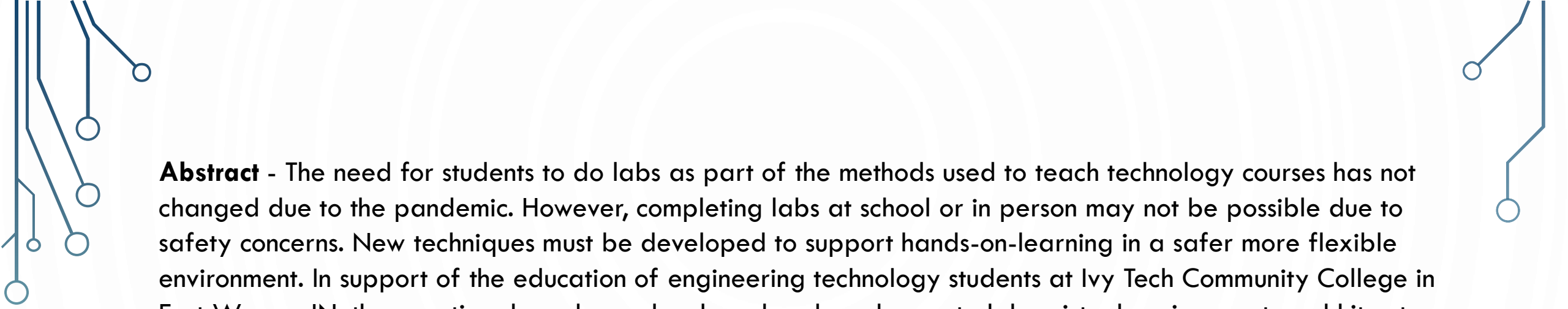


USING ALTERNATIVE METHODS TO SUPPORT HANDS-ON-LEARNING (LABS)

ANDREW BELL

7/21-22/2021





Abstract - The need for students to do labs as part of the methods used to teach technology courses has not changed due to the pandemic. However, completing labs at school or in person may not be possible due to safety concerns. New techniques must be developed to support hands-on-learning in a safer more flexible environment. In support of the education of engineering technology students at Ivy Tech Community College in Fort Wayne, IN, three options have been developed and used: remote labs, virtual environment, and kits at home. This presentation will discuss how these options have been developed and lessons learned regarding their use.



Key deliverables:

- 1.) How to develop remote labs that can be accessed by students anywhere.
- 2.) How virtual reality can be used to fill the gap for labs.
- 3.) How to create and offer kits that students can use at home.

Key takeaways:

- 1.) What computer resources and equipment were used to develop remote labs.
- 2.) Developing your own virtual reality in Second Life.
- 3.) How you can work with vendors to design and offer take home kits for students.

Remote Labs

What is a remote lab?

A remote lab allows users to interface to experiments and equipment that are in a remote location. Remote labs are conceptually related to the “Internet of Things” IoT

Our model for Remote Lab is MECH-NET

They use LabView (software) and cRIO (hardware) to access Wind Tunnels, Engines, and other expensive equipment in a remote lab setting (Mentor Ohio).

Our reasons are

- 1.) lack of space (1 sq meter per engineering student)¹
- 2.) improved learning for students²
- 3.) better use of equipment that is currently under utilized³
- 4.) experimental testbed for future NSF ATE grants related to IoT

1 – 2017 Engineering Program Review for FW and 2018 Engineering Advisory Board Meeting

2 – Improving Learning Outcomes In EE2010I Using NI MYDAQ in an Inverted Lab

3 – Last inventory show we have ~ 175K of equipment from TecQuipment (not being used)

MECH-NET
.com

440.975.0258 | info@mech-net.com

why a remote lab | how it works | sample screen shots | capabilities | request a demo | contact us

Key Factors to Remote Lab

- **STEM education** (Science, Technology, Engineering and Math) to conduct true STEM education the equipment must be research quality with extremely accurate data.
- **Affordability** – By operating the equipment remotely and only paying a small hourly fee to operate the equipment makes the equipment affordable to a much larger audience.
- **Safety** – Students are not exposed to moving parts and dangerous fuels in the laboratory
- **No maintenance required by the schools** – The laboratory experiment will be set up and ready to run when the student logs in. No models changes or repairs will be required by the technical staff of the school.
- **Access to many different types of equipment** – online access for experiments on wind tunnels, single cylinder engines and turbine engines

We have been recently written up in *Wind Tunnel International 2010*.
Read what they had to say.
[Check Out Our Equipment List!](#)

Remote Laboratory Experiments For STEM Education

Attending school based conferences we often hear from the education teachers and professors, "I would love to have this equipment in my classroom but I do not have the room for it or my school could never afford it." **This is no longer a problem.**

The Mech-Net Remote Lab provides the student and professor access to state-of-the-art research quality laboratory wind tunnels, single cylinder engines and turbine engines to conduct real-time, hands-on experiments via the internet at an hourly rate. The Mech-Net Remote Lab is a valuable tool to improving your students' STEM (Science, Technology, Engineering and Math) education skills.

[See Our Media Rich Aerodynamics Lab and Other Experiments](#)

[Download Our Venturi Effect PowerPoint](#)

You can perform your own experiments or use one of Mech-Net established experiments. Mech-Net laboratory experiments have been designed to expose the students to as many different engineering, science and physics disciplines as possible. These experiments allow your students to not only learn valuable lessons in math and science but also be exposed to problem solving of our current energy and infrastructure needs.

