Piloting Pathways for Computational Thinking in a General Education Curriculum

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Project Vision

“Computational Thinking” a standard general education category in the undergraduate curriculum at all academic institutions nationwide.

Project Goals

1. To provide a viable and replicable means of incorporating computational thinking into the undergraduate general education curriculum for all undergraduate students to learn.

2. To demonstrate the intrinsic importance of computational thinking as a part of the general education of all undergraduate students to the academic administration of Towson University, and ultimately other academic institutions nationwide.
Project Objectives

1. To develop a model for creating pathways of computational thinking in a general education (GenEd) curriculum through its application in a variety of disciplines.

2. To develop a freshman level introductory computational thinking course, and two discipline-specific computational thinking courses in two distinct non-computing disciplines, based on the model developed.

3. To engage faculty from various colleges at Towson University in the development of general education “Computational Thinking” courses from the perspective of their discipline.

4. To demonstrate the kind of learning that can occur in various disciplines through the perspective of the concepts of computational thinking.
Project Outcomes

1. The Academic Administration at Towson University fostering the development of computational thinking throughout the academic curriculum.

2. Faculty from different colleges at Towson University fostering the continued development of course curricula based on the integration of computational thinking.

3. Student majors from different colleges at Towson University enrolling in and successfully completing “computational thinking” courses.
Our Model

Fall - Inform the University Community
Workshops held for each of the 6 colleges on campus

January - Faculty Submit CT Course Proposals
Provide workshop for supporting this effort

Spring - Select Most Promising Course Proposals
Provide summer stipend for full course development

Following Fall and Spring - Pilot CT Courses
Workshops held at beginning and end of summer
Used Existing Interdisciplinary Course as Exemplar

“Creative Programming and Programming Creativity — Introductory Computer Science for Artists”

Faculty member Christopher Ariza in music had developed the course for the Honors College. *Not about using digital technology.* Rather, it explored the “diverse procedural and conceptual approaches to creative expression”

As a faculty fellow on the project, described his approach of combing music and computer science at each of the six college workshops as an exemplar for those considering the development of a CT course.
Demonstrated Faculty Interest Among Colleges

**College of Science and Mathematics**
Interest from Biology, Chemistry. Math and Physics not so much

**College of Liberal Arts**
Dean of college very supportive. Individual faculty interest:
• Geology ("exactly what I’ve been trying to teach")
• Political science
• Sociology (social networks)
• English (digital humanities)

**College of Business and Economics**
• Economics
• Management
Demonstrated Faculty Interest (cont.)

**College of Health Professions**
- Kinesiology (“I don’t know how to model work”)
- Many others showed interest and saw relevance to their subject

**College of Fine Arts and Communication**
- Interest from the chair of music department. Individual faculty:
  - Music
  - Visual Arts

**College of Education**
- Interest from educational technology group
Computational Thinking Courses Developed

► **Everyday Computational Thinking**  
Department of Computer and Information Sciences (Fall 2009, Fall 2010)

► **Computational Thinking and the Humanities**  
Department of English (Fall 2009, Fall 2010)

► **Computational Thinking: Developing Life Skills for Weight Management**  
Department of Kinesiology (Spring 2010, Spring 2011)

► **Revolutionary Networks**  
Department of Sociology, Anthropology and Criminal Justice (Spring 2010)

► **Computational Thinking: Creative Work with Audio and Video**  
Department of Music (Spring 2010, Fall 2011)
# Everyday Computational Thinking Course

<table>
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<tr>
<th>Week 1</th>
<th>Introduction to Computational Thinking</th>
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<tr>
<td>Week 2</td>
<td>Computational Thinking in Everyday Life</td>
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<td>Week 4</td>
<td>Algorithms</td>
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<td>What Algorithms Can and Cannot Do</td>
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<td>Week 10</td>
<td>Cryptography</td>
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<td>Week 11</td>
<td>Social Networks</td>
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<td>Week 12</td>
<td>Computer Simulation</td>
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<td>Week 13</td>
<td>Artificial Intelligence</td>
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Materials and Examples Used

**TOPIC: Representation and Abstraction**

- Photo Art by Chris Jordan
- London Subway Map

**TOPIC: Algorithmic Methods**

- **Enumeration** – Finding which key opens a given lock
- **Greedy Method** – Packing the car for a camping trip (using biggest spaces first)
- **Divide and Conquer** – Each family member looking in different room for lost keys
- **Dynamic Programming** – When lost, trying to get home ([example](#))
- **Heuristic Method** – Should I open an email attachment?
- **Randomized Approach** – Food Co-op Member Worker Scheduling ([example](#))
TOPIC: Algorithm Analysis

Class Attendance Taking Example - Two options for taking attendance

(a) Read down alphabetized list of student names
(b) Go around the room and ask each student’s name

First approach (reading down class list)

- Read off first name on list
- Look up to see if hand raised (look around room)
- If present, then check off name on list, otherwise, call out again, “not here?”
- Continue until reach end of the class list
- Later, if unchecked names on list, repeat steps for late students

Second approach (going around classroom)

Go around room and ask each student their name.

