Georgia Institute of Technology
Office of the Provost and Executive Vice President for Academic Affairs

May 28, 2013

Dr. Mike Rogers
Assistant Vice Chancellor for Academic Affairs
University System of Georgia
270 Washington Street, SW
Atlanta, GA 20224-1450

Dear Dr. Rogers and Esteemed Members of the Selection Committee:

It is my distinct honor to nominate the College of Computing Threads program for the 2014 Regents' Teaching Excellence Awards Department/Program Award. This program is an excellent example of the result of an academic unit renewing its curriculum and instructional approach to truly focus on student learning and achievement.

In 2003 the faculty of the College of Computing at Georgia Tech undertook a massive effort to completely redesign their undergraduate curriculum in an attempt to reverse declining enrollments and the students' sense that their learning was irrelevant. The faculty put student success at the forefront, and developed a novel approach to computing education—one that has the potential to change the way the subject is addressed across the country. Now that students are graduating under the new curriculum, it is time to shine a spotlight on what the program has achieved.

As the packet materials indicate, this new curricular approach eliminated the traditional idea of a "core" set of courses that all students must take along with electives to round out the major. In place of these old stand-bys, the students now elect which threads they will follow (each must choose two that intertwine to create the major). Part of the genius of this approach is that by careful design, each student is still assured of learning the core concepts and knowledge that the faculty agree is critical to a CS degree, but this is done in the context of material and approach that is relevant to where the student wants to go with the degree. This approach engages students in their learning at a much higher level—they understand why that are taking the classes that they are enrolled in and why they are learning the related material.

Rafael L. Bras
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Perhaps more important than the specifics of the evolving curriculum in the College of Computing is their new approach to undergraduate education. They have revamped their processes (everything from advising to assessment) to ensure that current students are being well advised of their options and how to proceed through the curriculum. These steps happen in concert with measurement to determine whether the program is meeting its goals. The College of Computing has designed a critical feedback loop that regularly informs its course offerings and advising.

Finally, I believe that fostering a culture where faculty are increasingly engaged in designing and implementing a new curricular approach has enhanced the College of Computing's efforts to reward faculty for their attention to undergraduate education. At a research university like Georgia Tech, there is always going to be a focus on scholarship. What is impressive about the College of Computing is that there is also a significant focus on teaching quality, advising quality, and indeed educational quality, too.

In his updated version of his best-selling book *The World is Flat*, Thomas L. Friedman cited the Threads curriculum and wrote that the Georgia Tech model anticipates that "the world is increasingly going to be operating off the flat-world platform, with its tools for all kinds of horizontal collaboration." I am pleased that our College of Computing is a national leader in computing education and is helping shape the future of this important field through its Threads curriculum.

Sincerely,

Rafael L. Bras, Sc.D.
Provost and Executive Vice President of Academic Affairs
Georgia Institute of Technology

Fact Profile

The Georgia Tech College of Computing is a national leader in the creation of real-world computing research that drives social and scientific progress. We are transforming undergraduate education by expanding the horizons of our students with contextual and cross-disciplinary computing education, international study experiences, and a focus on human-centered solutions. Our graduate programs are ranked 10th in the country by ***U.S. News and World Report***, with specific areas such as theory, databases, systems, graphics/user interfaces and artificial intelligence ranked in the Top 10. The Study Abroad program was listed under "Programs to Look For" (2008) and Undergraduate research, creative projects, and internship programs listed under "Programs to Look For" (2007). At Georgia Tech, we are defining the new face of computing.

The College of Computing has 3 schools: School of Interactive Computing, School of Computer Science, School of Computational Science & Engineering. At the undergraduate level the College of Computing has two degree programs: Computer Science (Threads) and Computational Media. The Masters level consists of the following programs: Computer Science, Human Computer Interaction, Information Security, Computational Science and Engineering. At the Ph.D level, the programs consist of Computer Science, Human-Centered Computing, Algorithms, Combinatorics and Optimization, Bioengineering, Bioinformatics, Robotics, Computational Science and Engineering.

The College of Computing by the Numbers for Fall 2012

Faculty

- **88** academic faculty (includes 10 joint faculty)
- **26** research faculty
- **7** instructional faculty
- **14** post docs
- **33** female faculty, researchers and instructors

Students

- **1278** enrolled in Bachelor degree programs
- **398** enrolled in Masters degree programs
- **298** Doctoral programs
- **19**% of undergraduates are women
- **11**% of undergraduates are underrepresented minorities
- Highest starting salary of any major at Georgia Tech (Spring 2009 seniors)
- Highest job placement rate of any major at Georgia Tech (Spring 2009 seniors)

Freshman Profile

- Average SAT: **1386**
- Average Entering GPA: **3.9**
- **273** Total Computing Freshmen (225 Men, 48 Women)
- **Majors: 237** Computer Science majors, **36** Computational Media majors
- **140** Georgia Residents

Georgia Tech's College of Computing Threads Initiative

In 2003, the faculty of the College of Computing agreed that their top priority for the next several years would be a reassessment and rethinking of their undergraduate curriculum from top-to-bottom. The faculty adopted the strategic goal of creating a new way of developing, organizing and delivering computing education. With the support of the administration and the participation of the faculty, this effort over the balance of the decade has resulted in:

