co-curricular Education Award at Georgia Tech. Both Mary and Fisayo are lecturers in the Division of Computing Instruction in the College of Computing (in fact, Fisayo is the Chair of DCI), and have long been dedicated champions of not only computing education, but computing education at scale and focused on reach and access. Their work in developing online infrastructure for introductory CS courses is a natural progression of their long-standing commitment, and has proven to be innovative, important, and impactful.

It is helpful to understand that both CS1331 and CS1332 cover fundamental and crucial concepts in computing. They act not only as the building blocks for later work—theoretical and practical—for majors, but act as the basic gateway to computational thinking for anyone who needs to grok the model-languages-machine equivalent at the base of formulating and understanding problems that can be expressed computationally. By developing not just the material but the support infrastructure for these courses and making it all available online, they have empowered as many students across as many disciplines in just the last year and half as most educators can dream to do in an entire career.

I am not exaggerating here: through their MOOCs, Mary and Fisayo have taught at least 40,000 students in eighteen months. These are students they have touched beyond even the (quite literally thousands of GT students they teach on campus each term. Further, even as we make these courses available to universities across the state, their work has become a cornerstone in Georgia Tech’s efforts to support post-baccalaureates trying to shift careers into computing as a part of our bridge programs into MSes. In fact, their material is being integrated into the Constellations Center for Equity in Computing’s programs for providing support to high school students who might not otherwise be exposed to computing.

Again, these are more than just the courses themselves. Mary and Fisayo have built an infrastructure that supports these courses and makes them truly accessible to a wide variety of potential students.

I could not be more supportive of Mary and Fisayo’s work and their suitability for this award. Please do not hesitate to reach out to me if you need to.
Sincerely,

Charles Isbell
John P. Imlay Jr. Dean, College of Computing
Georgia Institute of Technology
February 11, 2022

To the Georgia Tech institute awards committee,

It is my pleasure to express my enthusiastic support for the nomination of Mary Hudachek-Buswell and Olufisayo Omojokun for the Innovation in Co-curricular Education Award for their work on online versions of CS1331: Introduction to Object-Oriented Programming and CS1332: Data Structures & Algorithms.

Of course, CS1331: Introduction to Object-Oriented Programming and CS1332: Data Structures & Algorithms are for-credit classes taken by on-campus CS majors and minors—but the Innovation in Co-curricular Education Award is about learning “outside the traditional curriculum”, so why are these classes good candidates for that award? There is some significant relevance there: they help us scale up the number of computer science majors we can handle, they help us extend computer science education to more minors, and they help us innovate with how to teach computer science itself. But these are all somewhat tangential to this specific award.

The stronger relevance to the Innovation in Co-curricular Education Award, however, comes in the way that this content has been used to expand access to Georgia Tech computer science education to the rest of the world. The courses have launched as MOOCs offered via the edX platform, through which anyone in the world can register and engage with the same content used to teach the course for-credit. The two courses—divided into seven mini-courses to match the engagement patterns of MOOC learners—have garnered over 40,000 enrollments in only eighteen months. 3,000 of these enrollments have been paid, which opens the opportunity for the student to complete the course for a certificate. To date, these mini-courses have been completed over 1,700 times.

Among other uses, these MOOCs are our recommended content for prospective online MSCS students who need to brush up on their computer science skills before entering the program. This has been enormously powerful: our online MSCS program is large and well-respected, but historically students have been on their own if they did not yet meet admissions requirements. Through the courses developed by Drs. Hudachek-Buswell and Omojokun, we have been able to offer a devoted pathway into the OMSCS program, which is especially important for historically underrepresented audiences that did not have access to CS education during their prior undergraduate work. Similarly, work is now underway to open up Dual Enrollment sections of CS1331 and CS1332, allowing high school students from around the state to get access to world-class computing education.
What is crucially important here is that the content Drs. Hudachek-Buswell and Omojokun have developed is used for our for-credit classes. We put our name, our reputation, our credit, and the future of our students on the line when we endorse these courses as equal alternatives to the on-campus version. It is because we have so much confidence in these classes that they are then able to have the impact they have out in the rest of the world. We accept them as a way to fulfill the admission criteria for OMSCS because we know they are the equivalent of what we deliver to our students on campus. They draw attention on these global platforms because they are parallel to our for-credit offerings.

But this relationship goes both ways as well: just as our endorsement of this online content for our for-credit classes helps lend credibility to our MOOC classes, so also our willingness to open up our curriculum to the world enhances our for-credit offerings. We are transparent in what students will receive if they come to Georgia Tech. This is a risk: typically students do not get such a first-hand preview of the learning experience before committing to a university. The fact that Drs. Hudachek-Buswell and Omojokun have opened up access to their authentic teaching content to the world is a sign of our confidence in our curriculum.

