1 Project Vision: Changing Computing using Locally Meaningful Context

In Thomas Friedman’s best-selling book *The World is Flat*, he highlights the problems facing computer science faculty in the United States [10]. In a flat world, workers anywhere can compete on a level playing field with workers in the US. Jobs such as accounting and even software development can be performed as well, or even better, off-shore as within this country. Any job that can be defined as a narrow set of skills—no matter how intellectually challenging—is completely exportable, and often at an apparent lower cost than the same job can be performed in the US. Friedman also suggests the nature of a solution. The jobs that can be sent off-shore are those that are decontextualized, meaning that there are few connections between the job and other jobs, between the discipline of the job and other disciplines.

Similarly, Daniel Pink argues that we are in a move from an Intellectual Age to a Conceptual Age [17], driven by some of the same forces identified by Friedman. Pink identifies several important trends and new skills that are important in this shift. In particular, he points out that those who innovate will demonstrate symphonic thinking, the ability to integrate ideas across different disciplines or fields. Integrating across several fields facilitates insight and innovation.

At the same time, there have been several studies exploring how computer science is perceived by under-represented groups (see, for example, [1]). Students report that they do not see the relevance of what they are learning, that it focuses on seemingly irrelevant and tedious details [15], and that there is little opportunity for exercising creativity [16]. This perception has practical consequences for learning [18] and retention [3]. In short, students need to understand why they are studying what they are studying. This is important for innovating, integrating, and facilitating the most basic learning. Learning happens when we connect new information to existing knowledge [14], and unless we activate that prior knowledge first, students only have “brittle knowledge” [8]—knowledge that will get them past exams, but will not be used successfully outside of the classroom. Studies of higher education show that retention is improved by simple measures such as improved counseling that explains to students why they are taking the classes that they are taking. By making students aware of the context that makes what they are studying important, we have an opportunity to both improve learning and dramatically improve retention [7].

The need for context may also explain some of the decline in student interest in computer science. Why do students enter computer science? Most students who apply for the CS major have not had significant computer science experience. They express interest in CS because they are interested in video games or perhaps the technology behind cell phones and digital audio players, or maybe they are attracted by the dramatic impact of computing in areas like the Human Genome Project; however, historically when they enter their first computer science class, they hear nothing about any of that, instead focused on sorting algorithms and traveling salesmen. The context that the students are interested in, that they came for, does not match with their introductory experiences. It is no surprise that the students find this unattractive.

We find a resonance between Friedman’s call for contextualization, Pink’s notion of symphonic thinking and the body of pedagogical research that suggests that students learn better when their classroom experiences are situated. The lesson for educators is straightforward: we must innovate in our curriculum and in how we approach what we teach students; we must make the classroom experience personally meaningful and motivating for our students. These requirements are driven both by the need for us to be role models for our students and by the challenges faced by our field.

To that end the Georgia Institute of Technology (*Georgia Tech*), has recently developed Threads™, a new structuring principle for computing curricula [11, 12]. The Threads model represents a natural evolution of contextualized computing education, extending the application of that idea to an entire undergraduate computing degree. The principle of contextualization begins with the very first class and continues until graduation. It includes an infrastructure for intentional advising, as well as the development of robust software support for administrators, advisors, educators, and students. Threads represents both a process for understanding and developing curricula, and a set of outcomes derived from the application of that process.
**Project Goals, Objectives and Outcomes.** We seek to apply the Threads process at a set of diverse institutions and to examine how the outcomes differ on each campus. We will measure quantities such as enrollment and retention rates but also qualitative results such as improved awareness of the contextual depth of computing for students and parents, and improved consensus regarding the interdisciplinary breadth of the field amongst faculty. We have formed an alliance of education organizations interested in this model and this alliance will evaluate, adopt and extend Threads among its broad and diverse community of computing departments. In particular we propose:

1. To assess the application of Threads and its supporting programs at Georgia Tech. This evaluation includes the development of new assessment instruments applicable at each stage of the educational process, and the application of such instruments to students, educators, employers and advisors.

2. To study the application of the Threads model to a diverse set of departments and universities. Aside from Georgia Tech, our alliance includes three diverse campuses within the University System of Georgia (USG): Armstrong Atlantic State University (AASU), Kennesaw State University (KSU) and Southern Polytechnic State University (SPSU). The alliance also includes Brooklyn College of the City University of New York (BC-CUNY). BC-CUNY’s recent curriculum redevelopment efforts fit naturally with the context-based, interdisciplinary nature of the programs in the USG. The alliance represents variety in size, student demographics, educational mission, technical emphasis and geography.

3. To disseminate our results, experiences, assessment tools, software support infrastructure, and development process to the larger computing community. By the end of this process, we plan to provide lessons learned, software, and several examples of Threads-based computing degrees.

As detailed in Section 3, 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.

2 **Current State: Threads at Georgia Tech**

Threads are partial paths through a computing degree. They 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 both students and faculty. A thread makes its set of courses cohesive, providing an overall meaning for the set, and individual meaning for each course. A thread also 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.

