Project-Based Learning Using Raspberry Pi

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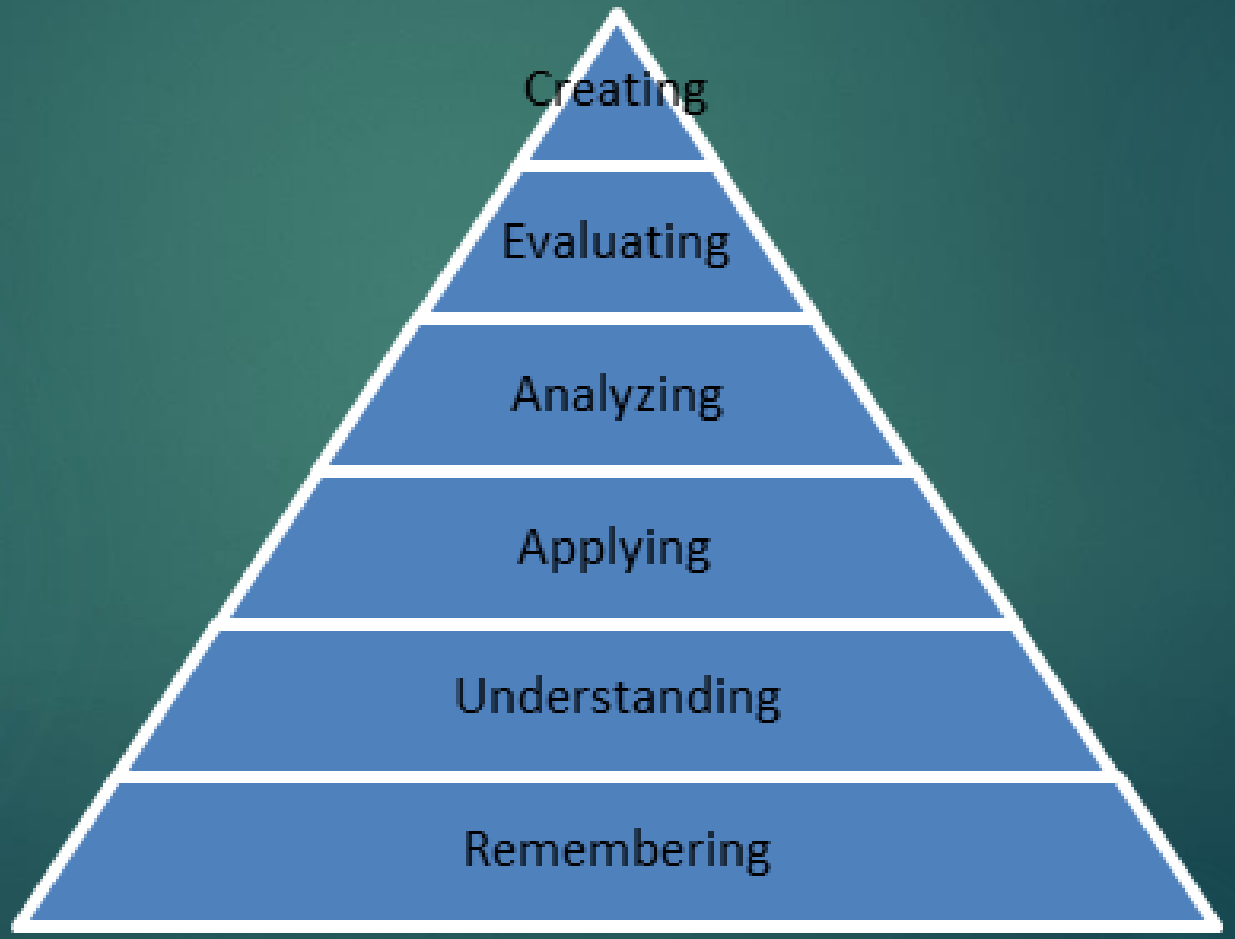
Deeper Learning

- The skills that a student must possess to succeed in the 21st century.
- There are six main competencies:
  1. Master core academic content
  2. Think critically and solve complex problems
  3. Work collaboratively
  4. Communicate effectively
  5. Learn how to learn
  6. Develop academic mindsets

