Warm-up question

• In your own words, **what is research?**
"What is Research?"

Seminar Talk
In your own words, **what is research?**

(answers courtesy of my CS 470 class)
What is research?

- “Research is the process of finding information.”
- “Research is when you use your own time to understand and describe in words a topic you did not know about before.”
- “Looking for credible information pertaining to a specific topic.”
- “Utilization of academic, peer-reviewed publications in order to better understand or solve a problem.”
- “It's taking concepts or ideas and collecting valuable information pertaining to it, with some fact checking of course!”
What is research?

- “Working at the edge of knowledge in a field attempting to push that frontier a little further with your work.”
- “Thorough investigation into a subject, with the end result of finding new information.”
- “Research is building on the work of others on a topic of the researchers choice to posit new arguments and find new discoveries that might interest yourself or the general public.”
- “Learning new things then doing those things then writing about those things.”
What is research?

- The former is **secondary** research
  - Wikipedia: "summary, collation and/or synthesis of existing research"

- The latter is **primary** research
  - OECD 2015: "creative and systematic work undertaken to increase the stock of [human] knowledge"
  - Goal: **novelty**!
  - Many subcategories:
    - Purpose: theoretical vs. applied
    - Target: formal vs. natural vs. social
    - Methodology: scientific vs. historical vs. artistic
Knowledge (visualized)

all current human CS knowledge

based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/
Knowledge (visualized)

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Knowledge (visualized)

all current human CS knowledge

M.S.

based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/
Knowledge (visualized)

all current human CS knowledge

specializing

based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/
Knowledge (visualized)

all current human CS knowledge

publish a paper!

based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/
all current human CS knowledge

world expert in topic XYZ!!

based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/
Knowledge (visualized)

all current human CS knowledge

"wait, you're still in school?!?"

based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/
Knowledge (visualized)

all current human CS knowledge

Ph.D. (yay!)

based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/
Knowledge (visualized)

all current human CS knowledge

(the big picture)

based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/
Another perspective

- As faculty advisors ...
  - Undergrad projects: we have a reference solution
  - Graduate projects: we know a solution is possible
  - Research projects: we think a solution *might* be possible
What is research?

• “Research is the process of systematically casting a fishing rod into the unknown and hoping that you reel in something worthwhile.

Sometimes you catch nothing, sometimes you get something worthwhile, and sometimes you get something that looks worthless until it's published by somebody else three years later.

But regardless you slowly begin to learn about the world on the other end of that hook.”
If that is what, now how?

- My advisor from UVA (Bill Wulf)
  - “We don’t really know how so we use the apprentice model.”
- More detailed references
  - How to pick an advisor
    - “Getting Started in Undergraduate Research”
  - How to read a paper
    - “How to Read an Engineering Research Paper”
- What I wish I knew/organization
  - “Organizing your Research and Developing your Research Skills”
  - “Everything I Wanted to Know about CS Graduate School at the Beginning but Didn’t Learn Until Later”
Dr. Dee A. B. Weikle

Research Interests
- Education (POGIL Project, Fourth Hour)
- Workload Characterization (E-Flynn)
- Computer Architecture (FPGA Design)
Computer Architecture

**Program/Workload**

- Current Processor Design
- + New Idea

**Issues**
1. Running requires building new idea.
2. Simulation necessary…but huge.\(^7\)

**Measurements**

47 Measurements

**COMPARE**

118 Program/Workload
System Design

Victim Caches

A victim cache is a relatively small but fully associative cache placed between the L1 (data, instruction, or both) and L2 cache layers. It captures lines evicted from L1 cache memory, thereby reducing L2 cache accesses and compensating for L1 conflict misses. Their small size in comparison to other cache layers make them worth exploring for use in both high-performance and embedded systems.

Goals:
- Set up infrastructure for fpga design
- Make power measurements for each
Flynn’s Taxonomy

int binary_search( int nums[], int first, int last, int x) {
    while (first <= last) {
        int center = (first + last) / 2;
        if (x > nums[center]) {
            first = center + 1;
        } else if (x < nums[center]) {
            last = center -1;
        } else {
            return center;
        }
    }
    return -1;
}

int main() {
    int nums[] = { 1, 4, 8, 14, 17, 19, 25, 27, 29, 48, 49, 51, 53,
                  57, 79};
    binary_search[nums, 0, 15, 14];
}

Figure 2: C++ code for a binary search
E-Flynn at JMU

Kylie Davidson, Ryan Heick, and Mac Koslowski

Test Algorithms and Assembly Code:

Simple Main

```c
int main (void)
{
    int x = 0;
    int y = 2;
    x = y;
    return x;
}
```

Quick Sort

```c
void quicksort(int [], int left, int right)
{
    int pivot;
    while (left < right)
    {
        pivot = (left + right)/2;
        while (array[left] < pivot)
        {
            left++;
        }
        while (array[right] > pivot)
        {
            right--;
        }
        if (left <= right)
        {
            int temp = array[left];
            array[left] = array[right];
            array[right] = temp;
        }
    }
}
```

Bubble Sort

```c
int main (int argv, const char *argv[])
{
    int i, j;
    int array[] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};
    for (i = 0; i < 9; i++)
    {
        for (j = i + 1; j < 10; j++)
        {
            if (array[i] > array[j])
            {
                int temp = array[i];
                array[i] = array[j];
                array[j] = temp;
            }
        }
    }
    return 0;
}
```
Dr. Michael Lam
My research interests (Mike Lam)

- Program analysis (CS 430, 432)
- Systems-level software tools (CS 261)
- High-performance computing (CS 470)
- Real number representations (CS 261)

I write software tools (primarily instrumentation-based) to analyze computer programs, with the goal of improving performance or improving accuracy.