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 quite significant. First, it assures that no matter what students choose, they will fulfill the requirements for an accredited 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 must every computing student take, something that becomes a practical impediment to establishing a flexible degree program. Instead, faculty seek to identify a set of threads that: (a) make sense given the emphases and strengths of their department, (b) make sense to students, including students one hopes to attract, and (c) 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
Table 1: The Eight Threads at Georgia Tech.

<table>
<thead>
<tr>
<th>Computational Modeling</th>
<th>Computing for representing the world, as in the computational sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embodiment</td>
<td>Computing within physical constraints, as in areas like robotics and real-time embedded systems</td>
</tr>
<tr>
<td>Foundations</td>
<td>Fundamental models of computing, such as computer science theory</td>
</tr>
<tr>
<td>Information Internetworking</td>
<td>Computing for storing, recalling and communicating information</td>
</tr>
<tr>
<td>Intelligence</td>
<td>Computing as cognition, its representation and processes</td>
</tr>
<tr>
<td>Media</td>
<td>Computing for expression, as in the processing, creation, and presentation of multimedia</td>
</tr>
<tr>
<td>People</td>
<td>Computing for people, including the design of human-centered systems</td>
</tr>
<tr>
<td>Platforms</td>
<td>Computing across hardware and software architectures with different characteristics and properties</td>
</tr>
</tbody>
</table>

it is the only way to meet the $\frac{2}{3} + \frac{2}{3} = 1$ 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.

Table 1 lists the eight threads currently taught at Georgia Tech. Many traditional computer science courses fall naturally into each of these threads. For example, a course in human-computer interaction (HCI) naturally falls under the People thread, and a course on robotics naturally falls under Embodiment. 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. For example, the People thread requires courses in psychology as well as allowing breadth in cognitive science, HCI and learning sciences. The Information Internetworking thread encompasses a set of management courses because understanding issues surrounding data policy is as important for the computing professional as understanding how to best implement joins in a database search. Similarly, the Embodiment thread requires courses in physics and psychophysics. Note that even though each thread draws on different requirements, in practice the total number of hours is not increased: in many institutions, classes such as psychology or physics can also fulfill other university requirements.

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 Foundations, or if she is interested in building secure distributed databases, then Platforms might make a good second thread. In the other direction, any given thread combination can lead to several careers. Consider the combination of Embodiment and People. One possible context or career focus within that combination would be social robotics, the development of robots who 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.

3 Implementation Plan

Our implementation plan focuses on adapting, extending and evaluating Threads as a national model, first by engaging four campuses in the Threads process and examining the outcomes, and second by including several additional campuses in discussions as the project unfolds. Throughout the course of the project,
workshops will be held that bring together the project partners and help ease the processes on each campus. The proposed work is driven by a desire to develop a useful model of curricular reform that integrates context throughout and aims to improve enrollment and retention and to broaden the perceived vision of computing. This section begins by detailing the process of designing and implementing a Threads-based curriculum, including description of key support mechanisms for advising students.

3.1 Designing Threads: The Process

The Threads program at Georgia Tech is the result of a long process of curriculum redesign that involved many steps. That process began in earnest more than two years ago and is still ongoing. In order for any institution to implement a Threads model fully, it must undergo four major phases:

I. Development of a local threads model. Such development includes: talking to students, faculty, and targeted industry; the conceptual work of constructing possible threads; and beginning the necessary committee work for a full-fledged curricular approval process. Required resources: the time of a local coordinator and a group of interested faculty, students, and advisors.

II. Implementation and phase-in of courses and infrastructure. Such implementation includes: formal course and curriculum development; and the construction of a permanent process for updating and modifying threads as needed. Required resources: a curriculum committee consisting of individuals in charge of each locally-defined thread as well as a chair for that committee.

III. Development of an advising infrastructure. Such development includes: developing necessary software infrastructure for (self-) advisement in exploring threads (e.g., Threadspace); developing formal immigration mechanisms for students (e.g., LEAP courses); and developing necessary advising infrastructure and committee support. Required resources: local IT support, the time of a local coordinator for the immigration courses and the participation of a set of advisors.

IV. Ongoing evaluation and assessment. Such evaluation includes: the development of appropriate evaluation instruments; and a process for carrying out such evaluation. Required resources: the time of an appropriately-trained group to develop the evaluation instruments and to gather data; and the time of a local coordinator to oversee the process.

3.2 Adapting Threads: Developing Local Models

The first step in the Threads process is to develop a conceptual model of Threads within a particular department. Departments will not be expected to adopt all, or even any, of Georgia Tech’s Threads, but rather to adapt the process to produce outcomes tailored to each department. Departments will play to their strengths and the strengths of its faculty. Members of the Georgia Tech Threads team will provide guidance for developing threads (see, for example, [12]), emphasizing the process that Georgia Tech underwent in order to instantiate change. The outcomes that result from different departments following the same process become the subject of several research questions:

- Applicability of the Process. If other campuses with different demographics, missions, and sizes attempt to undergo a similar process, will they result in similar outcomes? Is this process applicable to departments that are not strictly CS (e.g., information technology, information science)? Can the process be used to develop interdisciplinary programs? How important is avoiding the “core problem” in ensuring some measure of success?
• **Diversity of Outcome.** All other things being equal, how will Threads differ across schools? How will they be the same? Will similar departments arrive at similar conclusions or at what appear to be radically different conclusions? Are the differences substantial, both academically and administratively? How many new classes must be created? How important is the influence of local industry? What sort of resources can they provide?