See our presentation at Global Wind Tunnel Symposium, Nov 2-3, Pasadena Convention Center, California

GDJ Inc. | 7555 Tyler Boulevard | Mentor, OH 44060 | 440.975.0258 | F. 440.975.0256 | E. info@mech-net.com
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TC1337 – Classroom (original config)

Present State (*now past state*)

15 laptops

Wireless connection

Overhead projector

Instructor PC

Pros

Standard Classroom config

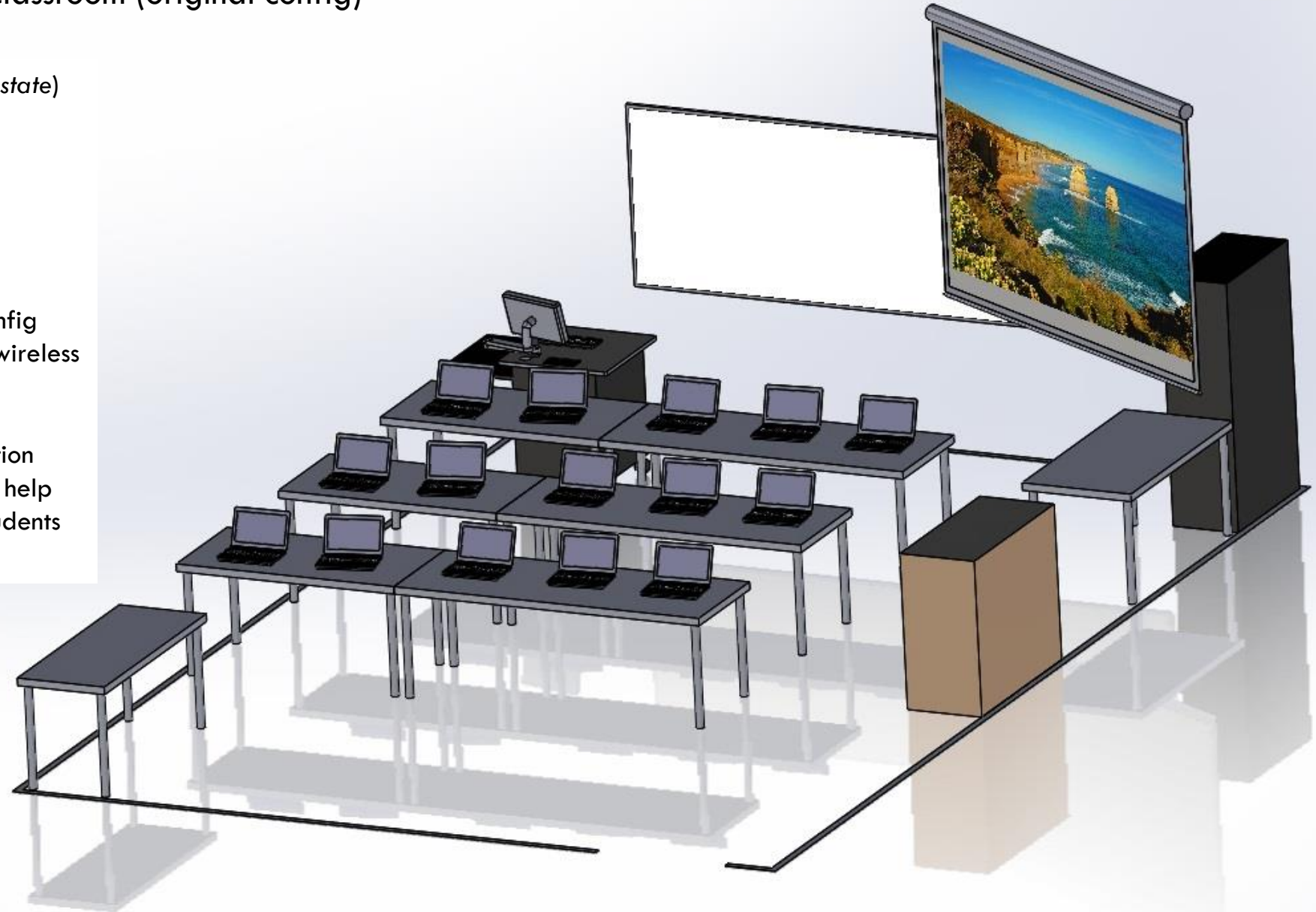
Has computer that are wireless

Cons

Tenuous internet connection

Difficult for instructor to help

No dual monitors for students



TC1337 – Remote Lab/Classroom (proposed and adopted)

Future State (*now current state*)