Current projects:
- **CRAFT and FloatSmith**
  Reports precision requirements for each instruction in a program
  Create mixed-precision versions of a program (binary and source level)
- **SHVAL**
  Simulates running programs with an alternate precision (e.g., double vs. single)
- **Automatic differentiation** (collaboration with LLNL)
  Rigorously quantify each input’s effect on each output
- **Less-Java** (new/upcoming collaboration with Dr. Stewart)
  New language/compiler for introductory programming
Dr. Michael Stewart

Teaches:
• Intro (CS 149 and 159)
• Interaction Design
• Web Development (eventually)
• Mobile App Development (eventually)

http://HCIentist.com
Human-Computer Interaction

Interdisciplinary research field centered around the way people use technology (or don’t) and the effects of technology use on people.

1. Gather qualitative and quantitative data about people and systems (evaluate)
2. Produce Implications for Design
3. Design
1. Evaluate (gather qualitative and quantitative data about people and systems)
EduGit

- publication, adoption, and attribution of curricular materials
- collaboration and critique of curricular materials
Process Oriented Guided Inquiry Learning in Introductory Computer Science

IntroCS POGIL

Helen Hu, Westminster College
Clif Kussmaul, Muhlenberg College
Chris Mayfield, James Madison University
Aman Yadav, Michigan State University
What is POGIL?

Model 1  Character Arrays

The primitive type `char` is used to store a single character, which can be a letter, a number, or a symbol. In contrast, the reference type `String` encapsulates an array of characters.

```java
char letter;  // letter A
letter = 'A';

char[] array;  // array
array = new char[]
        {'c', 'a', 't'};

String word;  // word
word = "dog";
```

Questions (15 min)

1. How is the syntax of character literals and string literals different?

2. What is the index of 'd' in the string above? What is the index of 'g'? In general, what is the index of the last character of a string?
Related Work (in Chem Ed)

Grade Distributions in General Chemistry

Data (n = 905) from small (~24 students) sections of three instructors using lecture approach (1990-94) prior to implementation of POGIL pedagogy (1994-98).

Performance on Organic Chemistry 2
Unannounced First Day Pre-Quiz

All students passed Organic Chemistry 1 at this institution during the previous semester.
All sections of Organic Chemistry 1 had more than 150 students.


5-Year Project in CS

**Existing Factors**
- IntroCS POGIL activities
  - enhanced activities

**IntroCS POGIL Project**
- # activities enhanced & used

**Outputs**
- better activities & learning

**Expected Outcomes**
-更好教学活动与学习
-更好的教授发展，采用与学习

**Long Term Impact**
-更方便的小众教师采用POGIL和其他策略
-更好的教授成果（动机、使用策略、有效性）
-更好的学生成果（动机、学习、保留、多样性）

**I: Activities**
- IntroCS POGIL activities

**II: Prof Dev & Support**
- POGIL workshops; faculty contexts
  - prof dev & support (teams, community)

**III: Faculty Data**
- knowledge of: learning strategies, adoption, communities, inclusion, etc

**IV: Student Data**
- surveys/interviews observations
  - surveys, etc qualitative data

# students learning outcomes

**Fig. 1: Logic Model**
Dr. Kevin Molloy
Computational Modeling of AntiMicrobial Peptides (AMPs) Characteristics

Motivation

- Reports of antibiotic resistance have increased
- The U.S. Center for disease control reports over 2 million infections and 23,000 deaths each year due to antibiotic-resistant bacteria and fungi in the US
- *Despite the urgency and the need, a slowdown is occurring* in delivering new antibiotics to market [1]

Slide adapted from D. Veltri - National Institute of Allergy and Infectious Diseases

Cycle of Antibiotic Resistance

- Bacterial proteins have a variety of 3D structures and functions

- Many antibiotics (blue) work by "docking" or interfacing with the protein (red) and blocking its natural function, resulting in the death of the bacteria

- Chance mutations in the DNA that codes for a protein can alter its shape and inhibit docking, allowing the bacteria to be "resistant" to the antibiotic

- A new antibiotic is now needed and the cycle repeats
Antimicrobial Peptides (AMPs) kill bacteria using mechanisms that are not as sensitive to the shape of specific proteins. They choose more general targets that are harder to be stopped by a few chance mutations and thus can be harder for certain species of bacteria to “resist”