Data will be gathered by each participant. A report of the different proposals, curricula, and the different administrative experiences will be a concrete outcome of the workshops.

### 3.3 Extending Threads: Implementing Local Models

Once a local model has been developed, it must be implemented; and in thinking about the implementation, many practical issues arise. As noted above and detailed below, the alliance is a diverse collection of departments. Some are CS departments, while others emphasize IT or information sciences. Some are unusually large while others are small. Some are housed at technical institutes while others are embedded within a liberal arts school. Some have a relatively stable major population while others experience a large amount of churn because of transfers in and out of their home institutions. Several questions naturally arise:

• **Transfer and Compatibility.** In practice, how different is the threads model compared to more conventional or traditional programs in computing (CS, IS, IT, etc)? In particular, will threads allow students to transfer to other universities without threads? Will threads allow students to transfer to other departments with their own different threads?

Many of the participating schools have strong relationships with community colleges. Is it possible to involve such colleges in a Threads model? The $2/3 + 2/3 = 1$ constraint of the Threads model appears to naturally create a $2 + 2$ model of education. Students begin as undeclared computationalists in their first two years and make increasingly focusing choices thereafter. Perhaps this model naturally supports community colleges. Students could transfer from a community college that didn’t follow the Threads program and still engage in Threads for their last two years. Would an immigration course still be needed for those students? Would students who have not been thinking about Threads from the beginning find the model opaque?

Some of our institutions have formal agreements with a number of DTAE (Department of Technical and Adult Education) institutions. How can a Threads model be used to prepare students from DTAE schools? Can a multi-staged Thread model still retain the current “pipelining” structure between schools such as SPSU and DTAE institutions?

• **Immigration Courses.** The immigration course described in the next section provides an opportunity to learn about computing, its interdisciplinary nature as well as the Threads program. Insofar as the course helps majors to think about computing, such a service course might bring other students into the major. To this end, are the immigration courses a useful model for non-majors? Would they be useful as a service course to community colleges, particularly those that are big feeders into the schools that are involved in this project?

• **Unifying IT and CS.** IT is a sub-area in the computing discipline with an emphasis on technology. As an academic discipline, IT focuses on meeting the needs of users within an organizational and social context through the selection, creation, application, integration, and administration of computing technologies [2]. The set of pervasive themes in IT are similar to those found in computer science—such as information security and assurance, user centeredness and advocacy, communication and leadership—but differ in some important ways.
Can a Threads model provide a unifying framework for IT and CS education? Would such a framework combine the two areas? Is there a way to create Threads just within an IT degree? There are several possible thrusts within IT that might support a threaded IT program: health care, biomedical information systems, e-government, digital forensics, entertainment computing, retail, and enterprise resource management. How about other related computing fields?

- **Unifying Computing and non-Computing.** If IT might be unified with CS under a Threads model, how about other non-computing degrees? Georgia Tech has already begun to create new interdisciplinary degrees such as Computational Music by defining a non-computing thread maintained by another department that is to be combined with a computing thread. Would it be possible to export this to other interdisciplinary degrees, such as the successful Media Computation degree [13]?

- **Resource-Constrained Departments.** How can a thread model be adopted by small (under 10 faculty), medium (10-25 faculty) and large (more than 25 faculty) departments? Does size affect institutional acceptance? Is the number of non-major service courses an issue?

In Georgia Tech’s implementation, there are eight threads. How much breadth is necessary to motivate students in careers in computing? For departments with a strong set of requirements imposed by their institutions, must depth of knowledge be sacrificed for additional breadth?

### 3.4 Supporting Threads: The Infrastructure

While Threads appears conceptually simple for students, the practical requirement of managing and exploring the space of possibilities in a threaded curriculum is non-trivial. In Georgia Tech’s case, there are \( \binom{8}{2} = 28 \) possible computing “degrees” with Threads. The cohesiveness of each individual thread is unhelpful if the students do not perceive the connection between the courses and their selected threads. In addition, academic professionals must manage the degree, integrating changes while maintaining consistency and ensuring accreditation. Threads is an ambitious application of contextualized computing, so to be truly successful, an integrated advising infrastructure is necessary. To that end, the alliance will develop systematic tools and processes that will support a high impact, strengths-based *intentional advising system* for students in the Threads programs. The approach will combine *developmental advising* and *strengths-based advising* models with newly developed *software tools*.