1. a radical reorganization of the undergraduate degree in computer science as *contextualized education;*
2. an infrastructure for *intentional advising* as a central way to support the academic success of our students;
3. *a culture of support for education*, including an organizational structure for continuous improvement and resources for assessment and educational delivery; and
4. a commitment to *dissemination* across other departments both of computer science and of other disciplines

Contextualized Education. The context of our efforts to rethink the computer science degree was the increasing fear of the global outsourcing of jobs like those in computer science. In addition to the changing economic landscape, several studies showed that students no longer saw the relevance of what they were learning. By contrast, the pedagogical research suggests that students learn better when their classroom experiences are situated in a context. In short, students needed to understand why they were studying what they were studying. This was a key component in innovating, integrating, and facilitating the most basic learning, because learning happens when we connect new information with existing knowledge. By making students aware of the context that makes what they are studying important, we have an opportunity to improve learning and dramatically improve retention.

To that end, the faculty developed Threads as a new structuring principle for computing curricula. The Threads model represents a natural evolution of contextualized education, extending the application of that idea from a single course to an entire undergraduate degree. Threads represents both a process for understanding and developing curricula, and a set of outcomes derived from the application of that process.

Threads are partial paths through a computing degree that embody a flexible set of technical skills both within and outside of computing. A thread:

> Serves as a context for interpreting the courses in a curriculum for students and faculty,
>
> Makes its set of courses cohesive, providing an overall meaning for the set, and individual meaning for each course, and

> Suggests a coordinated path through its courses so that the end result is expertise in the area of the thread. A thread is therefore a trajectory that leads through a set of courses, drawing them together towards a particular end.

In our case, there are eight threads: (1) Devices, (2) Information Internetworking, (3) Intelligence, (4) Media, (5) Modeling & Simulation, (6) People, (7) Systems & Architecture, and (8)Theory. Every student constructs her own personalized computing degree by weaving two threads. Each Thread is about 2/3 of a degree, but any pair of threads yields a complete degree. This constraint turns out to be significant. It assures that no matter what students choose, they will fulfill the requirements for a CS degree. Further, this is accomplished without solving "the core problem." That is, in describing a computing degree using threads, one can avoid asking what courses every computing student must take (something that becomes a practical impediment to establishing a flexible degree program). Instead, faculty have identified a set of threads that:

> Make sense given the emphases and strengths of the department,
>
> Make sense to students, including students one hopes to attract, and
>
> Make sense to the employers and graduate schools who will receive the graduates.

Nonetheless, every student under Georgia Tech's Threads still takes some data structures, some systems programming, some software engineering and so on because it is the only way to meet the 2/3+2/3 = 1 constraint. On the other hand, students can change their minds about their threads fairly late in the curriculum without having to worry about losing time. A student is an undeclared computationalist through her first two years. This flexibility is a natural consequence of the overlap that arises from the constraint. As a result, although there is no explicit core, a core has fallen out of this process, ensuring that each student is exposed to concepts necessary for a practitioner in the field.

Further, the relationship between thread combinations and real world careers is many-to-many. Any combination could actually be used as a stepping-stone to many different careers. A student interested in information security would almost certainly want to study Information Internetworking. If she is interested in encoding algorithms, then her second thread might be Theory. If she is interested in building secure distributed databases, then Systems & Architecture might make a good second thread, or if she is interested in building secure systems that users may actually use effectively she may focus on People. In the other direction, any given thread combination can lead to several careers. Consider the combination of Devices and People. One possible context or career focus within that combination would be social robotics, the development of robots that work in human social contexts. Another context or career focus might be advanced prosthetics, the development of devices with embedded computing that help to replace lost human limbs.

Finally, it is worth noting that because of the structure of the threads and the notion of an implicit core, many faculty participate in the development and care of multiple threads. Common courses and the organizational structure ensures continual cross discussion.

Intentional Advising. In reality, the construction of threads resulted in very few new courses. One way of thinking of the result of this process was a much more structured and coherent reordering of existing courses to reveal the underlying story or narrative of the degree. This restructuring has had a major impact on the way our students seek advice about their courses. In the past, students asked advisors questions such as "What course do I need to take next if I want to graduate next term? (The student then typically chose the one taught at 11am instead of 9 am.) As we implemented threads, we discovered that students began asking different questions such as "What thread should I choose to pursue a career I care about?" Further, the students were asking these less prescriptive and more intentional questions earlier in their matriculation.

One important impact of the thread process is that the College of Computing now has an advising mechanism that communicates the beliefs of the faculty about ways to prepare for certain kinds of computing careers in a structured way. This approach is consistent with the way in which the threads were constructed. They include requirements outside of computer science. For example, students taking the People thread take qualitative methods and experimental design from psychologists as well as programming, while students in Devices take hardware design labs with their electrical engineering colleagues.

Taking this view of curriculum as advising to heart, we have established an intentional advising program to address students needs. The program begins when students are accepted into our program and they are assigned student mentors who interact with them electronically, including via Facebook. Mentors are trained by our staff before interacting with students. We have also established a required introductory course that all new students take their first term. It provides an in-depth review of our curriculum (including each of the threads), various options for degrees (minors, research options, study abroad, etc.), as well as an introduction to the faculty (who work with small groups of the students sharing career and research advice) and the advising staff. This course is also an opportunity for new computer science students to develop relationships with students who might have similar thread interests. The course is supported by the same students who have chosen to be mentors. The mentor-mentee relationship continues formally throughout the first year.