15 laptops

Lan line connections

3 - 55" TVs

Instructor PC

Remote Lab Area

with 4 rack mounted PCs

Common remote area

Pros

Unique Classroom config

Has computer that are on lan line

Instructor has easy access to students

55" Monitors provide dual monitor

Modifiable Remote Lab Area

Cons

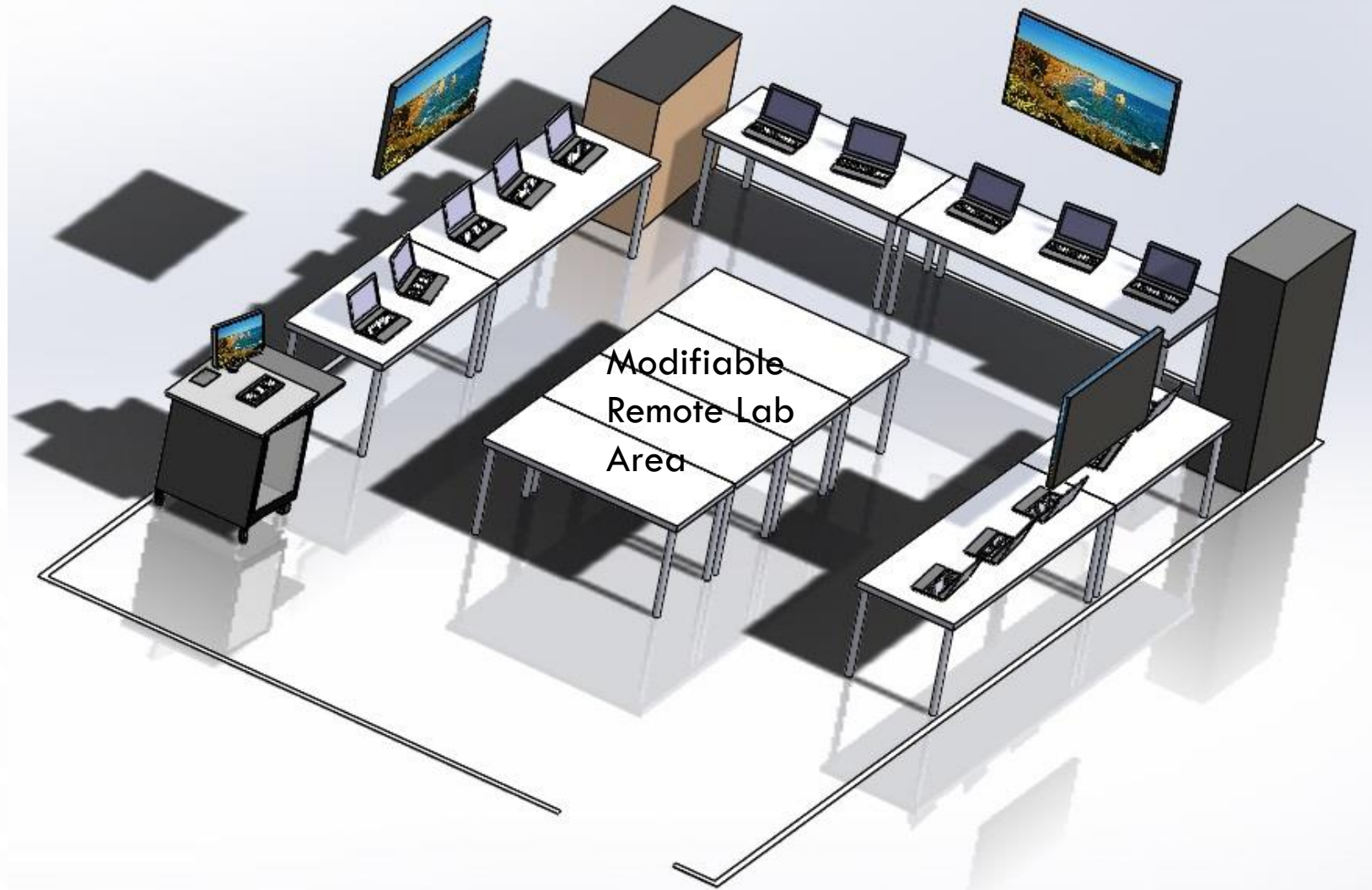
Cost for added lan lines

Cost for power

Cost for IP cameras ~ 200 each

Cost of 55" TVs ~ 500 each

Possible loss of classroom



TC1337 – Options for remote lab equipment

Remote Lab Area – Data Acquisition & Control

Option 1 - cRIO ~ 5K each

new technology

matches MECH-NET config

Expandable & more like industry

Supplement Your Control or Measurement System with NI Remote I/O

<http://www.ni.com/white-paper/53388/en/>

MECH-NET <http://www.mech-net.com/>

Developing Remote and Virtual Laboratories with LabVIEW

<https://web.archive.org/web/20190914091205/http://sine.ni.com/cs/app/doc/p/id/cs-13030>

Option 2 - Elvis II ~ 3K each

We already have 9 of them

Adaptable for mechanical or electrical

Has already been done at other schools

Open University talk on "An Internet of Laboratory Things" working in practice

<https://www.youtube.com/watch?v=v-k8-WXgNEM>

Using NI ELVIS and LabVIEW for Remote Engineering Electronics Experiments

<http://web.archive.org/web/20120120181734/http://sine.ni.com/cs/app/doc/p/id/cs-14002>

Option 3 - myRIO & myDAQ ~ 1K each

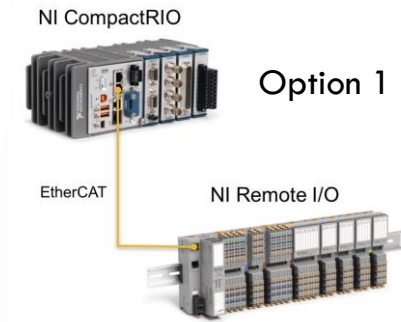
We already have 4 sets

Potential for inverted lab (student owned)