Developmental advising [9, 6], focuses on the unique needs of individual students as they evolve across their college careers. Developmental advising rests on several tenets:

- Advising is a continual process, with an accumulation of personal contacts that have a synergistic effect.
- The advisor’s responsibility includes attention to the student’s total experience in the institution.
- Advising is goal-related; that is, the advising process should include identification of academic, career, and personal goals as they relate to the college environment.
- Advisors should encourage students to utilize the full range of resources, services, and learning opportunities available within their institution.

Strengths-based advising, introduced by Anderson and Schreiner [20], promotes identification and intentional continual growth of one’s personal strengths. They argue that while weaknesses are to be recognized and managed, the major focus of successful students is on strengths and how they fit into choices, and motivation. There is a great deal of support for this position. Studies indicate that talent identification
and strengths development for students leads to gains in GPA, hope, and self-confidence, and declines in absenteeism and tardiness [5].

Similarly, a Gallup research survey of 2.24 million individuals in a variety of organizations concluded that organizations that emphasize the development of individual strengths and match talents to tasks do far better and nearly double their likelihood of success [4]. We plan to explore the integration of Gallup’s well-researched StrengthQuest instrument as part of our Intentional Advising tool box for Threads.

It is our intent to combine these components into a high-impact Threads-based advising process that is personalized, results in optimal placement in areas that align with student talents and strengths, and will thus promote increased success, satisfaction and retention in computing. We are focusing on two interrelated thrusts. The first thrust encompasses a set of direct individual and group-based advising experiences. The second revolves around online software support for the student as well as faculty. The goal of both thrusts is to provide continual guidance and support.

**Direct Guidance.** Advising begins immediately in the Threads model. At Georgia Tech, new computing students are required to take CS 1101 Freshman LEAP. It is a one-hour pass/fail course that meets weekly. In eight of these sessions, a different faculty member explains in some detail a different thread, its relationship to other threads, jobs, and technical research areas. Students are also divided into groups of about twenty and meet together as a cohort for the balance of the term. In these sessions they meet with a specific faculty member who talks about computing, research, education, or whatever strikes his or her fancy.

We are exploring another one-to-two hour LEAP course to be taken Spring of the sophomore year. Like CS 1101, this course would be a mechanism for students to explore their educational opportunities. Unlike CS 1101, this course would be letter grade and act as more of an early “capstone course” for undeclared computationalists. Again, faculty would be involved, and the course would provide team-based activities and hands-on exploration. There would be different sections, each focusing on a different thread. The idea is to allow students to better understand the choices before them at a critical time in their matriculation. We are exploring involving students as mentors as a part of this process as well.

In addition to the immigration courses, we also propose developing a set of non-required suggested courses. Our original efforts defined both **Threads**, describing what a student should know, and **Roles**, describing what a student might want to do with that knowledge. For example, in any Threads combination, a student might be a **Software Engineer**, perhaps a **Researcher**, or perhaps an **Entrepreneur, Communicator** or **Policy maker**. Roles are a set of activities and suggestions for students to prepare themselves for the roles that they wish to play within their chosen Threads. These courses are not required, but are useful in that they help guide students in a way that is complementary to Threads. Students are introduced to Roles in the immigration courses. Our plan is to invite students who are interested in being communicators to act as peer mentors in the sophomore LEAP course.

**Threadspace.** We propose to develop an online software system, **Threadspace**, for guiding students. For example, in one of the student views, the system presents a personalized plan for graduating under a pair of threads. A plan is a series of requirements that may be fulfilled by different courses that the student may choose. Threadspace respects temporary changes and supports what-if explorations: the student may switch threads to see how the courses they have taken or wish to take in the future are affected; they may bind specific courses to specific requirements; they may move requirements around; see which courses are likely available; and so on. The system performs ongoing auditing by never allowing the student to make an invalid choice.

The student application provides an overarching view of the student’s progress through the degree. It shows how far along the student is in fulfilling the requirements of each individual thread, including those she has not declared. It shows what courses have been completed, and what courses are planned for the future. It shows how individual courses map to degree requirements and vice versa. Figure 1 shows an early
Threadspace communicates to students the requirements behind threads, helps them to choose threads, and to plan for their entire matriculation. Although not shown here, other interfaces help instructors, advisors, and administrators to implement threads.

Figure 1: **A Prototype of Threadspace.** Threadspace could also be used to directly register for courses. Tied directly into the set of planned courses, it could further allow students to plan around likely future course availability.

Threadspace also supports advisors and faculty by providing aggregate statistics about desired courses. Just as students might be better informed about what courses will be available in the future, administrators can be better informed about how many students wish to take what courses when. Similarly, Threadspace would also provide demographics for specific courses. For example, we would like to be able to tell an instructor in an introductory course what percentage of her class is interested in each thread, so that examples and homework might be tuned to reflect the contexts of students’ interests.

Finally, Threadspace will also act as a portal and repository for community knowledge about Threads. Threadspace will hold online interest surveys; detailed information about each thread; presentations and documents used in the LEAP courses; careers associated with each thread; and so on.

### 3.5 Project Participants

There are three different groups in the Threads Alliance, each in a different phase of the curricular reform process:

1. This group has already accomplished phases I and II as well as parts of phase III. Having already developed some experience with the Threads model, this group will act as the preliminary laboratory. This group consists of Georgia Tech.

