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Learning Computational Thinking Using Open-Source Hardware-based Programming

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Learning Computational Thinking Using Open-Source Hardware-based Programming

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Outline

- Motivation
- What is Computational Thinking?
- Computational Thinking Misconceptions
- Problem Solving vs. Computational Thinking
- Proposed Hypothesis
- Study and Results
- Conclusion

Motivation

We do not acquire technical skills simply from the use of technology any more than engineering skills evolve from using automobiles or aeronautical engineering skills from flying.

Robert Tinker, Alvaro Galvis, and Andrew Zucker

The Concord Consortium

Motivation

Not everyone should be a programmer, but everyone should learn computational thinking to succeed as an engineer.

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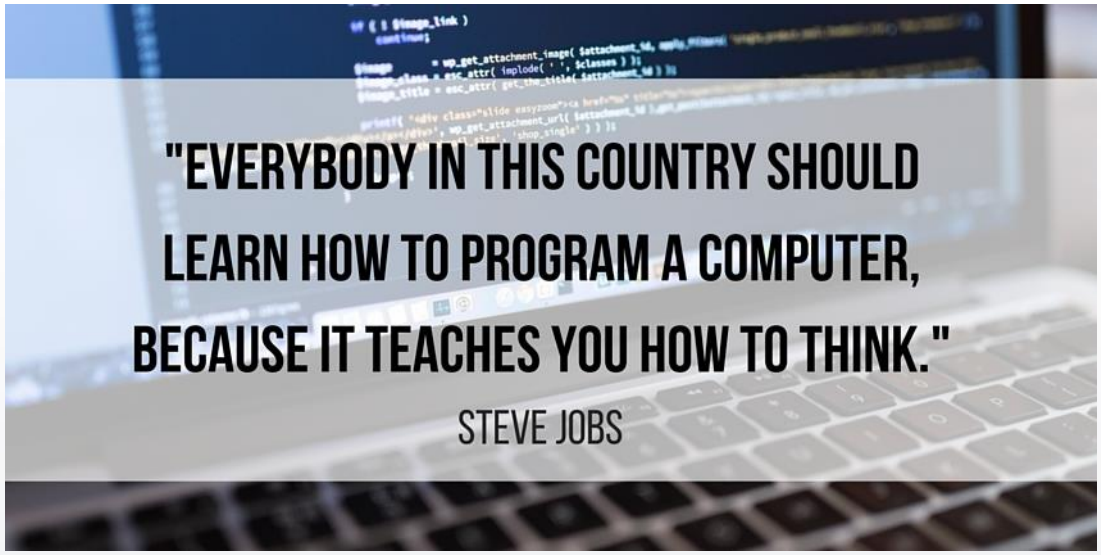

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What is Computational Thinking?

- Computational Thinking is a fundamental analytical skill that everyone can use to help solve problems, design systems, and understand human behavior.

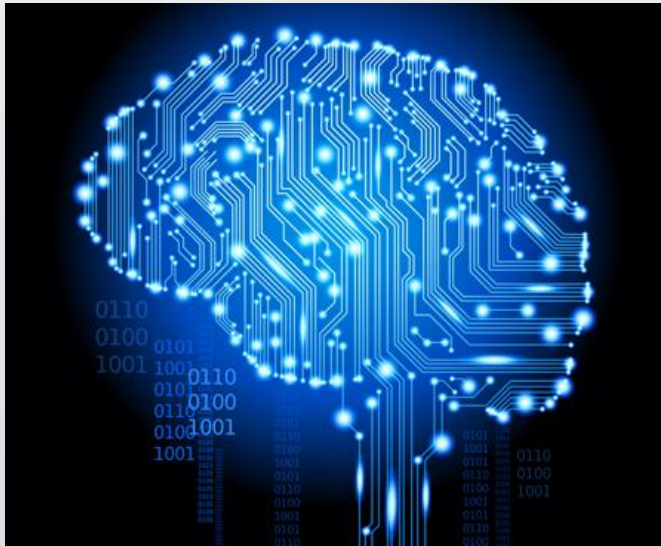
Physical Framework → modeling → **Computational Framework**

Modeling a problem involves:

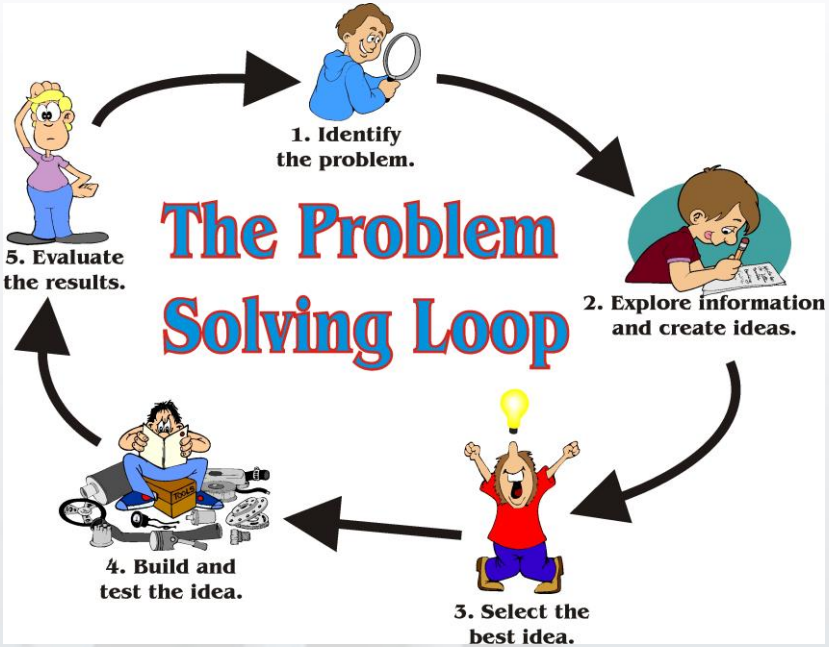
- formulating the problem,
- defining its inputs and outputs,
- dividing it into its basic components using Computational Thinking modalities.