Bloom's Taxonomy



Project-Based Learning

- Vehicle to apply:
  - Deeper Learning
  - Upper Level of Bloom's taxonomy

Raspberry Pi

- Has a 700Mhz processor
- Capable of reading the output from a sensor
- Contains a number of GPIO (General-Purpose input/output)
- One can easily read from or control a device using simple programs

The Assignment

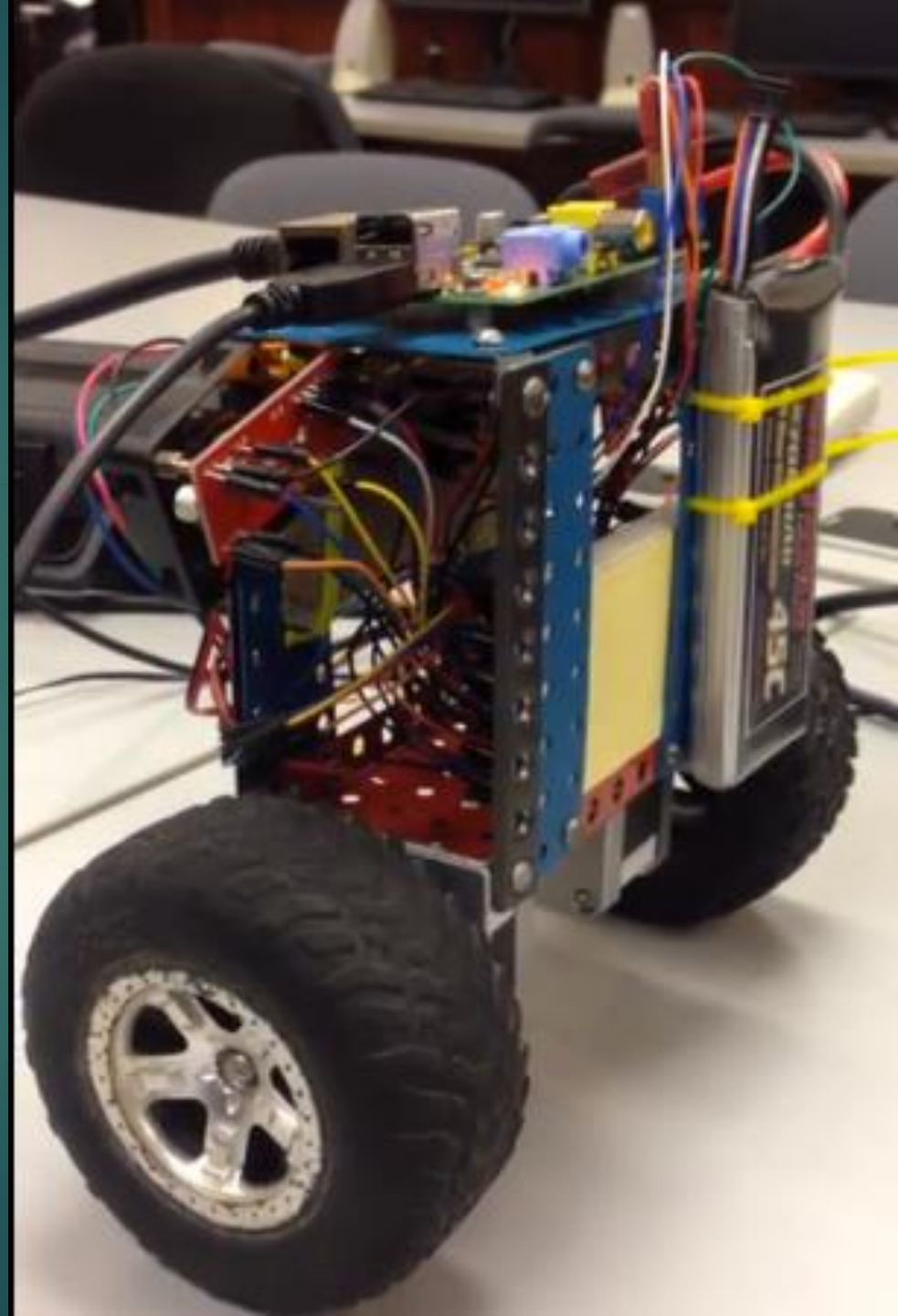
- Operating Systems course in Fall 2013.
- Perform a set of tutorials:
- Choose one of three options:
  1. Write an operating system to control a robot (or device) using the GPIO pins
  2. Enhance the operating system to be able to make graphical output
  3. Implement some Unix shell commands (copy, ls, history, cat...)
- Write a report and present project in class.