2. This group begins phase I during the first year of the grant. This group consists of Brooklyn College of the City University of New York (**BC-CUNY**) and a University System of Georgia Consortium: Kennesaw State University (**KSU**), Southern Polytechnic State University (**SPSU**), and Armstrong Atlantic State University (**AASU**).

3. This group consists of other schools that will be invited to the regular meetings of the first two groups, and will be asked to participate in thinking about how Threads might be applied in their singular cir-
Table 2: Population Statistics for Members of the Alliance. The numbers are for undergraduates only.

<table>
<thead>
<tr>
<th>Member</th>
<th>Students</th>
<th>Computing</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASU</td>
<td>6,279</td>
<td>145</td>
</tr>
<tr>
<td>Georgia Tech</td>
<td>11,842</td>
<td>968</td>
</tr>
<tr>
<td>KSU</td>
<td>18,500</td>
<td>1000</td>
</tr>
<tr>
<td>SPSU</td>
<td>4,200</td>
<td>554</td>
</tr>
<tr>
<td>BC-CUNY</td>
<td>11,172</td>
<td>300</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Faculty</th>
<th>Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18</td>
<td>CS/IT</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td>CS/CM</td>
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</tr>
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<td></td>
<td>30</td>
<td>IT/CS</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>CIS</td>
</tr>
</tbody>
</table>

3.5.1 Georgia Tech

Georgia Institute of Technology (Georgia Tech) is a predominantly Engineering school with highly rated programs in Engineering and Computing. Since Fall 1999, all students at Georgia Tech have been required to take a CS course. After four years of a relatively low success rate (only 72% of students completed the course earning an A, B, or C), Georgia Tech began offering three different CS1 courses, two of which are contextualized. The two contextualized courses enjoy much higher success rates (nearly 90%). Following on this success, Georgia Tech created and has recently implemented the Threads model, currently in its first year. With its three years of effort in developing and now deploying a Threads model, Georgia Tech is uniquely poised to lead this EAE initiative.

- Charles Isbell will be the PI, and is one of the developers of the Threads model and a co-developer of Threadspace. He will be responsible for managing the project as one of the global coordinators, will visit Group 2 and Group 3 schools, and run the workshops.
- Maureen Biggers will be a co-PI at Georgia Tech, and has several years of successful experience consulting with colleges and universities in student retention. She is a former Director of Academic Advising who has developed a nationally recognized advising program. She will be responsible for managing the efforts surrounding intentional advising and supervising the development of the corresponding assessment tools.
- Merrick Furst will also be a co-PI. As the Associate Dean of Academic Affairs and the originator of the Threads initiative, he is particularly aware of the political and academic challenges that arise in implementing programmatic changes of this scale. He will participate in the workshops and manage and support the College of Computing resources necessary to achieve Georgia Tech’s goals.
- Cedric Stallworth will be Senior Personnel. He is an instructor at the College of Computing, and is a former Assistant Director for The Office of Minority Education and Development as well as a former Associate Academic Advisor for the Athletic Association. He has co-developed the Threadspace student application and will be responsible for managing that effort.
- Mark Guzdial will act as a consultant on this project. He is the Director of Undergraduate Programs in the College of Computing; a member of the team that developed Threads; and a leader in computing education and contextualized computing in particular. He will provide advice in building assessment tools and will help us to leverage the Georgia Computes! alliance funded by an NSF Broadening Participation in Computing grant, of which he is the PI (http://www.georgiacomputes.org).
3.5.2 Armstrong Atlantic State University

Armstrong Atlantic State University offers more than 75 undergraduate and graduate degree and certificate programs in four schools and colleges, namely: College of Arts and Sciences, College of Education, College of Health Professions, and the School of Computing. Over 6000 students from Georgia, the nation and over 70 countries are currently enrolled in AASU. The Department of Computer Science is accredited by ABET (first in 1992 and renewed in 2006), and was the second institution in the state, after Georgia Tech, to gain accreditation as a department of Computer Science and among the first 100 in the US to gain accreditation. There are currently two synergistic NSF projects at AASU, namely: a CSEMS award (Computer Science, Engineering and Mathematics Scholarship Program) and a PRISM award (Partnerships for Reform in Science and Mathematics).

- Dr. Ashraf Saad will be the PI at AASU. He joined AASU in August 2006 as Head of the Department of Computer Science. He has over twelve years of experience as an educator. He served as PI and co-PI for two NSF ATE and CCLI projects. He has also worked over the past seven years in an advising capacity to several ATE projects at community colleges to advance information technology education nationwide.

3.5.3 Kennesaw State University

With a population of around 18,500, Kennesaw State University is the third largest university in Georgia. Although primarily a teaching institution, it has steadily increased its emphasis on research over the last decade. KSU serves a diverse, gender balanced student population with a large number of older and non-traditional students. Transfer applications represent slightly less than 1/3 of all applications, and transfer students represent 40% of new undergraduates. KSU’s computing education comprises both Computer Science and Information Science, the latter accounting for roughly twice the number of graduates each year.