This is the mutually symbiotic relationship between our MOOC offerings and our for-credit offerings that Drs. Hudachek-Buswell and Omojokun have helped create. They developed online courses—before COVID-19 made that mandatory—that we offered for identical course credit. Because they were offered for course credit, they receive clout and attention globally, setting them apart from the hundreds of other online CS classes that have no strong assertion of the content’s quality. Because they’re made available publicly, the world can see the quality of a Georgia Tech education, expanding the pool of students who may be interested in attending Georgia Tech.

The work of Drs. Hudachek-Buswell and Omojokun has been revolutionary in expanding global access to a Georgia Tech education, both in making the content available and in expanding the number of students who would consider joining Georgia Tech in the first place. They embody the spirit of the Innovation in Co-curricular Education Award.

Sincerely,

David Joyner, PhD
Executive Director of Online Education & OMSCS
College of Computing, Georgia Institute of Technology
Dear Award Committee,

I'm a 3rd-year student who took Dr. Hudachek-Buswell's CS1332 online course, Data Structures & Algorithms, during my 1st semester at Georgia Tech. As a 3rd-year transfer student and having not taken a computer science class in a long time, I was anxious about diving back into my major. After finishing the course, I can confidently say there was never a reason to worry. Thanks to a phenomenal online adaptation of the material, I left the course feeling more than ready to tackle greater programming challenges.

In the course, each module contained videos with both notes and step-by-step examples diagramming the material. This practice of complementing the usual lecture-driven teaching style with one focused on guiding you through examples with detailed diagrams made learning new concepts much more manageable and was by far my favorite aspect of the course. I especially appreciated having access to the "csvistool," a visualization aid that helped me learn the intricacies of each data structure and algorithm. Working through my own examples and predicting outcomes was an exceptional study technique, and it makes me wonder why more classes do not create similar resources.

Since I have moved on from the course, my programming style has become more defined and professional. Now, I always use brackets for loops and branches, regardless of if they are one line or not. I have begun adding documentation comments above my methods so that other people can easily understand what my code does. When approached with a problem, I consider the time complexity of my solutions before programming, rather than using the first solution that comes to mind. Another significant benefit from the course is having new tools to simplify complex problems and speedup slow problems. Take the quickselect algorithm, for instance. One would be hard-pressed to develop an array-only algorithm with better time complexity than one that utilizes the quicksort algorithm or the heaps data structure. No other course in my curriculum thus far has taught me how to program better than CS1332.

I recently got the chance to apply what I've learned for a project in CS4240. Tasked with creating an algorithm to optimize a given intermediate representation of some code, I utilized my knowledge of queues and how they are used in minimum...
spanning tree algorithms to devise my approach for optimization. Because of the plethora of data structures covered in the course, I can analyze situations and determine the most optimal data structure for all future problems.

I highly recommend the CS1332 Online Course & MOOCs Development for Undergraduate Education in the College of Computing be chosen for the 2022 Innovation in Co-curricular Education award. Data Structures & Algorithms has been, by far, the most impactful and useful course I have taken in my time here at the Georgia Institute of Technology.

Sincerely, Sebastian Jankowski
Georgia Institute of Technology
Computer Science
Dear Award Committee,

I’m a second-year student who took Dr. Omojokun’s CS1331 course, Introduction to Object-Oriented Programming, during my first semester at Georgia Tech. As a first-year student, I had minimal programming experience and was not familiar with either Java or the concept of Object-Oriented Programming. However, after taking the course, I can write basic programs in Java and understand various methods of object-oriented programming such as encapsulation, inheritance, and polymorphism. Other than that, the nontraditional nature of the course also encouraged me to actively learn about the course material thoroughly and continue to stay curious about computer science.

The course was taught in short video-based programming demos and slides instead of long one-hour lectures. This allowed me to understand specific concepts bit by bit both conceptually and how they were applied in specific programs. Everything was explained in more concise manner such that I could grasp the main idea related to each topic, yet there were also textual explanations attached in case I needed more clarifications. I was able to watch and read the modules as many times as I wanted which also allowed me to make sure that I am fully understanding every concept before moving on to the next one. Another thing that I really liked about the course and found it invaluable was the knowledge checks attached to each module. By completing the knowledge checks after watching videos from each module, I could apply and assess my understanding of the new concepts learned and receive instant feedback which I found very helpful. Instead of having to wait till study guides to be published or midterms to arrive, I was able to apply my knowledge and assess them myself. In general, the course further encouraged and taught me to actively learn about important programming concepts.

Compared to other course I have taken that are more traditionally taught, Dr. Omojokun’s Introduction to Object Oriented Programming was taught in a mode that suited me the most. The nature of the course encouraged me to learn about various programming concepts in an active and systematic manner. It laid a very strong foundation for me as my introductory computer science course, allowing me to grasp important concepts that have been and will continue to be important as I progress through college and my career.