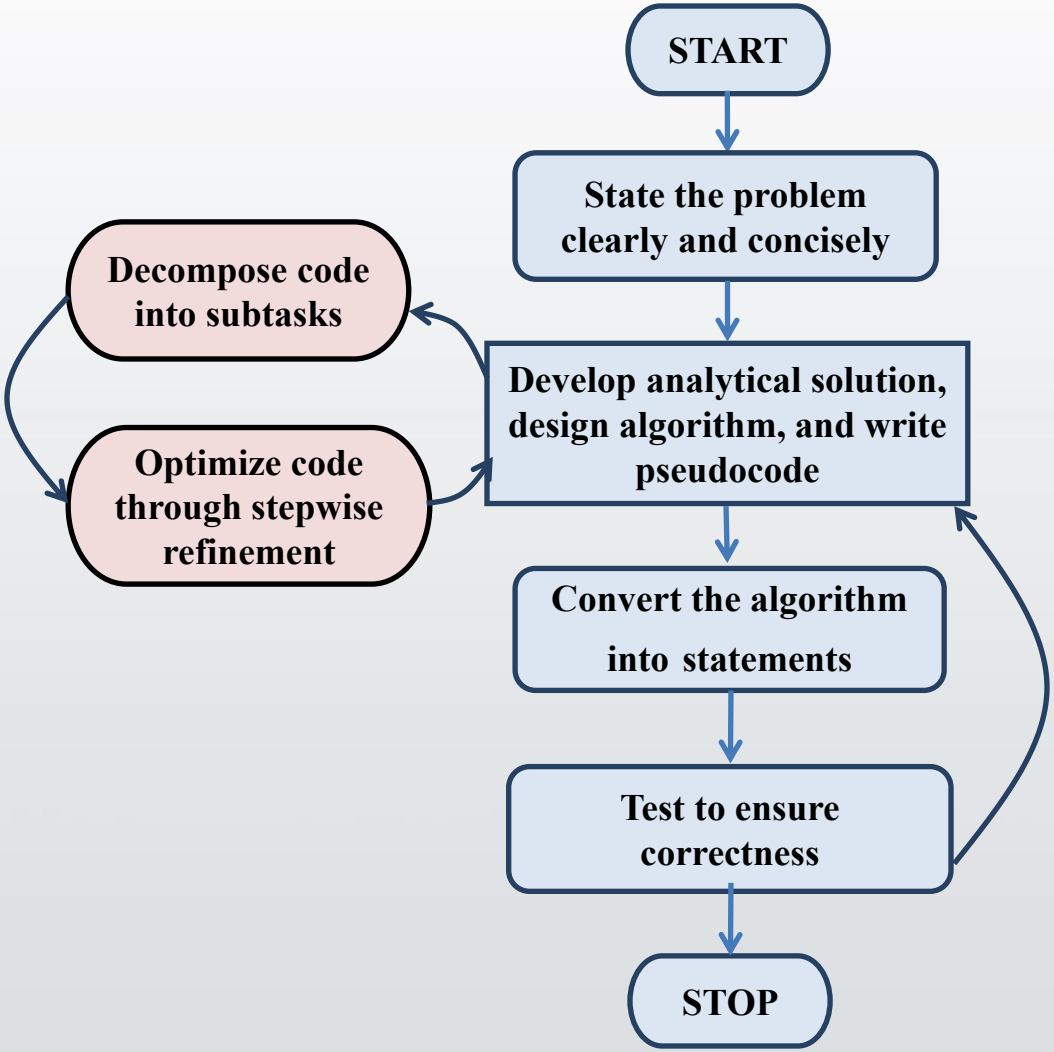
Computational Thinking Misconception

- It’s not just more technical details for using software.
- It’s not thinking like a computer.
- It’s not programming (necessarily).
- It doesn’t always require a computer.



Problem Solving vs. Computational Thinking





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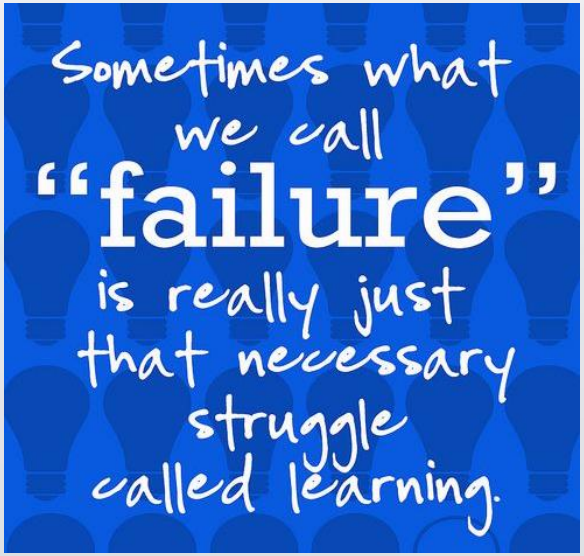
Problem Solving vs. Computational Thinking

If I find 10,000 ways something won't work, I haven't failed. I am not discouraged, because every wrong attempt discarded is another step forward.

Thomas A. Edison
1847 – 1931



Proposed Hypothesis

If engineering is very dependent on creative problem solving and Computational Thinking is a structured process that facilitates this, then Computational Thinking should be introduced using an authentic learning process that involves engineering design process.

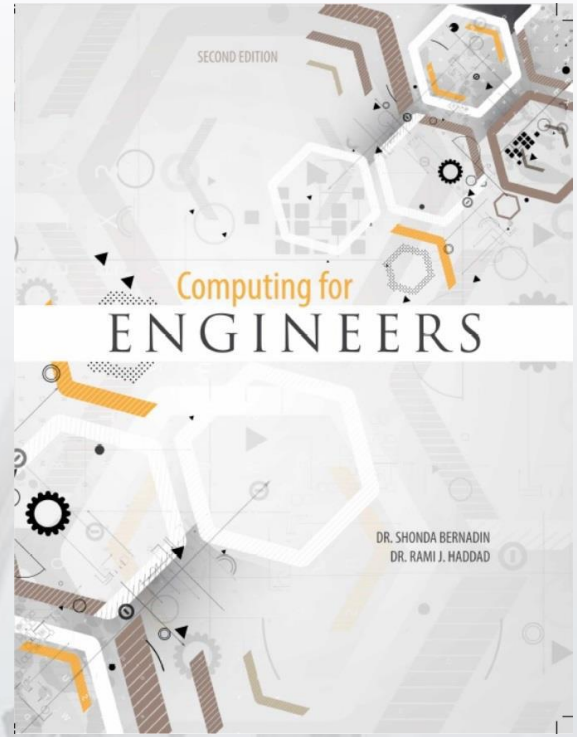
Proposed Model Implementation

- We proposed using hardware programming of a microcontroller (Arduino) to engineer a practical system/product.
- The proposed authentic learning activity was implemented in an introductory freshman course “ENGR1731 - Computing for Engineers”.
- The students’ performance improvement was directly and indirectly assessed.
- Within the two months of the course, the traditional model was used, while the authentic learning model was used for the remainder of the course.

Benefits of Proposed Model

1. Create an authentic learning environment where students can create real-world products.
2. Bridge the gap between the virtual/abstract nature of programming and the hands-on/applied nature of engineering students.
3. Address the basics of engineering principles and hands-on design at the freshman level.
4. Provides a unique opportunity for students to apply what they learned in a capstone-like project to help solidify their understanding of the topics being covered.
5. Develop the students' communication skills early-on by conducting presentations and writing reports.
6. Increase the students' overall performance and success in the course.