Very inexpensive with lots of support

Many schools use them

IMPROVING LEARNING OUTCOMES IN EE2010L USING NI MYDAQ IN AN INVERTED LAB



TC1337 – GRE PCs with local admin rights

Remote Lab Area - Computing

Computing with USB interface

4 rack mounted PCs ~ 800 each

Monitor with keyboard mouse ~ 600

Rack ~ 600

Dell PowerEdge R230 - rack-mountable

Xeon E3-1220V6 3 GHz - 8 GB - 1 TB

\$806.66

Tripp Lite KVM Rack Console w/ 19" LCD in

1URM Steel Drawer w Cable Kit

\$627.88

StarTech.com 22U 36in Knock Down Server

Rack Cabinet with Caster

\$607.12

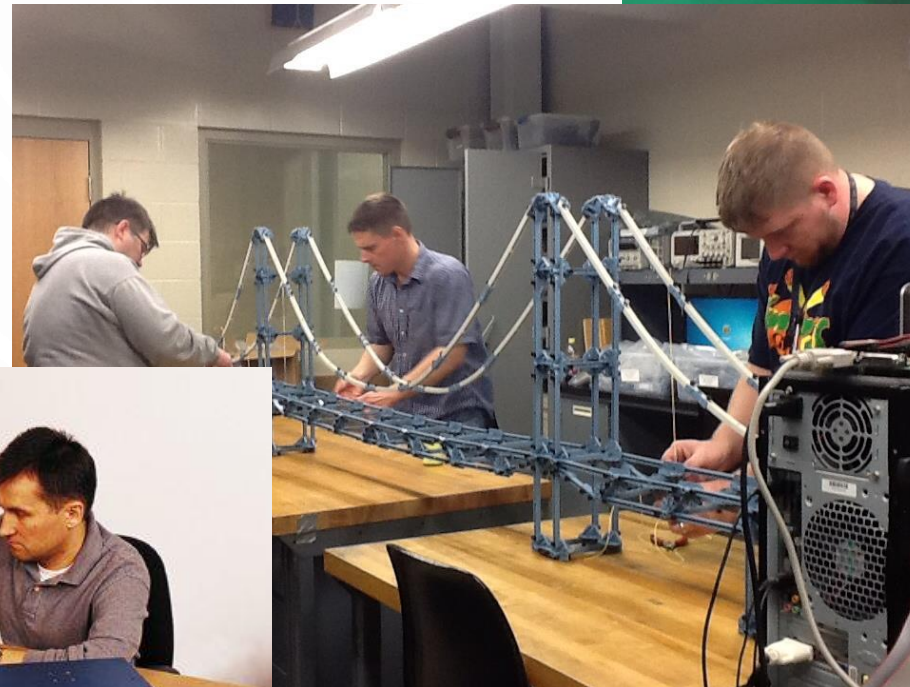
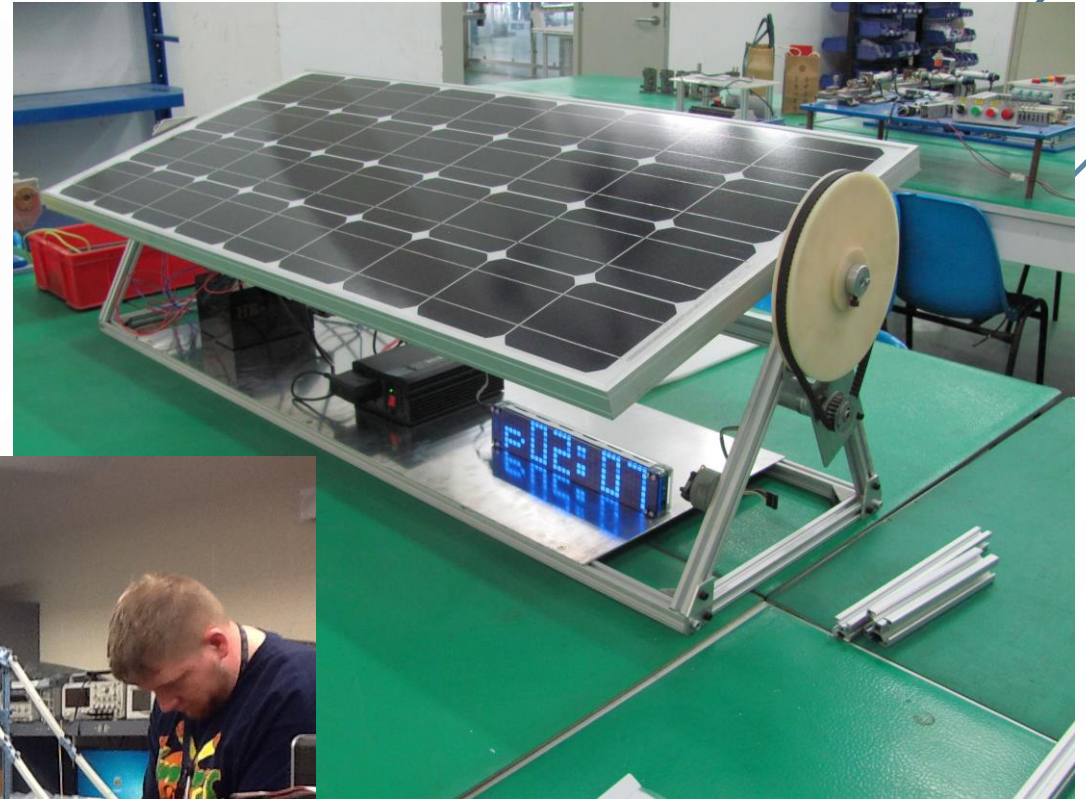