Culture of Organizational Support. The administration has adopted the faculty effort at curricular reform as a strategic goal and provided resources accordingly. To begin with, the College initiated a national search for an Associate Dean of Undergraduate Affairs whose duties included organizing and overseeing these efforts.

One of the first acts of the Associate Dean was to hire a Director of Assessment to restructure and implement a new assessment plan for Threads. Due to the unusual structure of the 8 Threads curriculum, assessment occurs at the foundational level as well as multiple points within each Thread. Each thread has its own mini assessment plan with specific outcomes tied to specific courses that in turn tie into the comprehensive assessment plan. There is also an Assistant Dean of Community who helps to oversee the intentional advising efforts (among other duties).

The Associate Dean acts an ex-officio member of the undergraduate curriculum committee. This committee is faculty-driven and made up of eight "shepherds" (one representing each thread) and a ninth member from the instructional faculty who oversees the common foundational courses. This structure encourages cross-threads discussion, consistency, and a culture of continuous improvement.

The administration recognizes outstanding teaching each year and provides a great deal of financial support for teaching assistants, typically well-trained undergraduates for lower division courses and area-specific graduate students for upper division courses. These assistants support the delivery of education and enhance the teaching of the faculty as they work together to facilitate learning in the undergraduate courses.

Dissemination. In order to truly assess and evaluate the viability of the Threads process, we seek to document our efforts and share our experiences, assessment tools, software support infrastructure, and development process with the larger community. There are several significant research issues that arise in implementing an organizing principle such as Threads. Our overarching research goal is to study these questions in a wide variety of situations. Our expectation is that by building a community of computing departments, we will be able to produce a generalizable process for developing and implementing locally-relevant Thread curricula, increase enrollment and retention for departments that adopt this approach, and improve the vision of computing as a whole. Over the next several years, we plan to provide lessons learned, software, and several examples of Threads-based computing degrees.

In part as the result of a grant from the National Science Foundation, we have been able to track and evaluate the development model in a variety of institutions. Aside from Georgia Tech, our alliance includes three campuses within the University System of Georgia: Armstrong Atlantic State University, Kennesaw State University and Southern Polytechnic State University. The alliance also includes Brooklyn College of the City University of New York. The alliance provides diversity in size, student demographics, educational mission, technical emphasis and geography.

Finally, faculty members in the School of Literature, Media, and Communication (LMC) at Georgia Tech have used the Threads model to restructure their own undergraduate degree program in Computational Media, a joint degree with the College of Computing which will be offered in Fall 2013. (This is the only undergraduate degree on campus

that crosses Colleges.) Although the Computational Media degree was developed before the Threads model was integrated into the structure, rethinking the degree now allows students to choose one thread from CoC and one thread from LMC. Such a strategy provides a much broader CM degree without additional administrative overhead.

We hope that our Threads initiative will become a model for future joint degrees at Georgia Tech. We are encouraged that faculty in the School of Literature, Media and Communication are now designing a set of threads for their internal non-computing degrees. In addition, we believe that our Threads initiative offers great potential for others in computing education who want to strengthen their undergraduate programs.

Evidence Supporting the Success of the College of Computing Threads Initiative

- **Student Graduation/Retention and Enrollment Data**
  This documentation illustrates (1) improvements in student retention in the degree program (2) increase in degree production and (3) increase in participation by women and other under-represented minorities. Quotes from graduates offer their impressions of the degree.

- **Assessment Results**
  This documentation provides both findings and the nature of the feedback loop in the College. Issues are identified, solutions are posed, new data is collected and the process repeats.

    - Student Satisfaction
      - Recommend the program?
      - Meet needs for graduate study?
      - Meet needs in career training?

    - Intentional Advising
      - Accurate information
      - Assistance with major and elective selections?
      - Overall quality of advising?

- **Distributions and Definitions**
  This material provides a brief description of the 8 Threads and indicates what Thread combinations graduates have selected.

    - Distribution of Threads Selected by Graduates
    - Definitions of the Threads

- **Impact of Threads Implementation on Student Services, Curricular Assessment, and Co-Curricular Programming**
  This documentation highlights changes that are occurring as a result of implementing the Threads initiative.

Graduation/Retention and Enrollment Data

Due to the structure and rigor of the Institute's general curriculum, the program's four-year graduation rates are not comparable to other institutions. However, if you look at the six-year graduation rates, our BSCS rates are comparable to other state, national rates or degree programs. As seen in the table below, there is a significant percentage increase from the four-year rates in comparison to the six-year graduation rates. The Retention and Graduation Rates table also shows a consistent improvement in the five year graduation rates since the inception of Threads curriculum in 2006, which lends to the flexibility of the curriculum.

Table 1: Retention and Graduation Rates

Year	Cohort Total	2nd Year Ret.	3rd Year Ret.	4th Year Ret.	4yr Grad	5yr Grad	6yr Grad
2004	185	87.5%	81.5%	79.9%	**29.7%**	**66.5%**	**79.7%**
2005	158	90.5%	83.5%	82.3%	**22.8%**	**63.3%**	**72.2%**
2006	231	92.6%	84.4%	83.1%	**30.7%**	**69.7%**	**76.2%**
2007	164	93.9%	89.6%	87.8%	**46.3%**	**74.4%**	
2008	172	93.6%	85.5%	84.3%	**42.4%**		

Impressions from Class of 2013 Graduates about Program

"Great program. Enjoyed immensely."