Research area: Develop algorithms to simulate AMP behavior so that we can better characterize:
- properties of AMPs that make them effective
- determine which AMP is best suited to kill a specific bacterial strains
- long term: How to adapt (design) AMPs to target specific strain

The MD photo taken from Wimley, Describing the Mechanism of Antimicrobial Peptide Action with Interfacial Activity Model (2010).
Dr. Michael Kirkpatrick
Computing Ethics & Society

The Code
ACM Code of Ethics and Professional Conduct

Preamble

Computing professionals’ actions change the world. To act responsibly, they should reflect upon the wider impacts of their work, consistently supporting the public good. The ACM Code of Ethics and Professional Conduct ("the Code") expresses the conscience of the profession.
Empirical CS Education

| CS2 Grade |Factor                  | Est. | SE   | t value | Pr(>|t|) |
| --- | --- | --- | --- | --- | --- |
| Baseline (pre-2013) | (Intercept) | 1.187 | 0.234 | 5.079 | < 1e-06 *** |
| CS1/1a combined | CS1.5 Grade | 0.512 | 0.075 | 6.788 | < 2e-10 *** |
| 2013-14 | Residual standard error: 0.723 on 177 degrees of freedom | Multiple R-squared: 0.2066, Adjusted R-squared: 0.2021 |
|          | F-statistic: 46.08 on 1 and 177 DF, p-value: 1.651e-10 |

Greater learning, but difficult

“[I]t’s easier to ask your peers that are in your immediate group if you don’t understand something.”

“I would say it was harder to do things out of class, but in class was a lot more valuable time.”

Correct answers emerged from discussion

“Even if everyone didn’t know the answer exactly, like when we talk about it we somehow come up with an answer.”

“I made a joke along the lines of as a group we work really well together, but as an individual entity we all suck.”

Mixed feelings on making projects collaborative

“I mean as programmers we’re gonna be working on teams and developing software programs.”

“I think there are others that might use that as a way to cruise.”

**Figure 4: CS1.5 retention did not drop after the intervention in CS1/1a.**

**Table 4: Spearman’s rank coefficients for underrepresented minority and women students, compared with those who scored a 5; however, the difference is rather weak.**

**Table 5:**

| CS1 Grade |Factor | Est. | SE   | t value | Pr(>|t|) |
| --- | --- | --- | --- | --- | --- |
| Baseline (pre-2013) | (Intercept) | 1.187 | 0.234 | 5.079 | < 1e-06 *** |
| CS1/1a combined | CS1.5 Grade | 0.512 | 0.075 | 6.788 | < 2e-10 *** |
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**Figure 5:**

- CS1/1a after Calculus change retention rates
- Multiple R-squared: 0.2066, Adjusted R-squared: 0.2021
- Residual standard error: 0.723 on 177 degrees of freedom
- F-statistic: 46.08 on 1 and 177 DF, p-value: 1.651e-10

**References:**

Teaching & Learning

Knowledge
Change
Abilities
Attitudes
Progress
Metacognition
Practice
Feedback

LEARNING

relative to
Area of Inquiry
Application
Context
Factual Knowledge

defined as
supported by

Change

Retrieval Practice
Interleaving
Spacing Effect
Elaborative Encoding

Experiment: Learning Effectiveness

- Passive: 6.2, 6.3, 6.5
- Active: 6.6, 6.7, 6.8

- Test of learning: Passive 6.2, Active 6.6
- I enjoyed this lecture: Passive 6.3, Active 6.7
- I feel like I learned a great deal from this lecture: Passive 6.5, Active 6.8
- Instructor was effective at teaching: Passive 6.6, Active 6.7
- I wish all my physics courses were taught this way: Passive 6.5, Active 6.7
Systems Security

x = array[q];

for (i = 0; i < 8; i++) {
    start_timer();
    y = array[i];
    stop_timer();
}
Deep Learning For Games

Artificial Echolocation
Autonomous Vehicles

Malware Identification
Dr. Jason Forsyth
Wearable Computing for Health and Wellness

• Instead of going to the doctor, bring the doctor with you.

• Automatic monitoring of heart rate, blood ox, respiration rate, sleep patterns

• Analysis of walking, gait, posture to detect falls or recover from injury
Carbon Monoxide Detection

Road-side Warning

Exercise Feedback
Proposed Solution: System

Supports patient adherence to exercise regime by increasing self-efficacy.
Too Legit to Overfit

Machine Learning

HCI: Patient Feedback

HCI: Physician Feedback
Dr. John Bowers
Not your math professors 3D printer
In [24]: # Run this to view the circle packing
viewer = PolyaccumDiskViewer(300, 300)
viewer.add_all(packing.verts)
viewer.show()

In [27]: # Run this to view the circle centers
viewer = PolyaccumDiskViewer(300, 300)
viewer.add_all([v.data for v in packing.verts]
for v in packing.verts]
viewer.show())

viewer.show()
These Slides

More Info