Look up name on class list, and put a check mark

Continue until no more students to ask

Later, if late arriving students, go around the room remembering who came in late based on where they are sitting, and ask their name.

Look up name on the class list, and put a check mark next to each name
Roundtable Arrangement of Classroom Seats (ordered)

Lecture Hall Arrangement of Seats (unordered)
Analysis Results for First (Traditional) Approach

- Best case when either no student late or all students late.
- Worst case when exactly half of the students on time.

Analysis Results for Second Approach

- Average, best and worst cases the same – each the same as the best case of the first approach.
- However, this results is based on the assumption that the instructor remembers where each person who came in late is sitting. So trade off of time and space.

Assumed time units for each step

1 time unit to read name from list
3 time units to look up and see if hand raised
2 time units to find a specific name on the list
1 time unit to glance at whole list to see if any names unchecked etc.
Diverse Set of Student Project Topics

• Effective Placement of Trees in Baltimore City
• Which and How Many Colleges to Apply To
• How to Schedule Time for a Fifty-Band Event
• Optimal Location of New Movie Theater
• Seating of people at IHOP / TGIF
• Finding Your Way In Washington DC (using heuristics)
• An Automated Process for Character/Story-Line Development
Placement of Bridge Across the Chesapeake Bay

Parameters Considered

- Amount of money available
- Length of bridge needed
- Effect on local ecosystem
- Depth of the bay at various points
- Populations at each end of possible bridge locations
- Distance from population centers to bridge
- The stability of the land
- Traffic flow
Proposed Bridge from Lake Shore to Gratitude Maryland
Computational Thinking and the Humanities

Tina Kelleher, Ph.D., Department of English, Towson University

Course Description: Through classic and contemporary readings, we will investigate how computational concepts and tools can be used to deepen our perspective on and understanding of cultural artifacts and literary texts. Topics covered include among other things:

- Borges’ engagement with issues of abstraction and modeling
- Carroll’s interest in making and breaking rules for language games
- Hardy and Faulkner’s use of maps to orient their imaginative worlds
- Poe’s fascination with code, encryption and hoaxes
- Pynchon’s experimentation with the ways chance and randomness affect a subject’s search for meaning

We’ll also consider the ways using virtual environments and text-analysis tools can enable one to model a well-known Shakespeare text to place the linguistic and social exchanges that transpire, as well as a variety of dramaturgical factors and elements, into a range of perspectives that generate fresh possibilities for adaptation, analysis and interpretation (using graph, network and systems theories). Conversely, we’ll also reflect on the ways artists and writers (such as Asimov and Gibson) have explored the limitations of computational thinking for understanding human emotions and experiences.

Assignments will allow class participants to choose an assigned story, film, play or poem to blog, encode, map, model, sample, simulate, storyboard, visualize, text-analyze. Students will also have the option to redesign a database, game, hypertext, or virtual world.
Computational Thinking and the Humanities

**Course Objectives:** To introduce the ways in which computational thinking applies to and figures within various methods of “close” and “distant” reading practices, so that students can use CT ideas, methods and tools to explore and to generate a range of possibilities for analysis and meaning making.

**Additional Objectives/Outcomes:**

1. To apprehend how a range of text-analyses methods and tools can be used for humanistic inquiry.

2. To apply basic graph, networks and systems principles, to place representational dynamics into perspective.

3. To design, use and work with various mapping and modeling tools.

4. To learn how algorithms can be used to delimit and test generic conventions and to generate language experiments.

5. To develop an understanding of challenges associated with applying technology in the arts and humanities.
Computational Thinking: Developing Life Skills for Weight Management

Gerald Jerome, Ph.D., Department of Kinesiology, Towson University

Course Description: This course explores obesity and healthy weight management from a public health perspective. It reviews scientific evidence of the impact of obesity and evidence based approaches to healthy weight management. Students will also develop a basic understanding of computational thinking and how it can be applied to develop a better understanding of the relationship between individuals, behaviors and the environment as it relates to healthy weight management.

Course Objectives: Through oral communication students will demonstrate an understanding of the general concept of computational thinking. In addition they will demonstrate the application of computational thinking in a series of projects designed to examine the interaction between people and the environment as it relates to healthy weight management.
Revolutionary Networks

Samuel Collins, Ph.D., Department of Sociology, Anthropology and Criminal Justice, Towson University

Course Description: This course will introduce a variety of tools drawn from the computer and information sciences. Computationally, networks can be described, constructed and predicted. Through anthropology and cultural studies, we can begin to understand the way people think about networks—their possibilities and their relevance for the constructed of identity and social life. The goal is to give students an introduction to both computational and non-computational methods for studying networks in order to provide a robust characterization of the network as a pervasive, cultural form, and to do so in such a way that students are able to generate their own, variously hybridized approaches.