"It was wonderful."

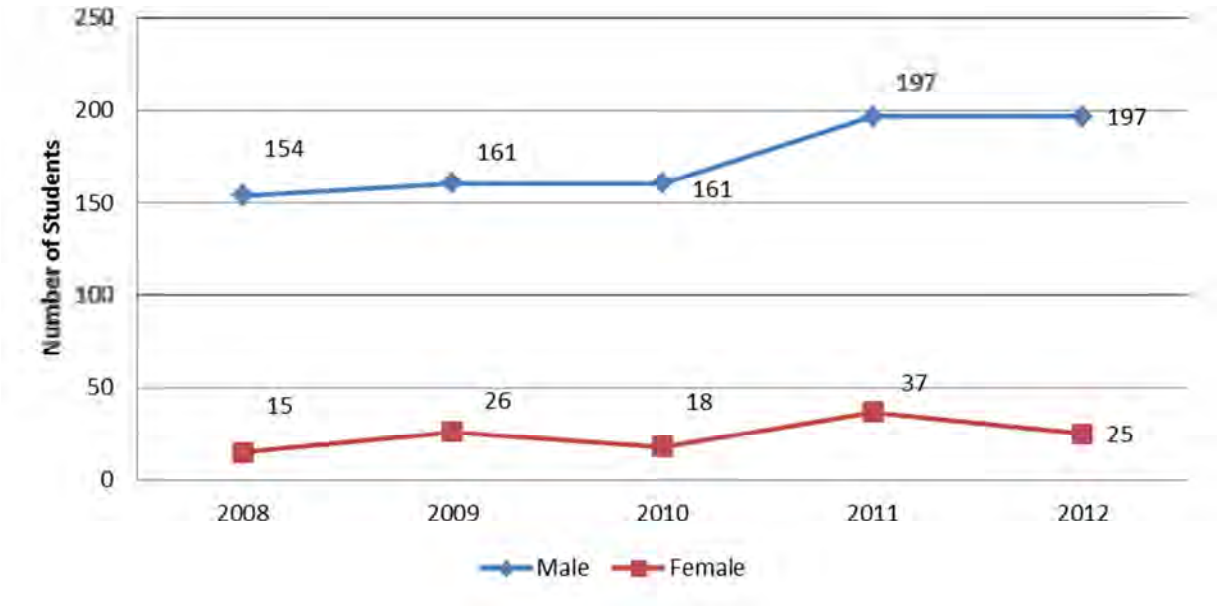
"Proud to be graduating with a B.S. in Computer Science from the Georgia Institute of Technology."

"I wish I could put into words the gratitude I have for everything the College of Computing has done for me. The systems you have in place are often looked upon in jealousy by other colleges and by my colleagues who wish they had the opportunity to be as involved as I got to be. It is because of all of the work that our Office of Enrollment, Outreach and Community does, that I was able to graduate. Keep it up."

Increase in BS Degree Production

After a few years of decline in BS degree production in computer science, the major has started to show an increase in the number of degrees conferred. Figure 1 (GT BS Degree Production) shows a general increase in degrees conferred by the College for the BSCS (Threads).

Figure 1 - BSCS Degree Production



Impressions from 2011 & 2012 Grads about Impact of Threads on Grad School Prep

"My threads relate pretty closely for my graduate school hopes, as I hope to come back to Georgia Tech for a Master's in HCI, so people and networks fit quite well."

"I am currently headed to a PhD in Robotics in Georgia Tech's College of Computing. Between my extensive research experience, in-depth education in artificial intelligence and computational theory, and the breadth and depth I've picked up from talking with Tech's professors, I'm about as well-prepped for grad school as you could possibly be."

"The threads allowed me to specialize into the field I want to enter, which is a huge help in grad school because grad school is all about gaining specialized knowledge"

"As I've worked with grad students, sometimes they're surprised at the level of knowledge I have with certain concepts. I think threads allow this very deep knowledge in certain areas to develop."

Impressions from 2011 & 2012 Grads about Impact of Threads on Industry/Job Prep

"I did learn a great deal of really awesome things that real world businesses such as Google and Pixar use in their businesses that directly relate to my thread picks".

"It prepared me well. I've had several internships and currently work with a startup."

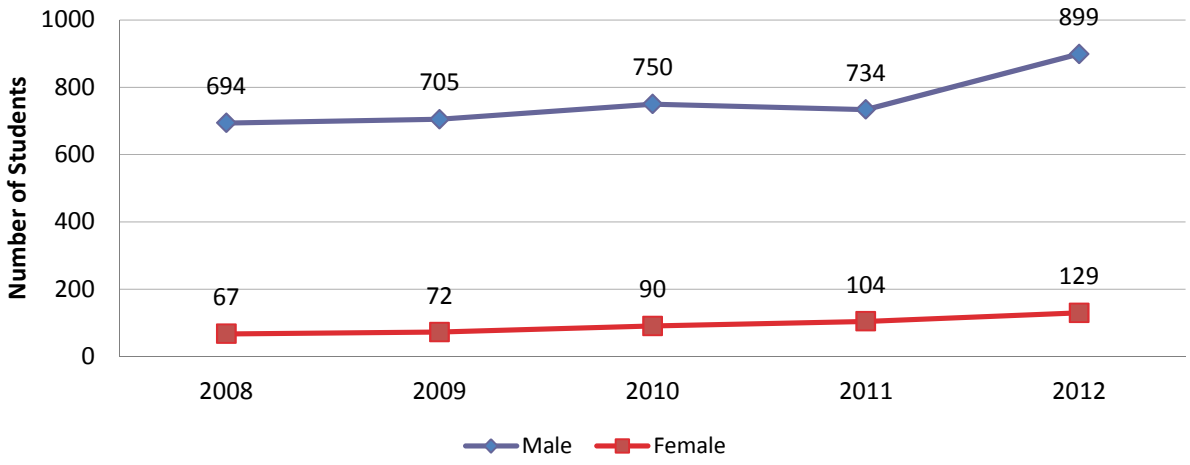
"I feel well prepared for my job and I feel my threads complemented my industry (Project management/Business analysis) well. I feel that my Management certificate was also very helpful toward this".