- Pamila Dembla will be the PI at KSU. She is actively involved in curriculum development at KSU as a member of the department, college and graduate program curriculum committees. Her research and community work focuses on encouraging and enabling students with disabilities to choose careers in computing. As PI she will be responsible for working with the department and the university to investigate the adaptability of the Threads model in the CSIS curricula.

- Jose Garrido will be co-PI at KSU. He has been the coordinator of the undergraduate Computer Science program from Fall 2002 until Fall 2005. During this period the CS program was expanded and later ABET accredited. He has been engaged in computer science education research for several years. Two important projects he developed are: the KKP project to facilitate the teaching and learning of Programming principles with Java using a Preprocessor for Java, and the Psim3/PsimJ project, which provide discrete-event object-oriented simulation for C++ and Java that are used in the Operating Systems course. Garrido has written several books on object-oriented simulation and programming. Garrido will work with Pamila Dembla and other interested faculty at KSU-CSIS department to investigate how to adapt the Threads model into the KSU-CSIS curricula.

3.5.4 Southern Polytechnic State University

SPSU is a four-year public residential institution within the University System of Georgia offering day, evening, and weekend classes, and serving 4,200 students pursuing bachelor’s and master’s degrees as well as academic credit certificate programs in a variety of technology, math and science-related fields. In 2006 SPSU was ranked #1 nationwide in the number of bachelor’s degrees in engineering technology awarded
to African American students, #4 in the number of students enrolled in engineering technology programs and #5 in the number of engineering technology degrees awarded to women “Profiles of Engineering and Engineering Technology Colleges”, published by the American Society for Engineering Education.

- Ju An (Andy) Wang will be the PI at SPSU. He will be responsible for managing the project as a local coordinator. As the Chair of the IT Department at SPSU and the Membership Committee Chair for ACM SIGITE (Special Interests Group in IT Education), he has been working on IT curriculum upgrade, outcome assessment, and program accreditation. He will lead the research thrust on how to adapt the Threads model to IT curricula and establish special threads for IT students.

- Patrick Bobbie will be a co-PI at SPSU. While SPSU has formal articulation agreements with a large number of DTAE institutions in Georgia and other states, Dr. Bobbie has been working with local DTAE schools through his NSF-funded projects COPIRE and LSAMP. Dr. Bobbie will lead the research thrust on the impact of a Threads-like curriculum on the computing curriculum in DTAE schools.

- Chih-Cheng Hung will be a co-PI at SPSU. Dr. Hung has extensive experience in research and education in computer science. He and his students have been working on research projects for applying intelligent technologies to education. He will lead the research thrust on SPSU-specific threads and assessment. Dr. Hung participated in the Yamacraw research project supported by the State of Georgia from 2000 to 2004 and has collaborated with Georgia Tech.

3.5.5 Brooklyn College

Brooklyn College is public liberal arts college and one of 19 campuses that comprise the City University of New York. There are about 11,000 undergraduates, approximately 60% of whom are female and 42% are ethnic minorities. The population is also working class, holding down part-time jobs while being the first in their families to attend college. A large percentage of Brooklyn College students transfer from community colleges within the CUNY system. BC-CUNY emphasizes teaching and is an active member of Project Kaleidescope [19]. The Computer and Information Science (CIS) department has 31 full-time faculty and just over 300 undergraduate majors.

- Elizabeth Sklar will be the PI at BC-CUNY. She is currently a PI on an NSF BPC demonstration grant focusing on attracting and retaining female and minority students through introductory computing courses (NSF BPC #05-40549), and is a co-PI on new CCLI grant focusing on development of interdisciplinary science and computing courses (NSF CCLI #06-33497). Dr. Sklar is a member of the CIS department’s undergraduate curriculum committee which is actively researching computing education reform and outcomes nationwide, with the intention of implementing new undergraduate programs within the next 1-2 years. Dr. Sklar’s responsibilities for the proposed project will involve: interfacing with departmental faculty to formulate threads that suit the needs and interests of the department and BC campus, coordinating with programs in other departments to design the inter-disciplinary components of BC’s threads, and consulting with college administration.

- Ira Rudowsky is a co-PI on BC’s BPC grant. As a prior longterm employee in the New York City financial industry, Dr. Rudowsky focuses on community involvement in the BPC project. Dr. Rudowsky’s responsibilities for the proposed project will involve: interfacing with local industries to identify primary needs of employers, collecting feedback from current students and alumni about the threads program, and communicating with other CUNY campuses.
Gerald Weiss is a founder of Turing’s Craft which produces CodeLab, a web-based interactive programming exercise system designed for introductory programming classes. He is also a member of the CIS department’s undergraduate curriculum committee. His responsibilities involve: devising a transition plan that will maintain coherence between the existing program and proposed new program, particularly through the introductory computing sequence, and interfacing with departmental advisors to adapt methods of communicating threads to students (e.g., via Threadspace).