This course has continued to positively influence my learning up to this day as it was my first programming course at Georgia Tech that has built my positive coding habits, teaching me how to approach programming problems, how to debug issues, and how to organize my code. It provided me with the essential foundation of programming knowledge and will definitely be of great use in the future as well as I learn other languages or frameworks.
I highly recommend the CS1331/1332 Online Courses & MOOCs Development for Undergraduate Education in the College of Computing be chosen for the 2022 Innovation in Co-curricular Education Award. Introduction to Object Oriented Programming has been, by far, the most impactful and useful course I have taken in my time here at the Georgia Institute of Technology.

Sincerely,
Rita Wai Pui Luk
Georgia Institute of Technology
Computer Science
Dear Award Committee,

My name is Ivan Leung and I am a 6th semester TA for Dr. Hudachek-Buswell in her CS 1332 Data Structures and Algorithms course. Over the past year and a half, I have personally worked with Dr. Hudachek-Buswell to build the CS 1332 EdX MOOC course from the ground up.

Our MOOC project first began in the summer of 2020, after I had just finished my first semester as a TA. Although I had never taken part in such a large-scale project before, Dr. HB's reassurance of the success of the MOOC helped to diminish any doubt that I had in my abilities to create tools for the course that would be used by individuals all around the world. In particular, my main role was to integrate our coding assignments into an online platform that would allow students to complete course assignments remotely and receive robust feedback. Through our weekly meetings and discussions, we shared progress on work that we had done and also challenged each other to continually create high-quality content that would align with the goals of the course.

One of our main goals was to design an autograder that would provide clear, in-depth feedback on errors in the student code. Because homework in CS 1332 at Georgia Tech is partly graded manually by TAs, the error feedback on our existing autograder is highly technical and generally only understood by TAs, who would need to convert the error message into clear and readable feedback for the student to understand. Since our MOOC coding assignments are required to be self-sustaining, we needed the feedback system to be as clear and in-depth as possible to minimize any questions that students would have about where and why their code is failing. We also wanted to include visual aids in the feedback to help students debug their code.

Over the coming months, I gained a new set of technical skills through developing scripts and utilities for our autograder, which would later serve as useful in future coursework and internships. I also learned so much about the dynamics of working in a collaborative environment and on such a large-scale project. Dr. HB’s trust in my abilities and also a consistent display of gratitude throughout my partaking in this project truly allowed me to feel valued as her TA. I was also able to witness her unwavering persistence and passion for making our MOOC course be the best that it can be. This opportunity is something that I will be forever grateful for, as it was one of the most impactful experiences I have had in college and also one that has led to the most personal growth.

While the experience of working to transition CS 1332 to EdX was truly a fruitful one, equally as rewarding were the interactions with the students taking the course after we officially launched! It was heartwarming to witness so many individuals from different walks of life all
coming together from around the world to enjoy and experience the beauty of data structures and algorithms together.

One of my favorite aspects of our MOOC was looking through the many introduction posts on the forums and reading their unique stories about what led them to take the course. High schoolers were taking the course in preparation for CS in college, middle-aged individuals taking the course as a refresher for getting back into software engineering, and elders taking the course as a way to get into CS as a retirement hobby. These were only a few among the numerous unique stories shared on the discussion boards. As a TA, reading these anecdotes inspired me and further fueled my passion to help extend CS 1332 beyond the classroom.

From having thought-provoking conversations with students on the discussion board about data structures, to reading and incorporating feedback from individuals that wanted to help contribute to the course, it was evident that the hard work that our team had poured into creating the MOOC over 1.5 years was undoubtedly worth it. The impact of the CS 1332 MOOC has extended far beyond the College of Computing and has even been recognized in Class Central’s “Top 100 Most Popular Free Online Courses of 2021” presented in November 2021.

If there is one class that speaks “innovation”, it is CS 1332 at Georgia Tech. As a 6th semester TA for the course, I have witnessed the class continually evolving and becoming better over time. While many classes are static, CS 1332 is always striving to grow. Dr. HB and her TAs are constantly sparking initiatives to help expand data structures and algorithms to outside the classroom and into the world. In addition to the MOOC, we also have a data structures and algorithms visualization tool that is accessible on the web and is continually being improved upon by our TAs and also from student feedback. I have also been given the opportunity to work on adding new content into our course; namely the Galil Rule for Boyer Moore Pattern Matching. The seemingly limitless vision and growth of CS 1332 have truly made TAing an enjoyable experience, and one that I will cherish even after my time in college.

Sincerely,
Ivan Leung
Georgia Institute of Technology
College of Computing
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