"I really like the level of depth I was able to get into by having some specialties, but I also liked that the "specialties" were generic enough so that I still have some breadth to it. I feel like I have some expertise already and I won't have to start fresh on the job, but that I don't have to worry about being tied to only one kind of project."

Enrollment Data

Since 2008 CS enrollment figures have consistently increased after a two-decade period of low enrollment. In addition, the CS major has shown systematic growth among women within computing, especially in CM. The flexibility of Threads contributes to learning in a contextual format that leads to more involvement (especially among minorities and women).

Figure 2 - Enrollment Trends 2008 - 2012



In addition to an increase in enrollment among women, there has also been an increase among minorities since 2006. The graph below shows the percentage increase in enrollment among the different groups.

Figure 3 - Percentage Change for Enrollment by Ethinicity

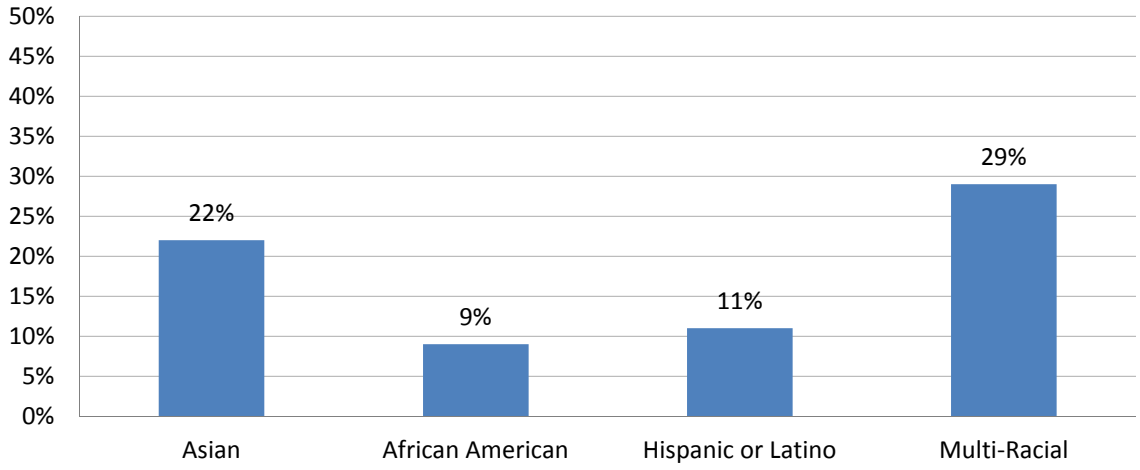
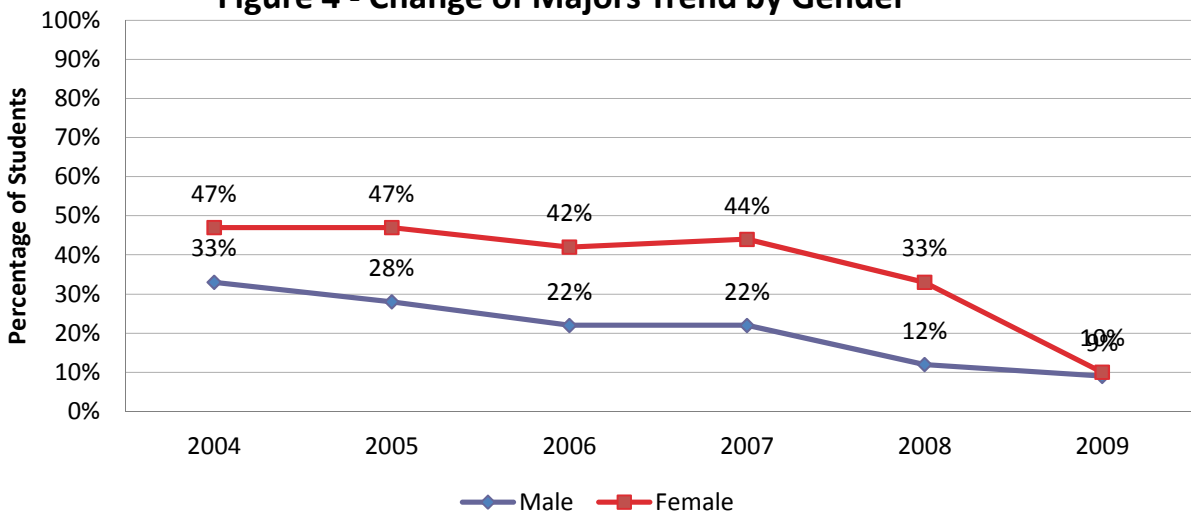


Figure 4 - Change of Majors Trend by Gender



Reduction in Change of Majors: Figure 4

One of the major issues noted in our efforts pre threads was the number of students leaving computer science once at Georgia Tech. This trend began to change after we implemented Threads as seen over the three years in Figure 4 shown below. The flexibility of Threads makes CS inclusive by partnering with other areas across disciplines, which stabilizes our major by improving retention among CS majors.