Course Objectives:

• Discuss the social and cultural characteristics of networks.
• Demonstrate the ways in which networks allow people to form connections with each other in a variety of contexts.
• Be able to analyze networks using concepts drawn from the social sciences and from the computer sciences.
• Utilize models for understanding computer-mediated social networks (e.g., small world, random network, etc.).
• Understand the challenges involved in scaling social network analysis for web-based social networking.
• Construct visualizations of computer mediated social networks using different techniques (e.g., sociograms).
• Understand the usefulness of computation in: 1) solving problems posed by social networks and 2) suggesting alternatives to existing computer-mediated social networks.
Computational Thinking: Creative Work with Audio and Video Using an Integrated Software Environment

William Kleinsasser, Ph.D., Department of Music, Towson University

Course Description: This is an interdisciplinary seminar-based exploration and hands-on introduction to computational thinking applied to creative problems using software that integrates audio and video data and processing. The course introduces students to thinking in terms of how sounds and visual information can be represented, interconnected, and developed for creative and expressive uses within the context of computational data and abstractions. The course does not require any previous programming experience and/or background in musical notation or music theory.

Course Objectives: As a result of this course students will be able to:

• demonstrate understanding of computational thinking principles as applied to the creative use of interconnected multimedia.

• demonstrate understanding of basic principles and methods for input, control, interconnection, and output of audio and video information based on recorded data and rendered output models.

• demonstrate understanding of how sonic and visual information can be modeled through analysis, decomposition, abstraction, and alternate forms of representation in computational systems.

• demonstrate the ability to design basic audio, video, and graphic processing systems in Max/MSP/Jitter.
Assessment / Implementation Evaluation

Informational meetings held for all six of the undergraduate degree-granting colleges on campus. **Number of departments represented within each college:**

- College of Science and Mathematics: 60%.
- College of Liberal Arts: 38%.
- College of Health Professions: 60%.
- College of Business and Economics: 17%
- College of Education: 17%
- College of Fine Arts and Communication: 33%
Assessment Informational Workshops

Computational Thinking
Informational Meetings Survey:
Mean Response

- Not interested in submitting now, but I might consider doing so in the future.
- I am interested in submitting a course proposal for consideration in this project.
- I am interested in applying computational thinking to my discipline.
- I now have a clear understanding of what computational thinking is.
- I have a clear understanding of what computational thinking is, because I attended

Strongly Disagree | Strongly Agree
Course Development Workshops

First Computational Thinking Workshop: Mean Response

- Might submit in future
- Plan to submit a course
- Workshop explained Seminar...
- Know what is needed to develop a...
- Clear post understanding
- Clear Prior understanding

Strongly Disagree | Strongly Agree
## Progress Evaluation – Courses

<table>
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<tr>
<th>Instructor</th>
<th>At Least 75% of Class</th>
<th>Findings</th>
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| Dierbach   | Yes                   | • Students had some difficulty in beginning of course understanding concepts/relevance of concepts  
              • Lectures could be formatted in a different way to highlight key concepts  
              • Active learning assignments were the most effective  
              • Lively discussion around key concepts should be encouraged  
              • Students demonstrated growth in subsequent assignments |
Student Results and Feedback AY 2009-2010

- Completing Students Passing Class: 100%
- Students Enrolled in Class: 100%
- Students Completing Class: 94%
- Students Who Would Recommend Class to Others: 90%
- Students Who “Enjoyed” Class: 90%
- Students Who Sited Some Level of Confusion in Class: 45%
Percent of Administrators Agreeing or Strongly Agreeing

- I would recommend CT courses to other colleagues on other campuses.
- My experience with the CT project has been very positive.
- I would recommend CT courses to other colleagues on campus.
- Courses in CT should NOT be limited only to the sciences or mathematics.
- Courses in CT should NOT be limited only to honors courses.
- CT has a role in general education.
- The concept of CT is a good match with the requirements of discipline based curriculum.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Introducing Computational Concepts in the High School Curriculum

Received an RET (Research Experiences for Teachers) supplemental funding to involve high-school teachers.

• **The first year was spent:**
  – Mapping CT concepts to high school Algebra and Geometry topics
  – Piloting modules with slides and exercises
  – Teachers attending regional workshop and meetings at TU

• **The RET is being further revised:**
  – Development of resource papers with CT concept background, examples, exercises, and discussion questions
  – Mapping resource papers tightly to course modules
  – Detailed feedback and meetings with teachers
  – Assessment in class exams

• **Currently:** 2 mathematics teachers involved
• **Goal:** Standardize resource papers involving multiple teachers across schools in the Baltimore County School System
Further Information

More project information and resources at http://triton.towson.edu/~compthnk

Forthcoming paper in the SIGCSE 2011 Proceedings
Questions?
Linked Slides Following
Finding your way home an example of dynamic programming

(back)

Recalling where have been already

familiar territory

7-eleven

home
A food co-op needed to have at least two workers in the co-op at any time. Members of the co-op volunteered to work a few hours each week to get members’ prices. There were problems with this approach, however. Too many times members who signed up for a given slot, showed up late, did not show up at all.

The co-op discovered that a better approach was to just let workers show up whenever they felt like it. Based on a simulation, this can work out better for the co-op, but at the inconvenience of each member, since there are times that they may show up and are not needed.
Geographically Correct London Subway Map (next)
Topological Map by Harry Beck in 1931 (back)