Course Material & Notes



MATLAB
The Language of Technical Computing

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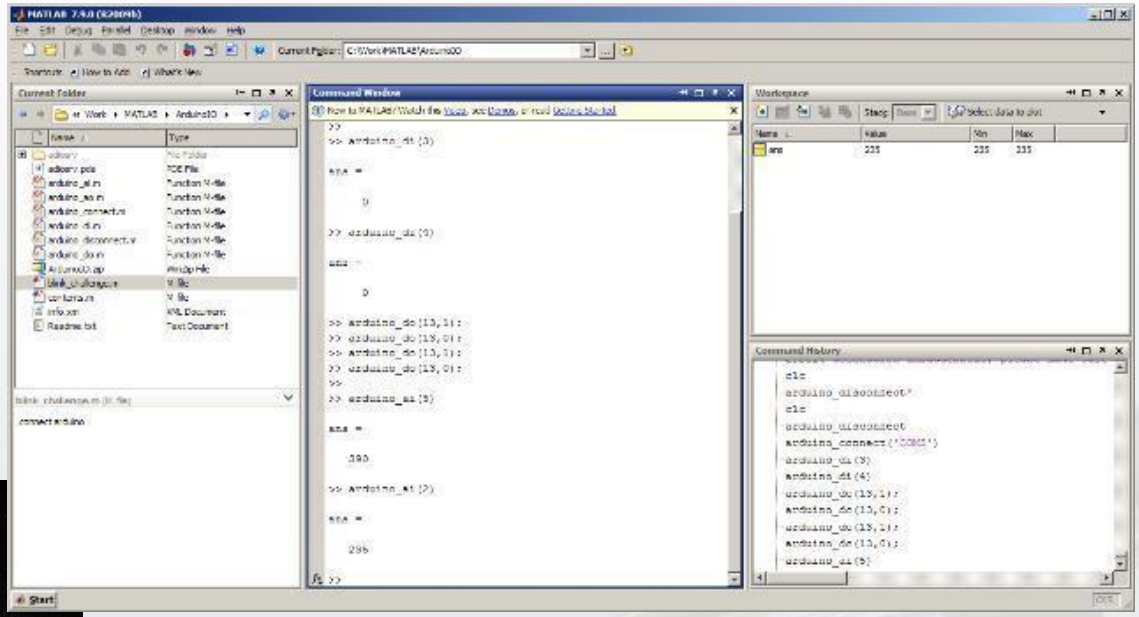
Lectures