The projects

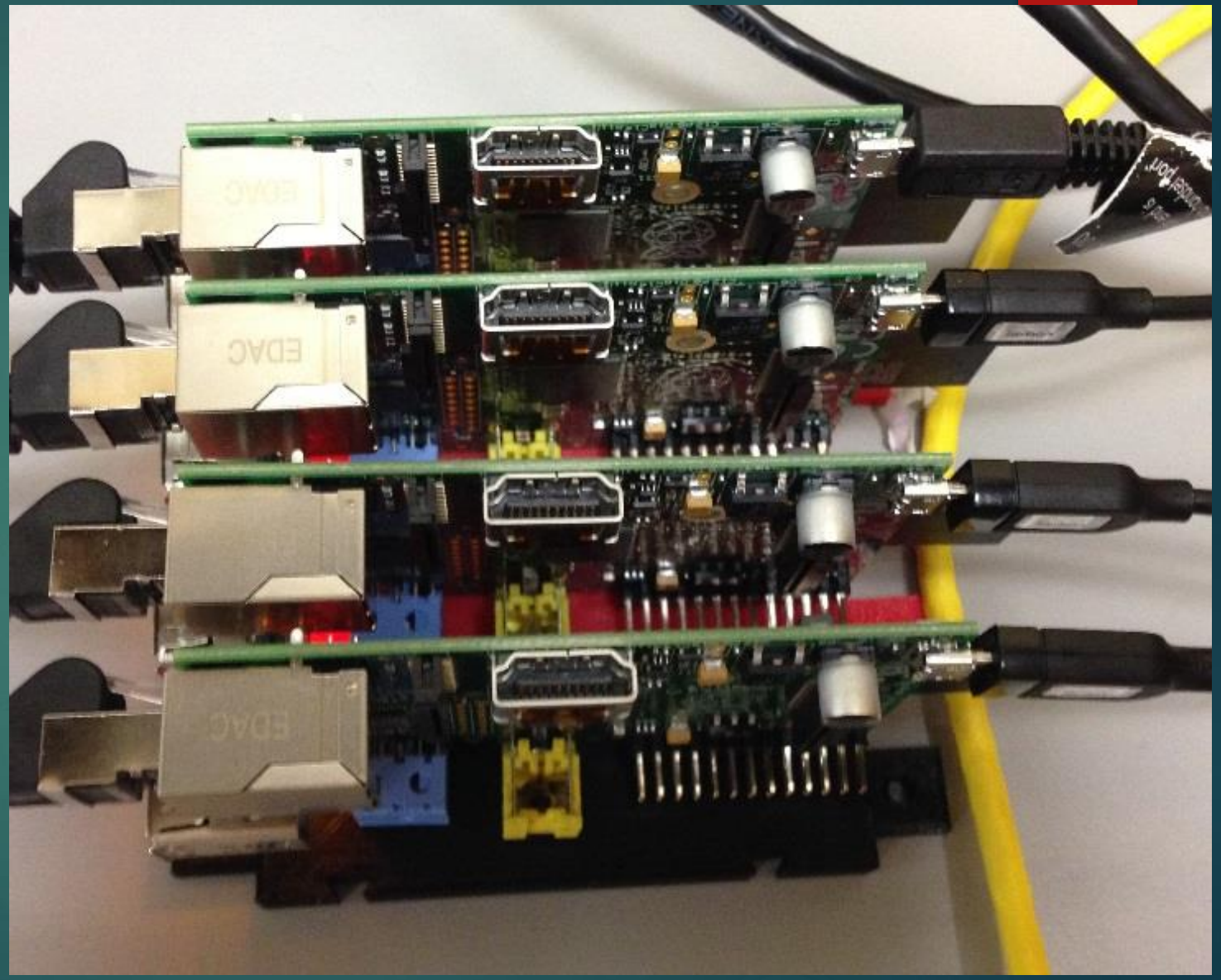
- The projects vary in the level of complexity and the time and effort that the students put into the project.
- Projects 1 and 2 were based on Option 1.
- Projects 3 and 4 were based on Option 2.
- Project 5 was a combination between Options 1 and 2
- Project 6 was based on Option 3.