Assessment Data

Student Satisfaction. The inception of Threads seemed to be the correct course of action to further advance the educational experience of future computationalists not only at Georgia Tech but also at other institutions. However, the curriculum is for the students, so it is necessary to get feedback from these important stakeholders. According to the following table, over a three-year period at least 80% of the graduating students said they would recommend the Threads program of study at Georgia Tech. Each year students' satisfaction with the program has increased.

Table 2: Would You Recommend Your Program Of Study To A Friend Or Relative

Answer	2008		2009		2010		2011	
	#	%	#	%	#	%	#	%
0 - Unsure	19	11.88%	14	8.97%	13	8.23%	--	--
1 - No	8	5.00%	9	5.77%	4	2.53%	--	--
2 - Yes	133	83.13%	133	85.26%	141	89.24%	--	--
TOTAL	**160**		**156**		**158**		**--**	**--**

Not only did the students recommend the program, but they also felt prepared for graduate studies. In 2008, 83% of the students stated that the program prepared students for graduate study adequately or very well. In 2010, 89% of graduates felt the same way.

Table 3: How Well Did Georgia Tech Meet Your Needs In Preparation For Graduate Study

Answer	2008		2009		2010		2011	
	#	%	#	%	#	%	#	%
1 – Poorly	1	0.63%	5	3.13%	5	3.16%	--	--
2 – Somewhat Adequately	16	10.13%	26	16.25%	17	10.76%	--	--
3 – Adequately	86	54.43%	72	45.00%	73	46.20%	--	--
4 – Very Well	55	34.81%	57	35.63%	63	39.87%	--	--
TOTAL	**158**		**160**		**158**		**--**	**--**

In addition to preparing for graduate school, 89% (2008) of the students stated that they were prepared for a career. This thought was echoed in 2011 where 93% of the students expressed the same opinion.

Table 4: How Well Did Georgia Tech Meet Your Needs In Career Training								
Answer	**2008**		**2009**		**2010**		**2011**	
	#	%	#	%	#	%	#	%
1 – Poorly	1	0.63%	2	1.25%	3	1.89%	5	2.62%
2 – Somewhat Adequately	23	14.47%	26	16.25%	20	12.58%	9	4.71%
3 – Adequately	78	49.06%	66	41.25%	71	44.65%	102	53.40%
4 – Very Well	57	35.85%	66	41.25%	65	40.88%	75	39.27%
TOTAL	**159**		**160**		**159**		**191**	

Intentional Advising. The advising staff at Georgia Tech is doing a great job of providing students with information that assists them with their matriculation through the Threads program. The very purpose of our advising staff is to assist students with degree requirements and course sequence information, which is evident in Table 5. The table shows that in both 2008 and 2009, 91.7% of the graduating students reported that advising in degree requirements and course sequence was either "good" or "excellent.

Table 5: Advising In Major: Accurate Information About Degree Requirements And Course Sequencing								
Answer	**2008**		**2009**		**2010**		**2011**	
	#	%	#	%	#	%	#	%
1 – Poor	1	0.63%	8	5.00%	5	3.13%	10	5.13%
2 – Fair	12	7.59%	12	7.50%	17	10.63%	16	8.21%
3 – Good	55	34.81%	56	35.00%	40	25.00%	47	24.10%
4 – Excellent	90	56.96%	84	52.50%	98	61.25%	122	62.56%
TOTAL	**158**		**160**		**160**		**195**	

As shown in Table 6, the level of satisfaction in "assistance with major concentration and elective selection" decreased from 2008 to 2009 from 81.4% to 72.3% in the "good" to "excellent" category. However, by 2011 students expressed the same level of satisfaction (81.9%) as in 2008 and 2009.

Table 6: Advising In Major: Assistance With Major Concentration And Elective Selection

Answer	2008		2009		2010		2011	
	#	%	#	%	#	%	#	%
1 – Poor	6	4.14%	8	5.67%	10	6.62%	5	2.73%
2 – Fair	21	14.48%	31	21.99%	19	12.58%	28	15.30%
3 – Good	64	44.14%	45	31.91%	49	32.45%	70	38.25%
4 – Excellent	54	37.24%	57	40.43%	73	48.34%	80	43.72%
TOTAL	**145**		**141**		**151**		**183**	

In Table 7, 95% of students thought that overall advising was either "good" or "excellent." However, in focus groups students noted that making sound decisions of what to take in reference to their area of concentration was difficult.