Hardware Programming using MATLAB

Arduino board answers to Matlab via USB



MATLAB sends a command or request to the Arduino board via USB

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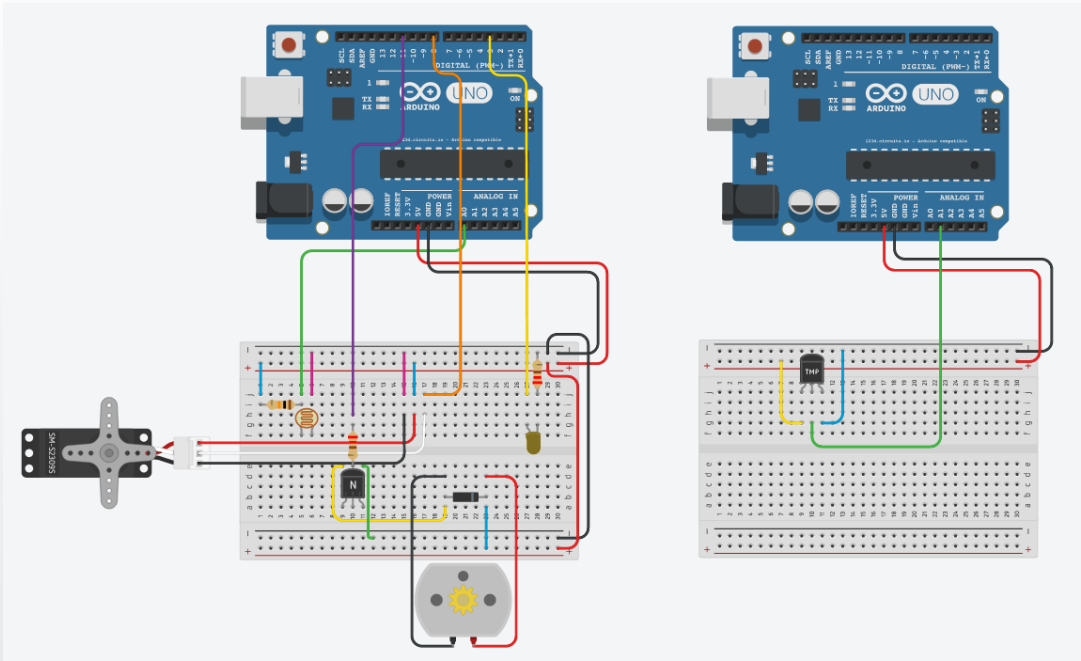
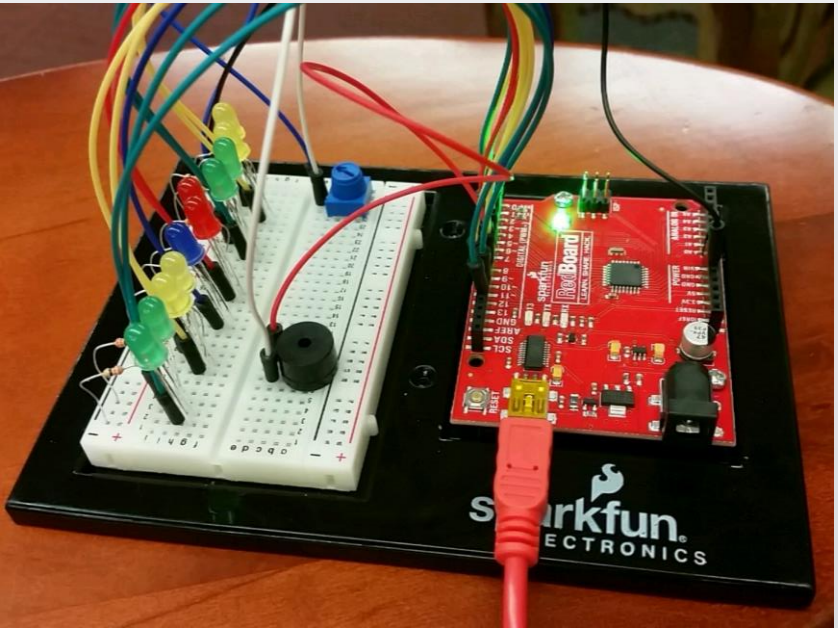
ENGR 1731 Students' System Designs





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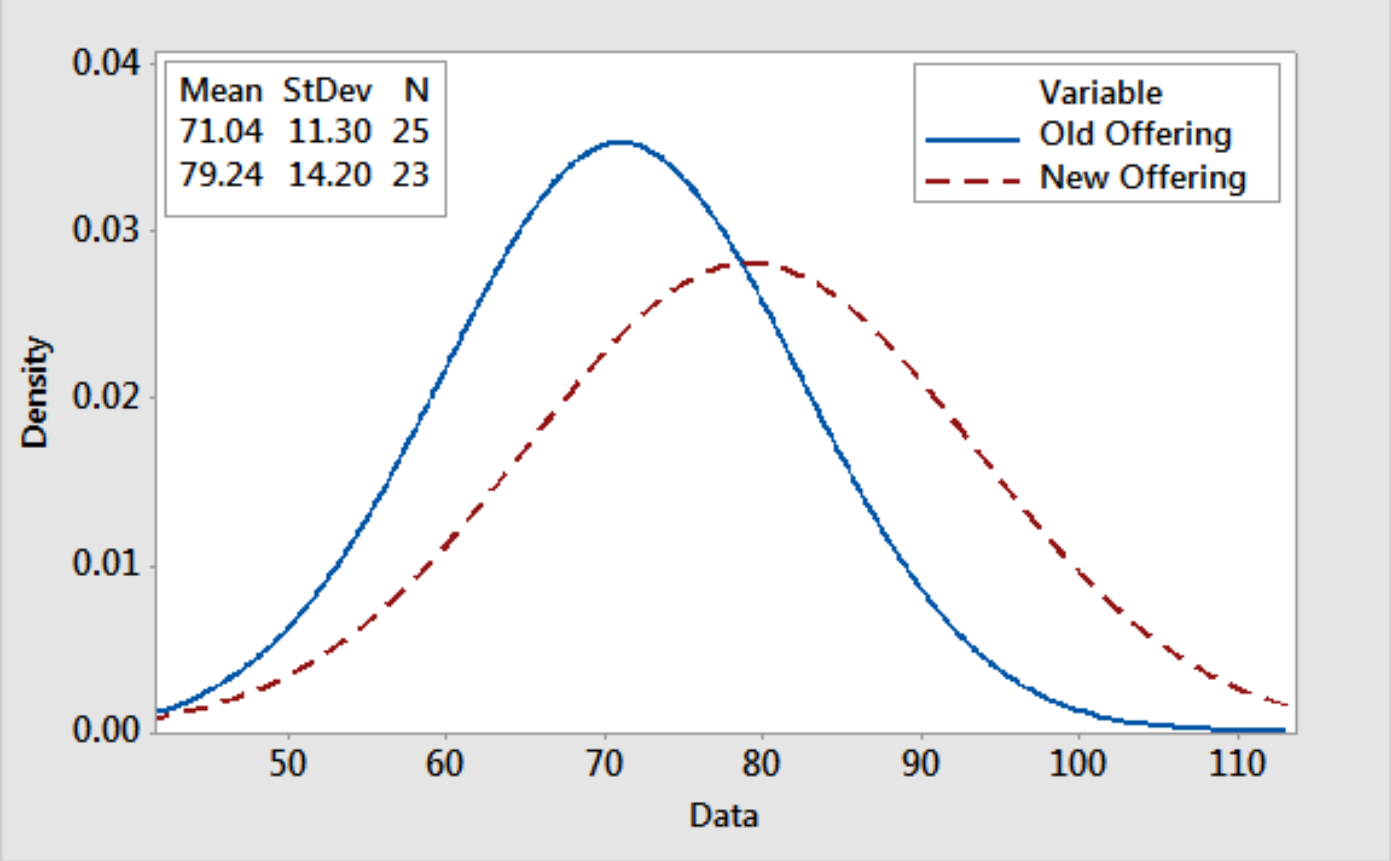
Study Details