Project 1

- The students used the Raspberry Pi to create an autonomous robot that is capable of balancing itself as an inverted pendulum.
- The robot dubbed RapiBaBot
- Published IEEE
  - "RapiBaBot: A Solution To The Inverted Pendulum Using a Raspberry Pi and its GPIO" Proceedings of IEEE Southeast Conference, March 13-16, 2014, Lexington, KY

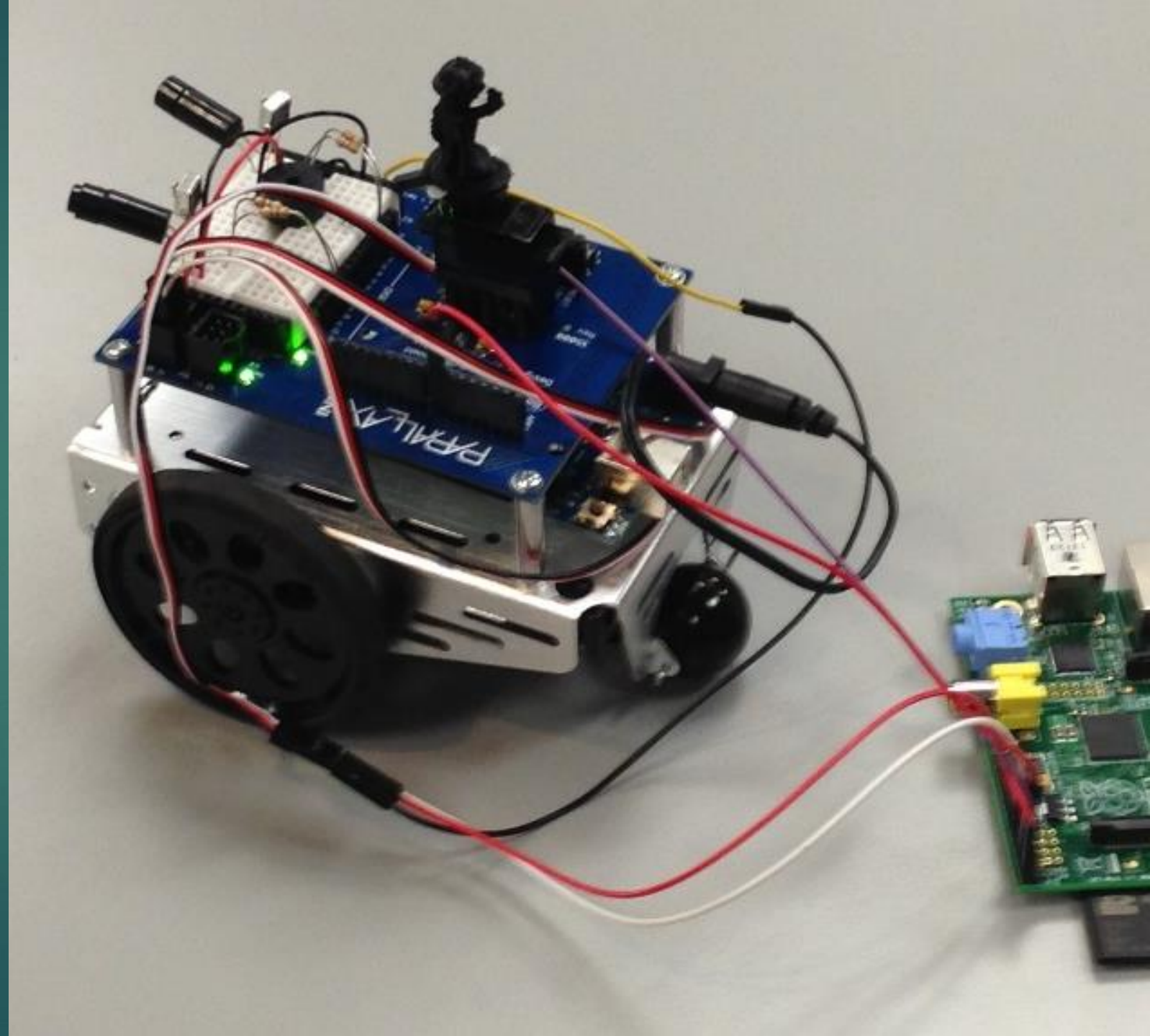


- Beowulf Cluster Using Raspberry Pi



Project 2

- The students used the Raspberry Pi and Arduino to create Combo Car
- A robot with self-preservation capabilities
- A rover robot that closely follows human users and act as an in-field assistant.
- Self defense capability.
  - close an external shell around itself when it loses track of the human user