TC1337 – original remote labs proposed

Remote Lab Area – Experiments
We already own much of this
No place to put it

Experiments on wheels

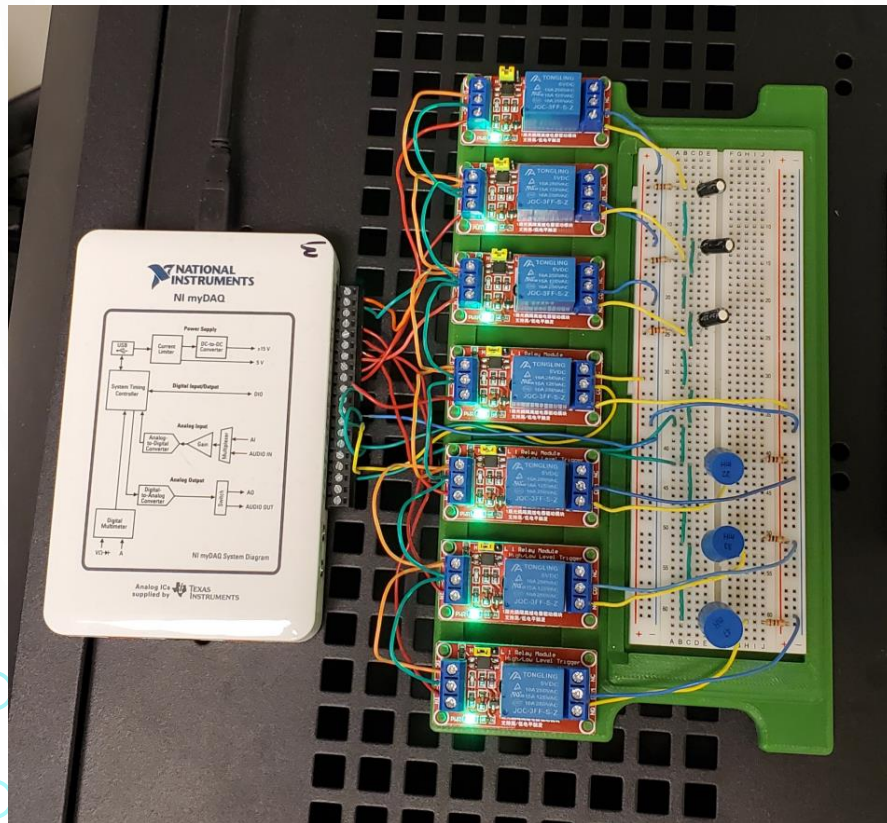
- Pasco Bridge
- Shake Table
- Mechanical
- Material Science
- MEMS
- Electronics



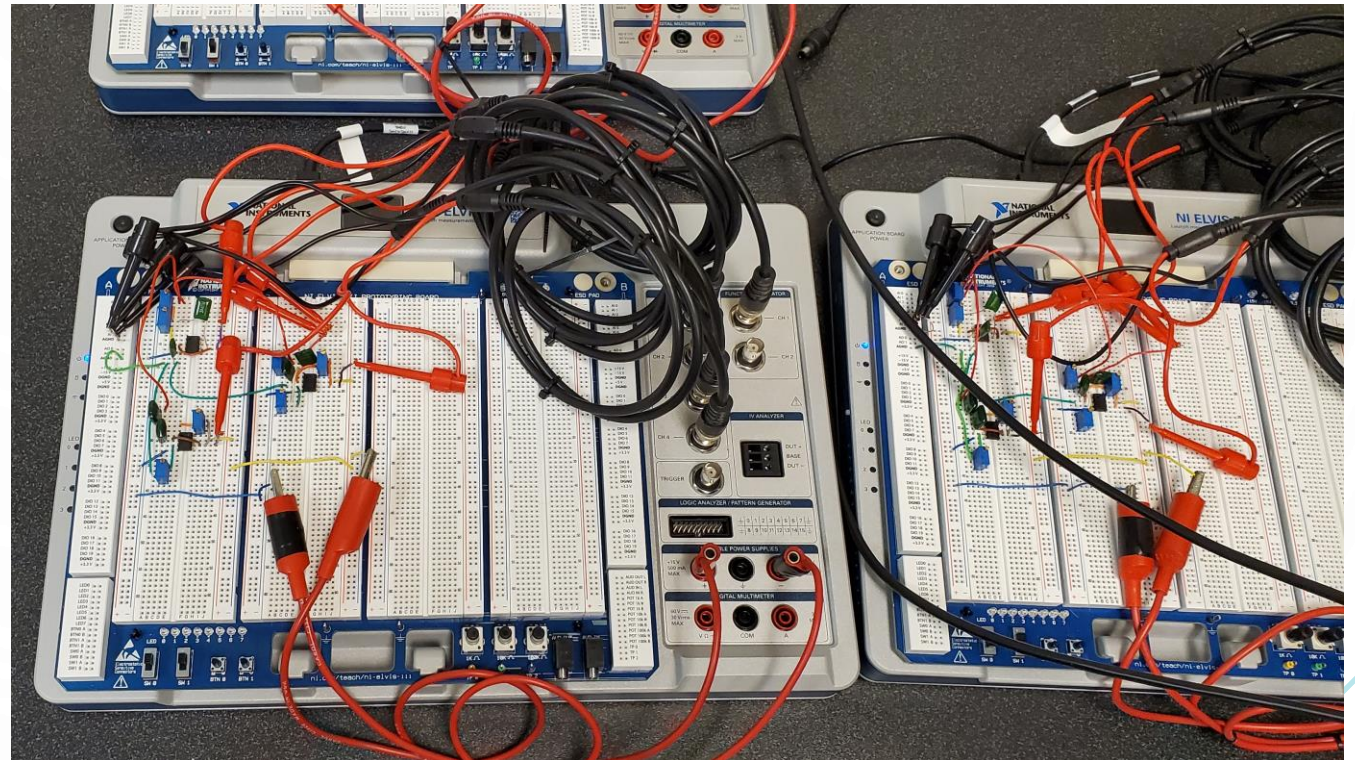
TC1337 – Current State – Electronics

Used in EECT 111, 112, 121, 211 courses

6 Remote Access labs using relays, NI myDAQ and breadboard



3 Remote Access labs using NI ELVIS IIIs



Virtual Reality

What is Second Life?