To test our hypothesis,

- a quantitative analysis was conducted to compare 2 offerings of this Computing for Engineers course (with and without Hardware programming).

Normal Fit of Data



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The new offering with hardware programming resulted in a higher final exam mean.

Statistical Analysis Results

General Linear Model: Final Exam Grade versus Offering

```
Method

Factor Information

Factor    Type   Levels  Values
Offering  Fixed       2  Proposed, Traditional


Analysis of Variance

Source       DF  Adj SS  Adj MS  F-Value  P-Value
  Offering    1   805.3   805.3     4.94    0.031
Error        46  7499.3   163.0
Total        47  8304.6
```

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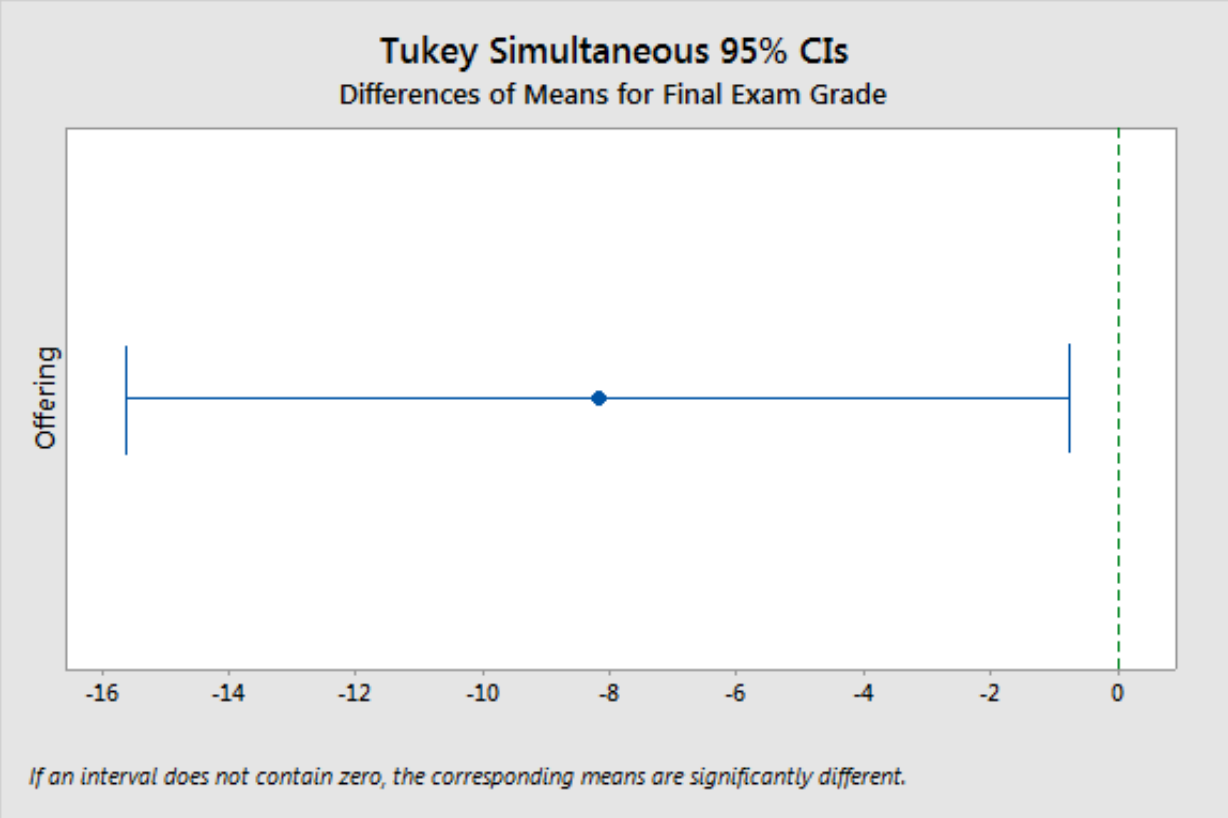
We achieved statistical significance with a confidence level of **96.9%**