4 Coordination and Work Plan

Our proposed work involves the staged introduction of departments to each of the phases outlined at the beginning of section 3. Conceptually, groups further along in the process contribute lessons learned and expertise to others; however, it is crucial to understand that each group and each department is unique. Information must flow forward and backward in order to support the project goals. Each participating institution is an independent laboratory, will develop locally-relevant Threads and will have a local coordinator who acts as a PI and manages the responsibility of moving through the four phases of Thread development. There will also be several globally-coordinated activities. For example, each year there will be two workshops where all of the PIs meet to share experiences and report results on their efforts.

A global coordination office will oversee the entire project. In the first year, the global coordinator’s office will: (a) manage the workshops; (b) travel to Group 2 (and possibly Group 3) departments to present experiences with developing local threads; (c) collect information among members; (d) disseminate that information, particularly among the local coordinators; and (e) generally act as an administrative office. The role of global coordination will diminish as the project progresses. The corresponding funds and responsibilities will shift to Group 2 coordinators. In addition to the common interactions and duties, each of the three groups has a different set of responsibilities for achieving the project’s overall goals.

Group 1 will house the global coordination office, host workshops in the first 1-2 years, act as the preliminary laboratory for developing advisement infrastructure, and develop and implement evaluation instruments. Specifically, Group 1 will:

1. Develop and publish in year 1 a four-year plan that will clearly present the developmental advising plan. It will (a) specifically provide action items for each academic year, from year one through graduation and (b) serve to aid not only decision making but resume building and strengths development. Components will be added as they are developed and each component will be regularly assessed.

2. Create an online interest inventory that will assist students in matching interests and self-reported talents to potential Threads and Roles. This will be developed and piloted for use during year one. Ideally, this tool ultimately will not be institution specific. While it will begin at Georgia Tech, we believe that it will eventually help prospective students identify which institutions have the Thread areas they are most interested in so they can make an educated choice about college selection options. This will be especially important for schools that enjoy a large number of transfer students.

3. Develop the online Threadspace portal. The system, compatible with the USG schools “Banner” systems, will be implemented for student use in year one.

4. Continue the currently available LEAP course and, in conjunction with Threadspace, plan for more sophisticated and personalized delivery of content. Further, a second course will be explored, to be offered to students at the end of their sophomore year. Content will be packaged online for use by Group 2 (and other interested) institutions.
5. Explore the possibility of using student-coaches for later advisement to ease resource requirements, and to evaluate other cost-efficient delivery models that might work best for Threads-based advising.

6. Create a public online support community for advisors who are involved in any stage of Threads implementation.

**Group 2** begins phase I during the first year of the grant. As this is also a research project, it is also possible (though we believe unlikely) that the Threads model may not be feasible for all the members of this group. Nonetheless, each member of Group 2 is committed to implementation of phase I. Although each individual institution will have a slightly different administrative process, each will:

1. Attend workshops. As noted above, these will be hosted initially by Group 1; however, by the end of year 2, some of the workshops will be hosted by members of Group 2. In particular, we expect Brooklyn College to host workshops to facilitate the cost-effective participation of other CUNY campuses and Rutgers University.

2. Discuss new curriculum ideas with department faculty to facilitate feedback. This process will be managed by the local coordinators who will also include separate discussions for students, alumni, members of the departmental advisory board and representatives from industry (particularly local industry).

3. Begin to design threads-like curricula for individual departments. This process will be specific to each department in Group 2 but will involve the resources noted in phase I.

   By the end of year 1, each group 2 department will produce a proposal that adapts and extends the threads model locally. The proposals will be presented to all project participants at a workshop at the end of the first year. In year 2, each continuing member of Group 2 will:

   1. Continue attending workshops.

   2. Focus on having the proposal passed by the department’s undergraduate curriculum committee, the full faculty and college committees.

   3. Design orientation courses specific to the local Threads model.

   4. Begin adapting Group 1’s software support tools.

   5. Begin adapting Group 1’s evaluation instrument(s), making any necessary modifications.

   There may be some needed changes to software, evaluation and advising components. For software, Group 1 will provide any necessary assistance. For evaluation and advising, the members of Group 2 will need to maintain continuity amongst campuses for evaluation, but also capture local characteristics that may not be revealed by Group 1 instruments. All changes and insights will be presented to all participants at the workshops. By the end of year 2, curricular proposals will be approved and support infrastructure will be ready for full deployment in year 3. During year 3, Group 2 responsibilities will shift:

   1. Deploy the new curriculum.

   2. Evaluate and assess the impact of the curricular changes during its first year.
3. Recruit other schools with whom they have a working relationship and begin working with them to explore the Threads model. We are particularly interested in community colleges that act as feeders into Group 2 departments. To facilitate this, funds will be provided to host smaller, more locally-focused workshops.

Again, all results will be presented to other members of the alliance and packaged for dissemination to the larger community.

**Group 3** acts as active visitors in the subset of the workshops they choose to attend. Other than attending the workshops, and participating in the activities therein, they have no formal responsibilities. Some members of this group may begin phase I of the process by year 3.