Ans – Second Life is a virtual reality that is accessible via the internet. You download a viewer, create an avatar and explore by walking, running, flying or teleporting. It is like playing a video game.

Is it used by other colleges?

Ans – Second Life has been used by many colleges. The peak usage was about 10 years ago but many colleges jumped in and didn't have a good game plan for the use of Second Life.

How do we get it?

Ans – The Second Life Viewer is free to download but if you want to build something you should buy some land.

Original inspiration: **Engineering Education Island: Teaching Engineering in Virtual Worlds**

<https://www.tandfonline.com/doi/full/10.11120/ital.2009.08030002>



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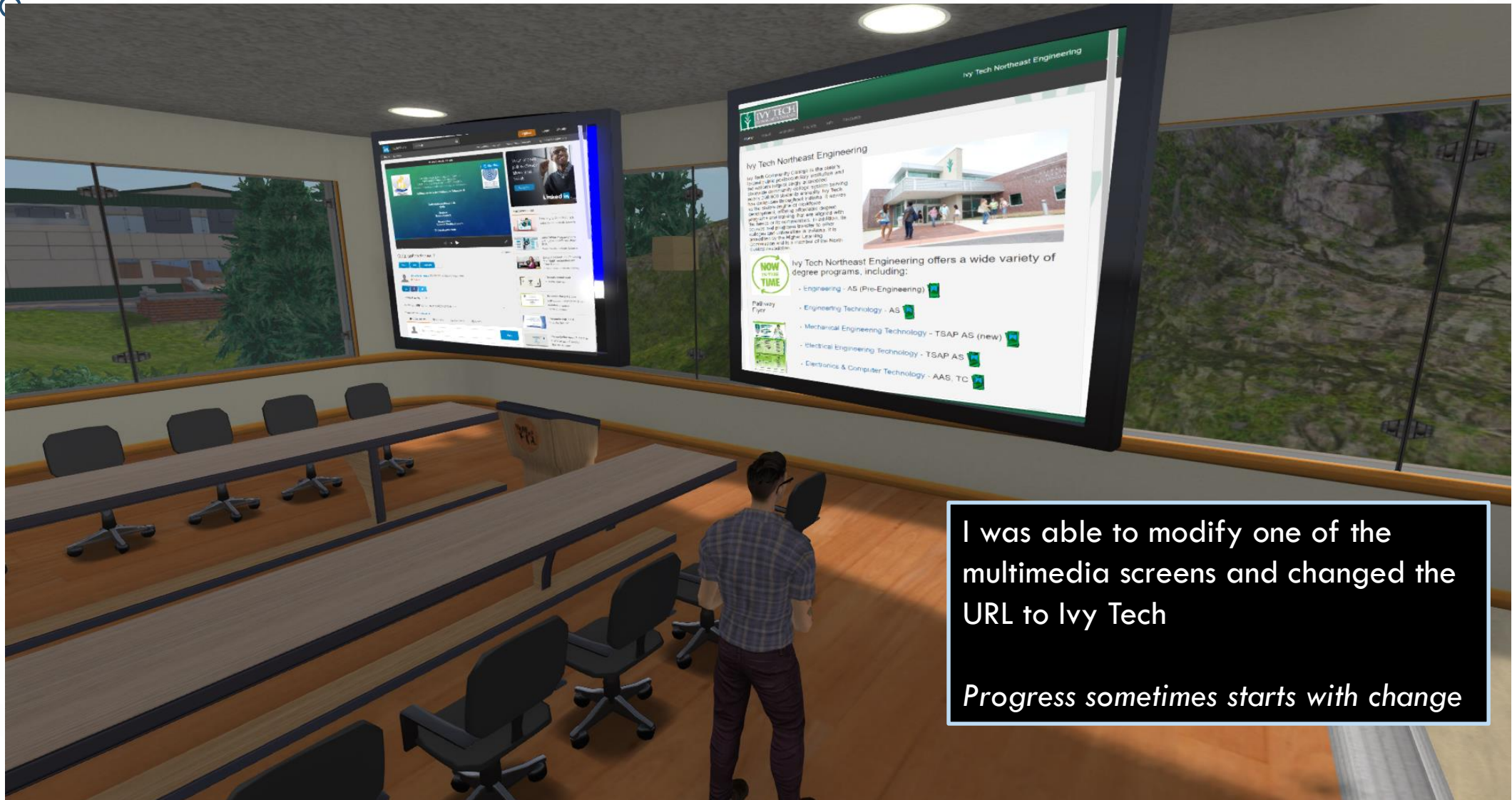
Evergreen Island 3 (now defunct)

You don't need your own island to explore. I looked at Evergreen Island 3 and other sites.

Explore, explore, explore



Evergreen Island 3 (now defunct)



I was able to modify one of the multimedia screens and changed the URL to Ivy Tech

Progress sometimes starts with change

The College of North West London (defunct)



Flying, teleporting, walking, sitting and running are all movements you can make in Second Life.