Pairwise Comparisons - Course Grades



Engineering students' academic achievement represented by their Final grade highlight the effectiveness of hardware programming

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Qualitative Assessment

"I liked how useful the material is and how many helpful resources were available to learn the material."

"I liked learning coding and interfacing with hardware like Arduino. Allows me to get ahead and learn more things."

"The Arduino project was fun and the labs are good too."

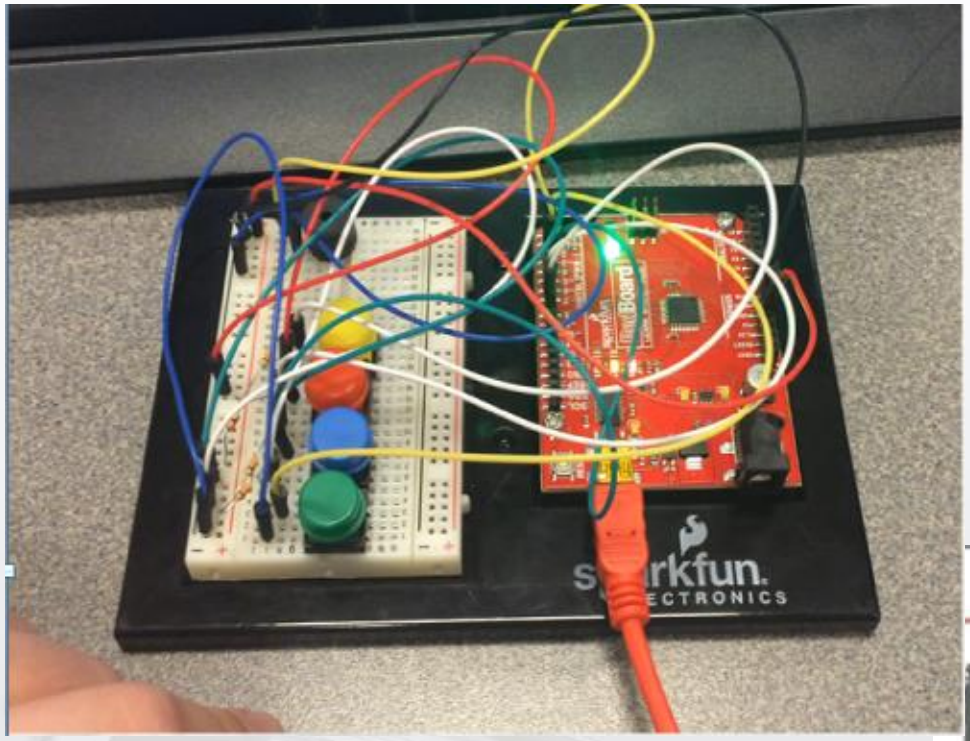
"The course itself is easy to be engaged in because it is fun to learn MATLAB and its uses (applications)"