**Funding Model.** Our funding model accounts for the different responsibilities of each Group, and the need for global coordination. The funding support for global coordination will decline sharply over the life of the grant as those responsibilities shift to the local institutions. Travel funds are held by the global coordination office but represent travel and accommodation for each of the participants as well as travel by the global coordination team. As workshops move to locations away from Georgia Tech—most notably New York—all necessary funds will be released accordingly. The budget also includes limited support for the development of Threadspace. Funds are also provided for graduate support for the initial development of assessment tools and for external evaluation of the workshops.

## Evaluation and Dissemination Plan

Evaluating a “structuring principle” is challenging and virtually impossible in the short timeline of its creation. Evidence of its impact—the response from across campus, from Georgia Tech College of Computing’s advisory board, from industry, members of the media, and students (both attending and potential)—has been overwhelmingly positive; however, a formal evaluation remains crucial. As such, there are multiple aspects of the project that will be evaluated:

- **Academic Performance.** Do students perform better or learn more because of Threads? How do we measure learning? Do we use traditional measures (grades, test scores, etc.) to measure success?

- **Personalization.** Will a Threads model lead to more personalized degree plans?

- **Post-Academic Performance.** Will Threads better prepare students for future careers? Does the Thread model create an impedance mismatch with graduate computing programs? How will students compare to traditional majors in terms of their job prospects, their advancement, and their latter year appreciation of the program?

- **Engagement.** Are students more engaged in their course work and the major because of Threads? Are course enrollments higher? What change in attitudes on the part of the students should be fostered so that they will succeed while pursuing a degree according to a Threads model? Is retention, particularly through the introductory sequence, higher because of Threads? At later stages when students must focus on a particular thread, are students more or less engaged in that process? Are they confused? What is the retention rate at each stage toward the degree? Are students more engaged in thinking about the relationships between their career choices and their courses? Which Threads are most popular and why? How is engagement impacted for women and under-represented minorities?

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1 The Georgia Tech College of Computing is committed to the continued development of Threadspace, and already provides some support for the developers. The goal here is to make Threadspace useful beyond Georgia Tech.
Data will be collected by comparing %WDF rates (percentage of withdrawals and failing grades) for students before and after the Threads model for specific courses. We will gather student enrollment/retention data with corresponding demographic information on each course each semester via an online or paper-based form to produce descriptive statistics.

- **Advisement Evaluation.** How much of any Threads success is due to the advising model? Are the LEAP courses useful to understanding the different threads? What specific elements of the advising model are taken advantage of and found most useful by students?

- **Software Evaluation.** Are the software tools developed as part of the project effective? Are they useful outside of Georgia Tech? Are they helpful for student planning? Faculty planning? Administrative planning? Is the student application for planning more or less useful than the repository of information?

- **Project Evaluation.** Is the project succeeding at its goals? Are the workshops an effective mechanism for sharing experiences? Do the participants like the workshops, or find them helpful? Are the workshops useful several months afterwards? What are they useful for? Are online materials effective for those that do not participate in the workshops? Are visits by Group 1 members useful in communicating the Threads developmental process?

All evaluation data will be reported on a schedule that maximizes its use. Ongoing performance data from feedback forms, interviews, observations, and discourse analyses will be turned around to the global coordination office as soon as it can be analyzed and communicated. Results will be reported to program staff once the data is analyzed. All data will be collated and presented at the workshops.

**Dissemination.** We have two major mechanisms for dissemination. First, we plan to hold two workshops each year. At the end of year 1 and during years 2 and 3, we plan to invite a number of Group 3 schools to participate in our discussions. We also plan to use workshops at the ACM SIGCSE (Computer Science Education) and ACM SIGITE (IT Education) conferences to present the curricula being developed in this project. Second, we plan to disseminate many of our results through publications in relevant conferences, including the ACM SIGCSE conference, the international ITICSE (Innovation and Technology in Computer Science Education) conference, and the ASEE/IEEE Frontiers in Education (FIE) conference. These are the main venues for scholars engaged in computing education. We expect to submit 2-3 papers per year in some combination of these CS Education conferences. We also plan to submit materials to the ACM Journal of Educational Resources in Computing for review of the material and dissemination at a broadly accessible (and indexed by the ACM Digital Library) level. We will have already presented an initial paper on Threads at Georgia Tech at SIGCSE [12]. In addition, the alliance will maintain a public web site as a repository and support community for other educators who are interested in implementing Threads.

### 6 Summary

This project encompasses a methodical approach to understanding the process of defining broad, flexible paths through a computing curriculum, and measuring and analyzing the outcomes of this process when applied to a variety of departments and interest groups. We will measure the impact of Georgia Tech’s implementation of the Threads model and set of supporting advising mechanisms, will facilitate, adapt and extend Threads to four diverse computing departments, evaluating its efficacy under a variety of conditions. The unique combination of talents and experiences brought together by the project team, coming from several campuses with differing personalities, promises to produce both research and implementation results with the potential to serve as national models.
References