Exploring is essential for learning

[http://wiki.secondlife.com/wiki/Second Life Education Directory](http://wiki.secondlife.com/wiki/Second_Life_Education_Directory)



Found another place in Second Life and talked to another educator to get ideas.

Networking is essential for success.

NOVA Community College (active) - <https://www.youtube.com/watch?v=FY8Cyk5CuGY>
<http://maps.secondlife.com/secondlife/NOVA%20Community%20College/107/164/23>

IvyTech Engineering Island

In April 2020 Ivy Tech purchased a pre-made island (Horizon Community Center) for ~ \$100 per month and \$1500 worth of Linden Dollars for the Second Life Marketplace




<https://www.connect.secondlife.com/explore>

<http://maps.secondlife.com/secondlife/IvyTech%20Engineering%20Island/206/120/21>

PLACES

Place Profile



Horizons Community Region
Region: IvyTech Engineering Island (206, 120, 21)
Owner: IvyTechEngineer

The Horizons Community Regions are places for the Horizons community to meet, hold events. [More](#)

Parcel	General
Rating:	General
Voice:	On
Fly:	On
Push:	Off
Build:	Off

Region

Teleport Map

What do we want to do with Second Life?

Ans – get back to the state of “Engineering Education Island: Teaching Engineering in Virtual Worlds”¹

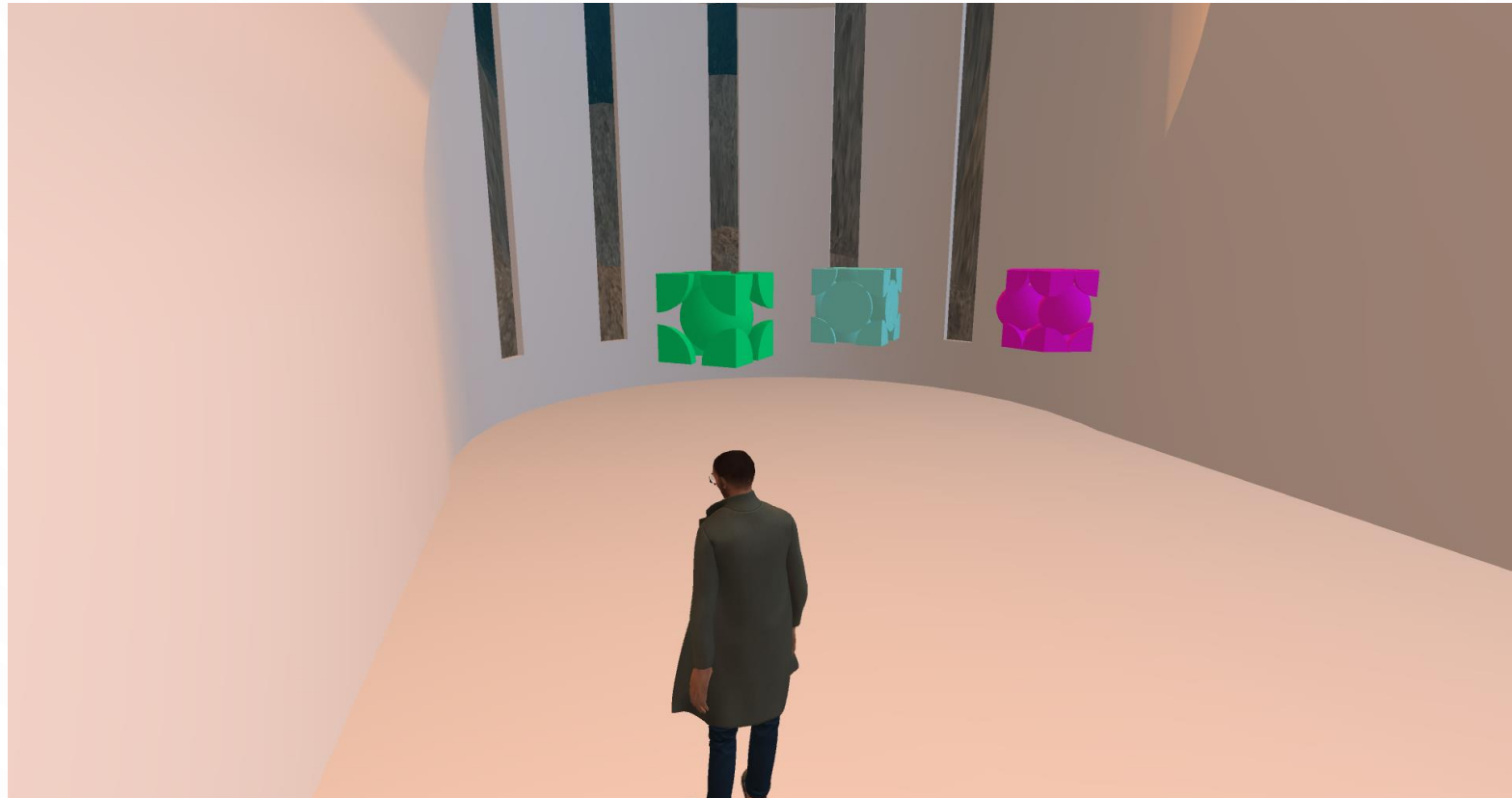


¹ - <https://www.tandfonline.com/doi/full/10.11120/ital.2009.08030002>

What do we want to do with Second Life?

Ans – Build a virtual cleanroom. Currently, we do not have the space or funds to build a clean room (this would cost in excess of 2 million dollars with a sizeable annual budget needed for material, equipment maintenance and supplies ~ 50K per year. But if we build a virtual clean room we could give the experience without the cost.