Table 7: Advising In Major: Quality Of Advising Overall

Answer	2008		2009		2010		2011	
	#	%	#	%	#	%	#	%
1 – Poor	1	0.64%	5	3.13%	0	0.00%	5	2.56%
2 – Fair	6	3.85%	13	8.13%	13	8.13%	14	7.18%
3 – Good	71	45.51%	55	34.38%	54	33.75%	64	32.82%
4 – Excellent	78	50.00%	87	54.37%	93	58.13%	112	57.44%
TOTAL	**156**		**160**		**160**		**195**	

As a result of these student responses, a pilot intentional advising program was developed to address the needs of students. The initial pilot program consisted of individual counseling sessions and a one-hour weekly freshman seminar class to discuss academic and career plans as it relates to personal interests and strengths. This intentional advising structure is advantageous to the student because it gives students some parameters to deal with choices that exist within

the curriculum. Although flexibility and choice is great, as we discovered, there is such a thing as "possibilities overload." The flexibility can be both a positive and a negative because it presents so many possibilities. The students who participated in the pilot program stated the following based on the exit assessment of the pilot program:

- 89% of participants agree or strongly agree that it has provided clear and consistent information about institutional requirements and effective advising about the choices students have to make regarding their programs of study and future career goals.
- 78% of participants agree or strongly agree that it has increased their understanding of expectations of the institution as well as expectations of faculty and staff.
- 89% of participants agree or strongly agree that if they have concerns, they know at least one GT faculty or staff member to whom they can turn.
- 78% of participants agree or strongly agree that they have enjoyed the frequency and quality of contact with faculty/staff.
- 92% of participants agree or strongly agree that it has increased their insight into how to leverage their strengths for achievement within CS.
- 84% of participants agree or strongly agree that it has increased their confidence in their ability to speak with a prospective employer about their strengths.
- 91% of participants agree or strongly agree that it has led them to feel more confident in their Threads selection.

In addition to the exit assessment, students had the following quotes concerning the intentional advising:

> *"I definitely feel more confident about my decisions, and feel more comfortable discussing them with others. Talking about my future plans helped me realize what I wanted out of my college career."*
>
> *"I was not sure what organizations to get involved with, and through this I learned more about where to get involved and I planned out my stay at tech."*
>
> *"It really helped me understand and pick threads."*
>
> *"Before this class I had no idea what threads I wanted to do, but after I narrowed my choices to 3 which is a very big step for me, and I am really grateful for that."*
>
> *"Learning more about the Thread program to help me decide which threads to take."*

These quotes are a direct reflection of addressing issues identified earlier in the Threads curriculum through focus groups and exit survey results. As a result of the intervention, students were able to take full advantage of their undergraduate experience.

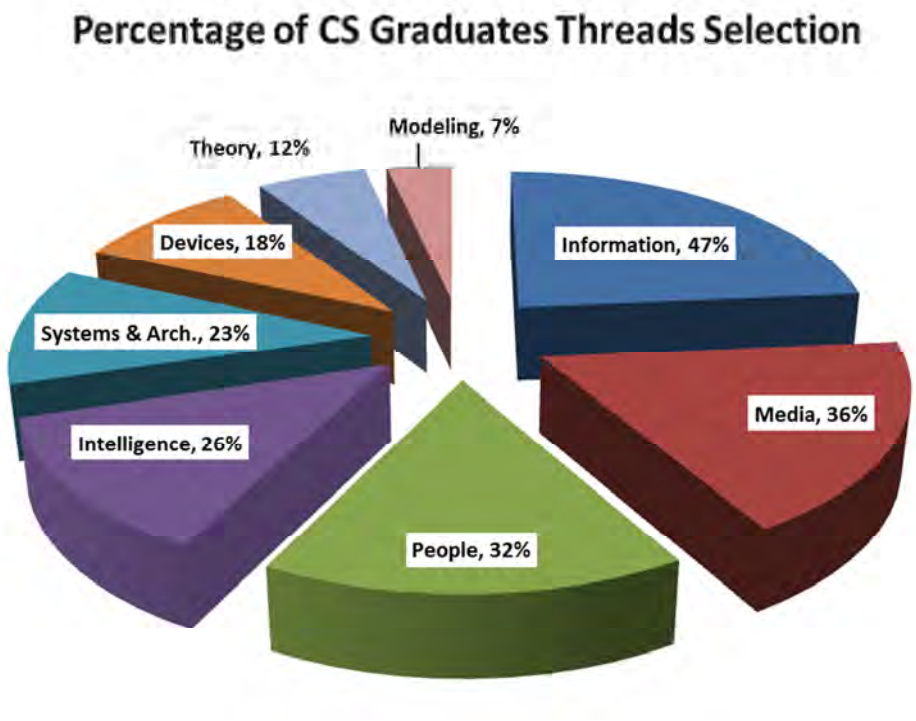
Thread Distributions and Definitions

Distribution of Thread Selection. Each student must select and complete the requirements for two Threads in order to attain a Bachelor of Science in Computer Science degree. Table 8 shows that BSCS graduates were mostly like to choose Media & People (14%) and Information Internetworks & Systems and Architecture (11%) as their Thread combinations followed by Information Internetworks & People (11%), Information Internetworks & Media (9%), Intelligence and Media (7%), and Information Internetworks & Devices (7%). The combinations that were least selected by graduates were Devices & Media, Devices & Modeling/Simulation, Devices & Theory, Media & Theory, Modeling and Simulation & Systems and Architecture. The least likely combinations included (1) Modeling/Simulation & Theory, (2) People & Systems and (3) Architecture, Devices & People, and (4) Media & Modeling/Simulation.