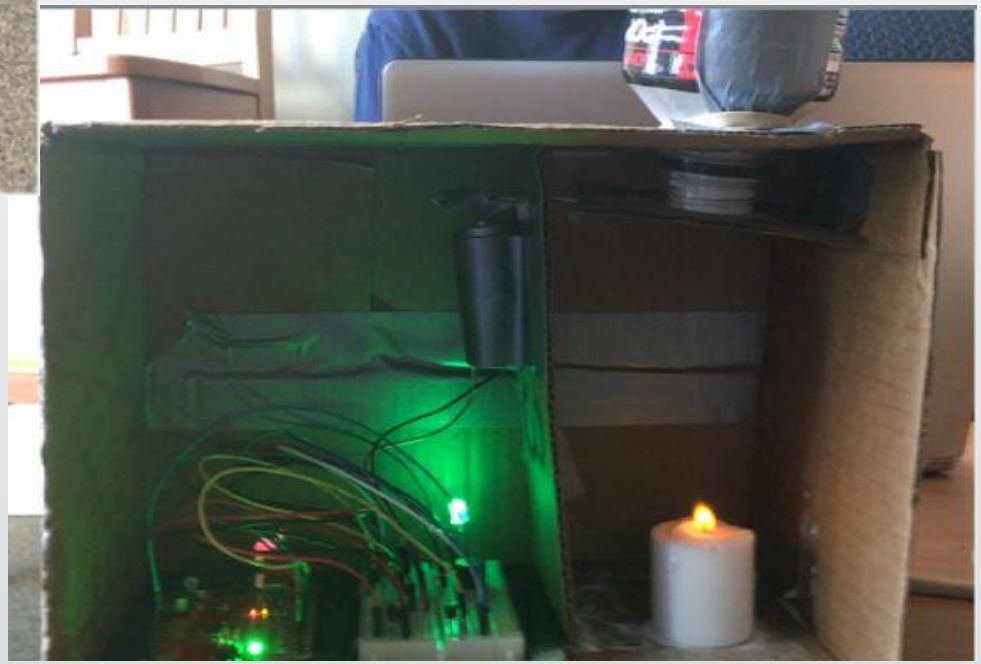
"We got to explore practical applications of what we have learned so far with sensors and Arduino board."

"The work was challenging but enjoyable."

"I liked being able to apply knowledge in real world."

Demonstration of Sample Designs





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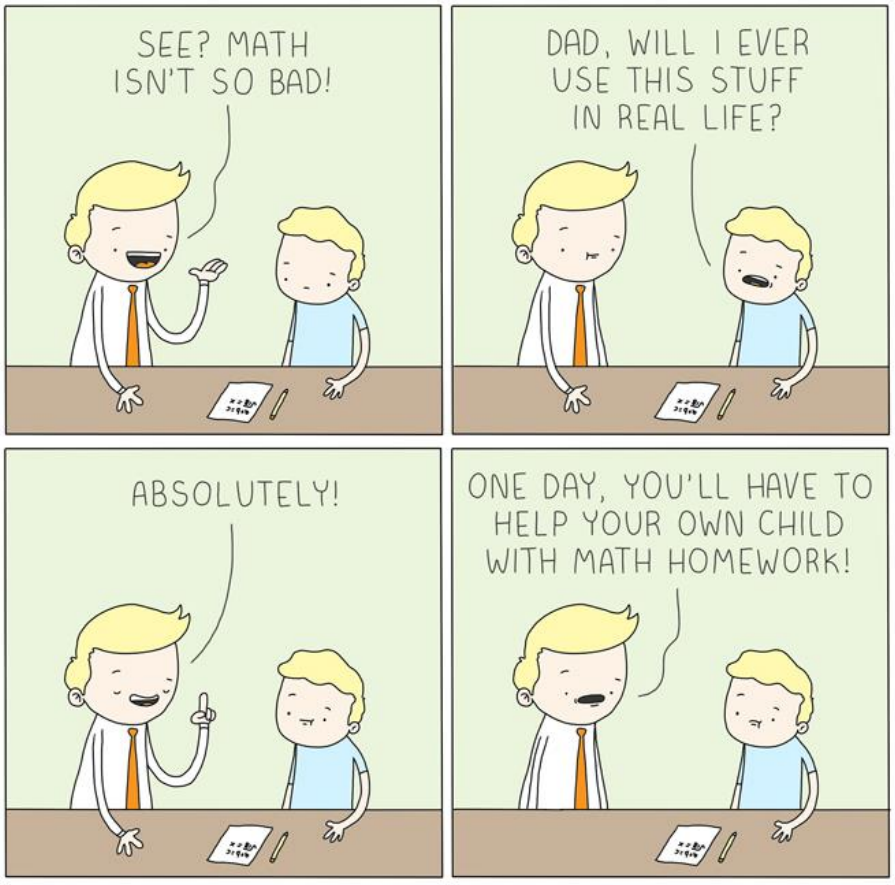
Conclusion

- A Computational Thinking authentic learning experience using hardware programing was presented.
- Hardware programming helped students better grasp Computational Thinking in a freshman course.
- We concluded that students' performance is statistical difference with over 96.9% confidence level when comparing 2 offering with/without hardware programming.

Questions?



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