Boolean Logic and Logic Gates, the Gateway to Understanding FPGAs.

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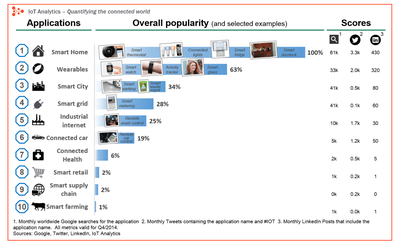
Summary

The Internet of Things (IoT) is a rapidly expanding and pervasive STEM growth area. IoT involves connectivity of embedded systems in physical devices based on existing and evolving communication technologies. "Smart" IoT applications can already be found in homes, wearables, cars, and throughout industry and supply.



Encompassing sensing, hardware, software, and networking, IoT provides a natural platform for real-world connections in Science, Math, and Computer Programming lessons.

This series of lessons focuses on the Field Programmable Gate Array (FPGA) programming aspect of IoT.

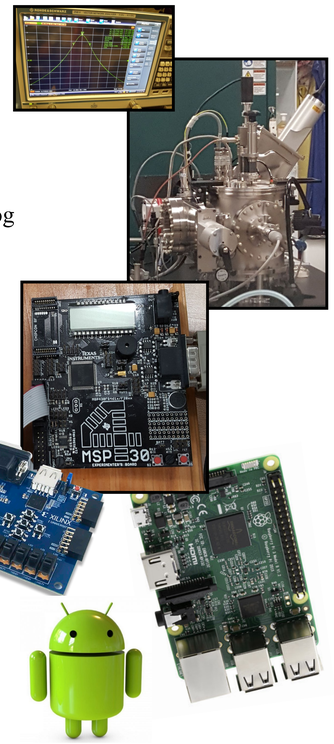
Research Activities

•Using MEMS Resonators as Sensors
- Temperature sensor
- Accelerometer
- Pressure sensor

•Hardware Embedded Systems
- MSP430 programmed in C
- Basys3 FPGA programmed in Verilog
  - Logic Gates
  - Lookup Tables

•Software and Networking
- Networking layers
  - Application
  - Transport
  - Network
  - Data
  - Physical
- Security and Privacy Issues
- Raspberry Pi
  - Setting up as a web server

•Mobile Programming
- Java
- Android Studio



Lessons Learned

This experience has provided several real-world STEM contexts which can be used as motivators and anchors for lessons in all of my classes.

•Concepts from the MEMS module are applicable to my Physics classes.

•In the Networking module, transmission rates can analyzed using Calculus.

•All of the modules *except* the MEMS module directly relate to Programming.

Lesson Plan

This series of lessons will use the Basys3 Field Programmable Gate Array (FPGA) as a STEM motivator in order to introduce students to Boolean Logic, Logic Gates, Truth Tables and Maps, and designing simple Logic Circuits.

Goals:

•Increase understanding of how computers work.

•Spark an interest in emergent STEM areas (IoT and FPGAs)

•Gain significant knowledge in a variety of manifestations of logic.

•Introduce IoT and FPGAs.

A	B	!B	A || !B
F	F		
F	T		
T	F		
T	T		

Sequence:

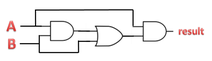
Day 1: Pre-test

Day 2: Introduction to Logic Operators (And, Or, Not, Truth Tables)

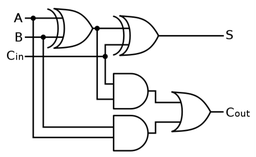
Day 3: More Truth Tables. Introduction to Truth Maps. Multiple Representations.

B \ A	0	1
0	0	1
1	1	1

Day 4: Logic Gates. Introduction to Building Circuits using Logic Gates.

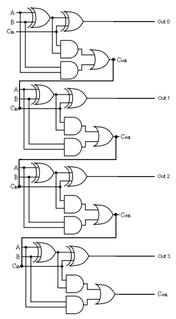


Day 5: Review the homework and CodingBat problem. Group investigation into multi-bit adder. Two new CodingBat problems.



Day 6: Introduction to IoT. Long-Term Assignment: Summary report on IoT. Continue group investigation.

Day 7: Introduction to Basys3. New Long-Term Assignment: Summary report on Basys3.



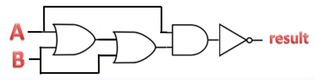
Day 8: Write a Java method to emulate adding two binary numbers using only logic operators.

Many days later… Discussion of summary reports on IoT and Basys3.

Debriefing on binary adder. Relate Logic Circuit design to Basys3.

Final Day Post-test. Options for further study.

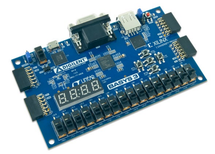
Follow-up Topics will appear on quizzes and tests. More advanced topics build on many of these concepts.



Additional Information

Implementation Strategy

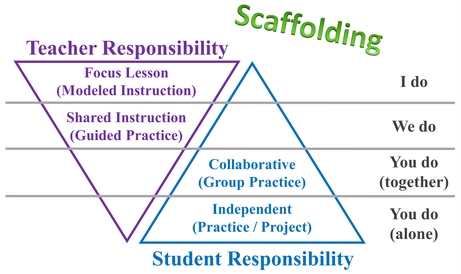
Many aspects of this research will eventually be include in my various Calculus, Physics, and Computer Programming classes. For example, the module on logic gates and Field Programmable Gate Arrays (FPGAs) naturally fits into my Computer Programming curriculum since Boolean Logic is already an integral part of the curriculum.



•Motivation:
- FPGAs and their use in the IoT field.
  - Emergent STEM areas.
  - Directly related to the curriculum.
  - Interesting, rich environment provides purpose for learning logic

•Strategies:
- Spiral learning
- Multiple representations
- Scaffolding / Gradual Release Model
- Repetition (for long-term learning)
- Progress monitoring
- Think-Pair-Share
- Chunking

The series of lessons will be taught in AP and IB Computer Science classes as part of the logic and truth tables section of the curriculum.



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Graphic in Summary section is from: https://iot-analytics.com/10-internet-of-things-applications