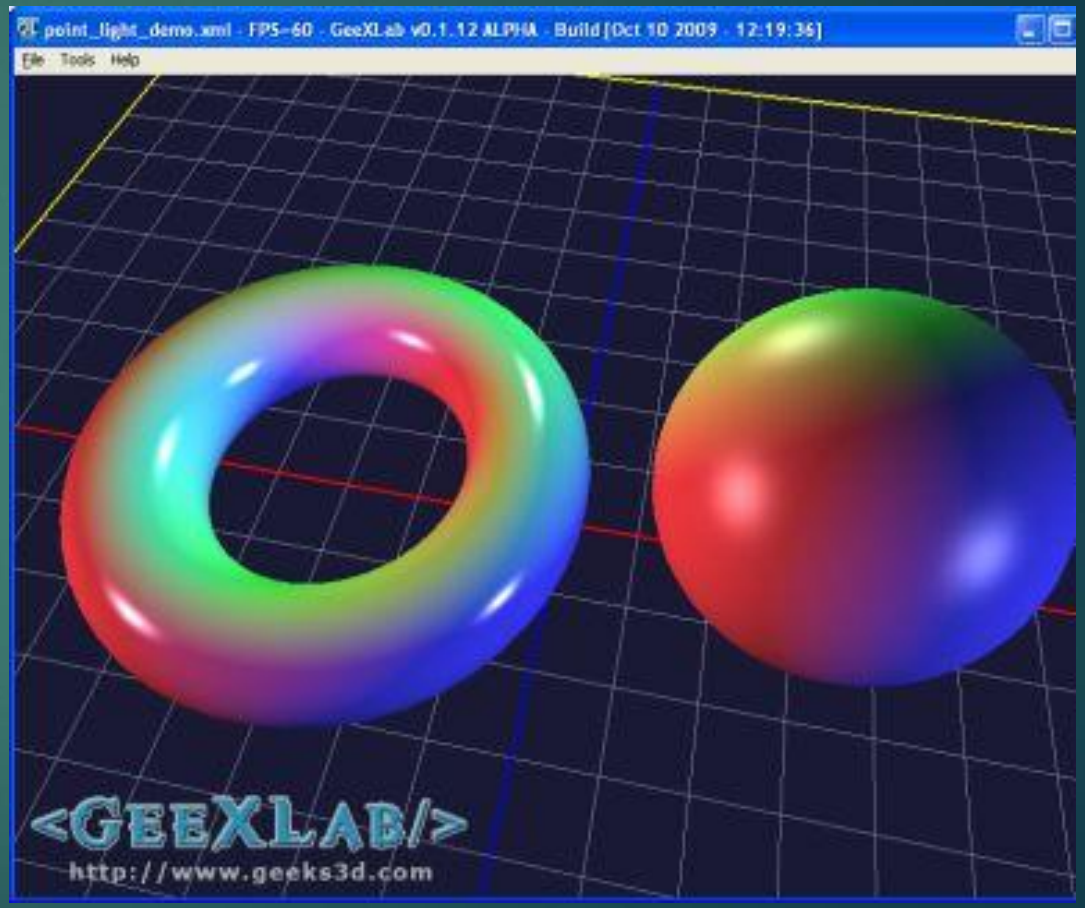


Project 3

- The students turned the Raspberry Pi into an emulator with full Super Ninntendo Entertainment System (SNES) support
- had to load the RetroPi Emulation Station software onto their Rasberry Pi.

Project 4

- Students implemented shaders in OpenGL for Embedded systems (OpenGL ES) on the Raspberry Pi.,
- OpenGL ES is a compact version of the OpenGL graphics library that has been adopted worldwide.
- The students in this group have been taking a computer graphics class and hence the motivation behind this project.



