Τέχνη : Introduction and Overview

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Project Team

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What does Τέχνη mean??

- Τέχνη is the Greek word for *art*.
- It is also the root of the word τεχνολογία, the Greek word for *technology*.
- Τέχνη is also the name given to a multi-year endeavor that has been funded by the NSF since 2003.
- One goal of the Τέχνη project is to re-establish the connection between art and technology and in so doing to improve *learning* in undergraduate computing curricula.
- We believe that *design* in the artistic sense promotes *computational thinking* in our problem domains.
The Τέχνη Vision

We envision a curriculum that

- attracts, retains, and challenges the very best students,
- motivates average students and provides them the skills they need to contribute to the rapidly changing computing field and,
- inspires faculty to stay abreast of leading-edge applications of computing.
In June 2007, the Téchnη project received three years of additional funding from the EAE (Extension, Adoption, and Evaluation) component of the CPATH program of the NSF. This funding will support:

- Extension of the Téchnη approach to upper division courses at Clemson
- Adoption of elements of the Téchnη approach at partners WCU and UNC-W
- The development and application of more rigorous evaluation (assessment) mechanisms

Elements of Téchnη have also been employed at Covenant College and Bob Jones University.
Underlying Theories of Learning

The Τέχνη approach is based upon a blending of

- Piaget’s constructivism melded with
- the cognitive apprenticeship as described by J. R. Anderson, Bandura, Vygotsky and others.
Useful knowledge must be constructed by the learner

Software development skills, like piano, golf, or welding skills must be learned and truly can’t be taught

But an appropriate level of “directional guidance” and support in problem resolution is essential for correctness and efficiency of learning (as in piano, golf, and welding).

Repetition (practice) is essential for reinforcement and the long-term retention of knowledge.

Codelab from TuringsCraft is a fine tool to support this
Other Approaches to Constructivism

All constructivists don’t share a common world view.

- For example, the "new New Math" a.k.a. "Everyday Math" (http://www.lit.net/orschools/) tended to favor unguided (or self-guided/peer-guided) constructivism.

- From the Τέχνη perspective, self-guided or peer-guided construction of knowledge promotes (at best) VERY inefficient learning.

- Everyday Math proponents may consider Τέχνη "bogo" constructivism because the importance we place upon guidance interferes with the "construction" process.
The Ῥεχνη approach

- Problem based instruction with problems taken from the visual domain
- Other domains certainly possible – aural proposed in Ῥεχνη I
- The focus is upon understanding and computational modeling of physical systems
- NOT “TEACHING GRAPHICS”… no graphics API’s or libraries are used in any Ῥεχνη course
- Semester long open-ended projects that motivate the use language elements and programming techniques.
- The architecture of the solution is provided by the instructor.
- The students construct the details of the solution.
- This approach is consistent with the cognitive apprenticeship as described by J. R. Anderson, Bandura, Vygotsky and others.
Open-ended assignments provide a mechanism that

- Challenges best students
- Provides a path to success to the average student
- Encourages creativity and computational thinking
The present Τέχνη curriculum

- CS1 - C / programming with digital image transformations
- CS2 - C/C++ / advanced C and basic C++ with raytracing
- CS3 - C++ / data structures - Problem domains have included surface reconstruction, photon mapping, and advanced raytracing.
- CSn - Database management systems – The MeTube projects
- non-CS Introductory programming for non CS majors
**CS 1 objectives**

Learning objectives are not radical. At the end of the course the student should understand:

- how the (extended) von Neumann machine operates
- how to create instances of basic data types
- how to set and reference values
- the implications of stack and heap residence
- the use of arithmetic and logical operators
- the use of looping and conditional control flow mechanisms
- how to create and manipulate arrays
- how to use formatted, byte, line/string, and block I/O facilities
- how to create functions and use them to partition a problem
- how to use dynamic memory allocation and pointers
- how to create and use hierarchically structured data types


**CS 1 problem domains**

- The C Language is used in CS-1 because it can be directly mapped to the von Neumann architecture.
- Introductory problems in counting, searching, accumulating, and recurrences.
- Writing and reading of ppm image files.
- Basic parsing of small regular languages.
- Basic image manipulations including: resizing, tiling, conversion to grayscale, gamma correction and monochrome conversion.
- More difficult image manipulations including: procedural blending, convolution filters, compositing and transfer of color scheme from one image to another.
CS 1 image manipulation language

sobel
{
    in0 in0.ppm
    out tmunson.sobel.ppm
}

bright
{
    in0 tmunson.sobel.ppm
    out tmunson.sobel3.ppm
    factor 1.2
}
The student should understand

- use of function pointers
- use of tables of function pointers to eliminate switch()
- use of function pointers is C "objects" to provide polymorphism
- use of hierarchical structures linked with void * pointers to simulate inheritance
CS 2 language objectives - C++

The student should understand

- that objects are a natural generalization of C constructs
- how to create and use instances of C++ classes
- how to make use of polymorphism and inheritance to minimize code duplication and facilitate reuse
- how to use C++ I/O facilities
- how to override operators in C++
- the use reference parameters in reducing the risk of pointer problems.
**CS 2 problem domain**

- Basic linear algebra operations: vector add, subtract, scaling, length; dot product, cross product, projection
- Use of rotation matrices as linear transforms in 3-D space
- Construction of generalized parsing routines
- A basic C language ray-tracer including sphere, infinite plane, and finite-plane objects with ambient lighting
- A C++ raytracer with support for tiled, textured, and procedural planes, boxes, surfaces of revolution sky, diffuse and specular point light sources, projector light sources, partial transparency, and refraction.
camera cam1
{
    pixeldim  800 600
    worlddim  8 6
    viewpoint 4 3 16
}
material green
{
    diffuse 1 9 1
    ambient 2 2 2
    shininess 100
}
light sun
{
    location 1 12 -18
    emissivity 100 100 100
}
spotlight red
{
    location 2 6 1
    emissivity 100 100 100
}
CS 2 - Projected textures - Tram Bethea
**CS3 - Data structures**

- Solve problems that are intractible with naive structures
- More depth (but less breadth) than traditional courses

Problem domains have included
- Surface reconstruction from point clouds
- Photon mapping
- Raytracing of scenes with millions of objects
CS 3 - Raytracing a "real" tree - Greg Stabler
Database management systems

Development of a multimedia database system modeled on the popular YouTube system built on:

- Apache web server
- PHP for server side scripting
- MySQL relational DBMS

Project milestones include

- Entity-Relationship Diagram (5th week)
- Schema and SQL statements for creating the DBMS and populating tables
- Functional requirements and SQL queries
- Working website with PHP scripts
- Live demonstration
Personal perspectives

Rule 1: to help, or at least to do no harm.

I strongly believe that the Τέχνη approach:
- Does not violate rule 1.
- Has inspired many of our best students to achieve at level FAR BEYOND that which was previously the case.

I tend to believe that the Τέχνη project
- has helped motivate and retain capable students
- has helped students who should have chosen another major do so after only one semester!

(Some) quantitative measures of are available in the papers on the Τέχνη web page.
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