Table 8: Thread Combinations of Graduates Fall 2007-Spring 2013

Thread Combination	Number of Graduates
Devices & Info Internetworks	**44**
Devices & Intelligence	**33**
Devices& Media	**16**
Devices & Modeling/Simulation	**1**
Devices & People	**19**
Devices & Systems and Architecture	**25**
Devices & Theory	**0**
Info Internetworks & Intelligence	**39**
Info Internetworks & Media	**68**
Info Internetworks & Modeling/Simulation	**17**
Info Internetworks & People	**85**
Info Internetworks & Systems and Architecture	**82**
Info Internetworks & Theory	**23**
Intelligence & Media	**47**
Intelligence & Modeling/Simulation	**9**
Intelligence & People	**23**
Intelligence & Systems and Architecture	**15**
Intelligence & Theory	**29**
Media & Modeling/Simulation	**10**
Media & People	**103**
Media & Systems and Architecture	**24**
Media & Theory	**7**
Modeling/Simulation & People	**2**
Modeling/Simulation & Systems and Architecture	**7**
Modeling/Simulation & Theory	**7**
People & Systems and Architecture	**2**
People & Theory	**7**
Systems and Architecture & Theory	**16**
TOTALS	**760**

The graph below shows that Information Internetworks was the most popular Thread among graduates with 27%. In addition to Information Internetworks, graduates seem to favor the People (19%), Media (18%), and Intelligence (13%) threads. The graph also shows that only 3% of the graduates chose Modeling and Simulation as one of its Thread selections.



Definition of Threads. Many traditional computer science courses fall naturally into each of these threads that are briefly described in Table 9. For example, a course in human-computer interaction (HCI) naturally falls under the People thread, and a course on robotics naturally falls under Devices.

Table 9: Brief Description of the 8 Threads

Modeling & Simulation	Representing natural and physical processes
Devices	Creating devices embedded in physical objects that interact in the physical world
Theory	Theoretical foundations underlying a wide range of computing disciplines
Information Internetworks	Representing, transforming, transmitting, and presenting information
Intelligence	Building top-to-bottom models of human-level intelligence

Media	Building systems in order to exploit computing's abilities to provide creative outlets
People	Designing, building, and evaluating systems that treat the human as a central component
Systems and Architecture	Creating computer architectures, systems and languages

On the other hand, it is important to understand that Threads are not tracks or specializations; rather, they are a set of interdisciplinary collections of courses that provide a broad set of flexible skills as seen in Table 9. For example, the People thread requires courses in psychology as well as allowing breadth in cognitive science, HCI and learning sciences. Similarly, the Devices thread requires courses in physics and electrical engineering. Note that even though each thread draws on different requirements, in practice the total number of hours is not increased: in our institution, as in others, classes such as psychology or physics can also fulfill other university requirements.

Implementation - Threads in Reality

The application of Threads has not only impacted the institute on a curricular level but it has had an impact in other areas as well. The curriculum has forced the following changes in student services support:

- Undergraduates now have a "steady state schedule" for the next two academic years. This helps students competently plan their academic path with the advising team.

- A "pilot" intentional advising program has been established with the college to address student's needs in four main areas: academically, socially, personally, and professionally. These four areas are the cornerstone in helping students (1) find out who they are as people and students, (2) promote the development of critical social skills, (3) identify what threads best suit them and their interests, and (4) translate their interests into a professional career.

- The College computing also made the freshmen seminar a college of computing focus seminar. The CS1100 course is a mandatory course that first time GT students take; this provides an in-depth review of our curriculum (including each of the threads), various options for degrees (minors, research options, study abroad, and so on), as well as an introduction to the faculty and the advising staff. This course is also an opportunity for new computer science students to develop relationships with students who might have similar thread interest. Recently, a CS100 for transfer students was implemented because the needs of transfer students are somewhat different than traditional first year students.

- In development is a software package called Threadspace which is designed to track the Thread selections of students on a yearly basis. One of the issues discovered through this process is the necessity of tracking of students' thread intentions, which impacts the level of service provided by our advising staff and faculty. The major issues involved in implementation are (1) finding resources and (2) developing policies to protect the rights of students and the purpose of the software.

From an assessment perspective, the curriculum has changed the way we assess the undergraduate curriculum. The change in curriculum has led to following actions:

- An assessment person was added to the staff to restructure and implement a new assessment plan for Threads. Due to the unusual structure of the curriculum (the 8 threads), assessment occurs at the foundational level as well as multiple points at the Thread level within each Thread. Specifically, each thread has its own mini assessment plan with specific outcomes tied to specific courses that links into the comprehensive assessment plan.

From a co-curricular perspective, Threads has spurned a need for interaction of students to complete the undergraduate experience. This is evident in the following programs:

- The College of Computing is in the fourth year of its freshmen mentor program, which has approximately 25-28 mentors and mentor groups to mentor approximately 150 to 160 students. This program was established to pair entering CS majors with a current CS major to assist with the transition of students to Georgia Tech academically and socially. The mentoring program is directly related to the CS1100 class by utilizing the mentoring groups as a basis for team building exercises as well as other activities when possible within the course.

- The number of active student organizations has grown to address the current and anticipated need of student-led organizations at the college level. The organizations link students according to social, personal and professional interests and help students establish social networks that assist them in all aspects of their life. Presently, there are 18 active student organizations that address the social interests and needs of computing students in the undergraduate experience.