Project 5

- Students were interested in designing a multiplayer game (Blackjack) that would communicate by using a bluetooth adaptor connected to the Raspberry Pi GPIO

Project 6

- The students developed a terminal simulator written in C, they dubbed the “termulator.”
- They followed a Read-Eval-Print-Loop (REPL) style code structure
- They used several key POSIX features

Evaluation

Q1: Did the project increase your interest in operating systems?	84.60% YES 7.70% NO 7.70% No Opinion
Q2: Did the project increase your understanding of operating systems?	69.23% YES 15.38% NO 15.38% No Opinion
Q3: Did you find the project useful?	92.30% YES 0.00% NO 7.70% No Opinion
Q4: Do you recommend this project in the future?	100% YES 0.00% NO 0.00% No Opinion
Q5: Rate the difficulty of the project on a scale from 1 to 5, where 1 is the least difficult and 5 is the most difficult	3.85
Q6: Approximately how many hours you spend on the project	21.31 hours

Evaluation

- Q7: What did you like most about the project?
  - I had never seen anything like these Raspberry Pis before. So in general I enjoyed being introduced to this technology. It has drawn interest in me to invest in one for my enjoyment.
  - It made me familiar with more POSIX commands
  - Programming and Interacting with robotics
  - Having to take hardware into consideration. The computer science course at Stetson is mostly software based, so having physical limitations was an interesting challenge.
  - The fact that I got to play video games on Raspberry Pi
  - The open ended chores (I think what the student meant here that the project assignment was not traditionally structured in a sense that it did not provide precise steps on how to complete the project)
  - The hands on experience with hardware and soldering. Also seeing how things interact and using the GPIO pins to communicate. Once it worked it was a wonderful feeling.
  - It was cool to see how much I could do with the Raspberry Pi.
  - The end result.
  - Finding and implementing various modules needed for coding was interesting. Seeing what files needed to be modified in order to make things work was very useful.
  - It was relevant to the class and allowed a broad selection for possible projects (robotics, graphics or command line) gave a good mixed bag for the class.
  - It was really interesting to see how OpenGL worked and was implemented in a system such as the Raspberry PI. This contrasted to WebGL on browsers which they use in the Graphics I course.
  - Having a tangible, cool result working on a long hard project. Also having an entire computer/operating system to do whatever we want with.

Evaluation

- Q8. What did you like least about the project?
  - Lack of specific resources for Raspberry Pi
  - The many errors and the high amounts of things not working in the beginning
  - The amount of time it took
  - Thought it would be more difficult
  - I feel that the tutorials provided were more applicable to Operating Systems than the project was. It may have just been our topic though.
  - Only that we started a bit late
  - I loved the project IT WAS FUN! But if I had to say something it was when the drivers fried because silly us put too much power in by accident. But I didn't dislike anything about this project. It was super fun.
  - I would have liked to do more.
  - Debugging.
  - The lack of clear guidelines was difficult for this project. Since the Raspberry PI is so simple, it allows for too many projects that may or may not pertain to operating systems.
  - There was a disparity for work required among the three project types meaning some people had to work more to get to the completed product than others.
  - It was very difficult to get into, since there wasn't a whole lot of references online on how to implement OpenGL on the Pi. There was a significant amount of time spent just guessing and checking until something worked correctly.
  - All of the problems. We tried to implement a difficult project that was hard, but things just seem harder on the Pis

Conclusion

- Deeper Learning is instrumental for the success and competency of students in 21st century.
- The Raspberry Pi provides a very beneficial and affordable tool for project based learning.
- evidence to their mastering of core academic content.
- The students thought critically and worked collaboratively to solve a complex problem
- Students have developed the skill to learn independently.
- Students have developed the skill to communicate effectively
- The projects enhanced the students desire and will to engage in learning and hence develop a positive academic mindset.

Conclusion

- The students used their knowledge not only in operating systems, but in computer graphics, algorithm analysis and computer networks in their projects
- Students persisted in developing the projects in spite of the challenges they faced.
- Some students embraced this environment and instead of working on one project they created two complex ones
- Others would have preferred a more traditional project where there is less room for innovation and creativity.
- We believe that the Raspberry Pi can be easily incorporated in projects in many computer science courses as well as STEM courses.