Status – in progress...



Examples of Second Life Presentations @ Ivy Tech (2020-2021)

Second Life Presentations

<https://www.youtube.com/watch?v=o3S8sou4oUQ>

Second Life Intro

<https://www.youtube.com/watch?v=QrWtgERTplg>

Wire Resistance Presentation in Second Life

https://www.youtube.com/watch?v=ll_cQQE4SeQ

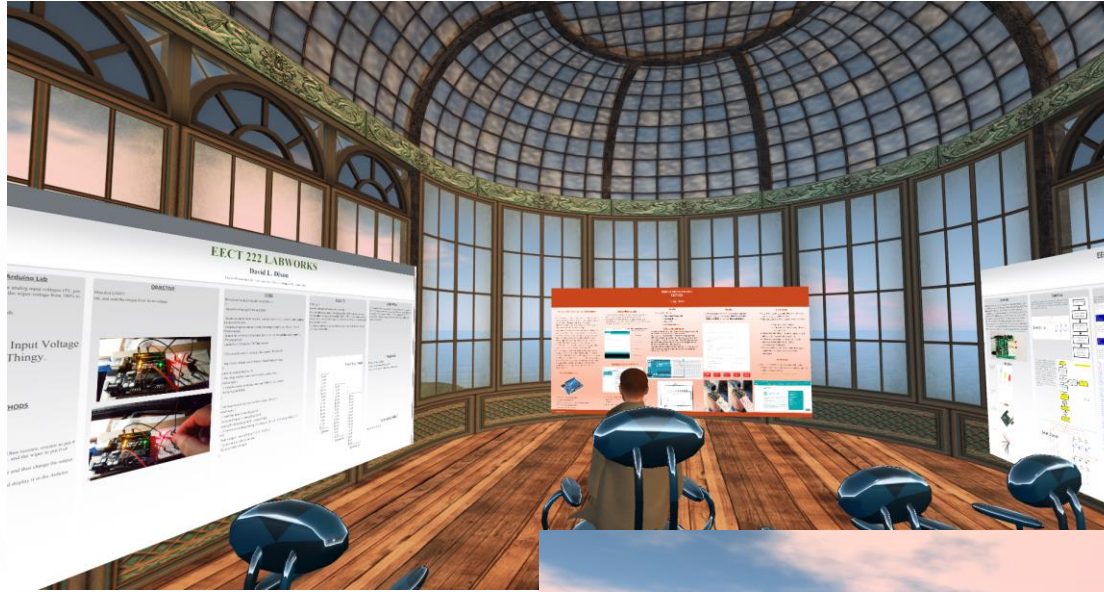
Mini-Lou in Second Life

https://www.youtube.com/watch?v=Qx7YvJmB_3o



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Examples of Second Life Presentations @ Ivy Tech (2020-2021)



Student presentations are recorded with Zoom but presented in Second Life

Presentations are as easy as uploading a single image to a webpage.



Students enjoy presenting in Second Life. They pick their own avatar and explore the IvyTech Engineering Island and beyond ...



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Examples of Second Life Presentations @ Ivy Tech (2020-2021)



Imagination will often carry us to worlds that never were. But without it we go nowhere. – Carl Sagan



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2021-04-27 07:01:58



Kits to take home

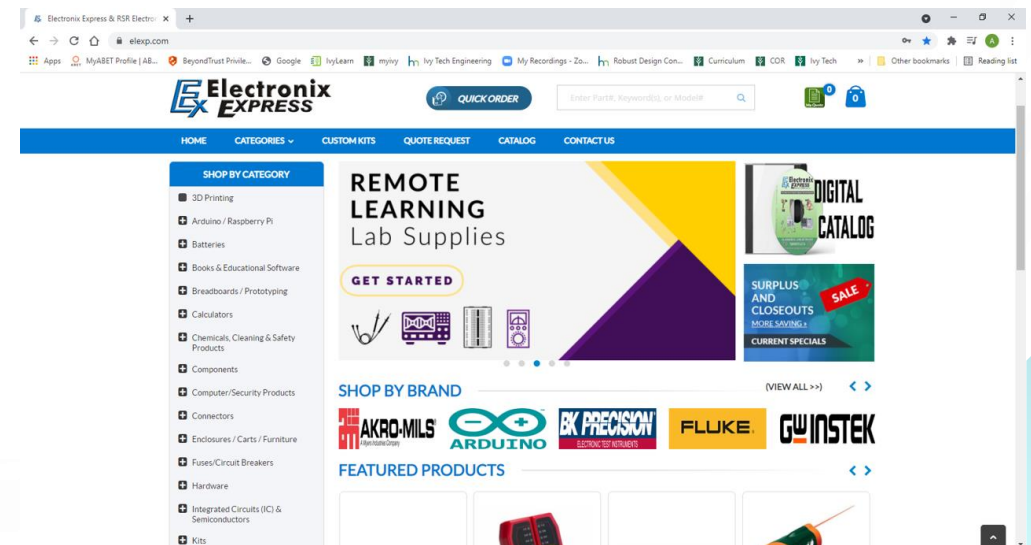
What are “kits”?

A kit allows users to conduct experiments from home at minimum cost. Initially, kits were distributed and paid for by the engineering program at a cost of ~ \$100 per student. However, in 2019 we were able to secure a vendor who would build the kits and sell them to the Barnes and Noble bookstore. Students could then purchase the kits from the bookstore to use in class as part of their “hands on learning” using their financial aid.

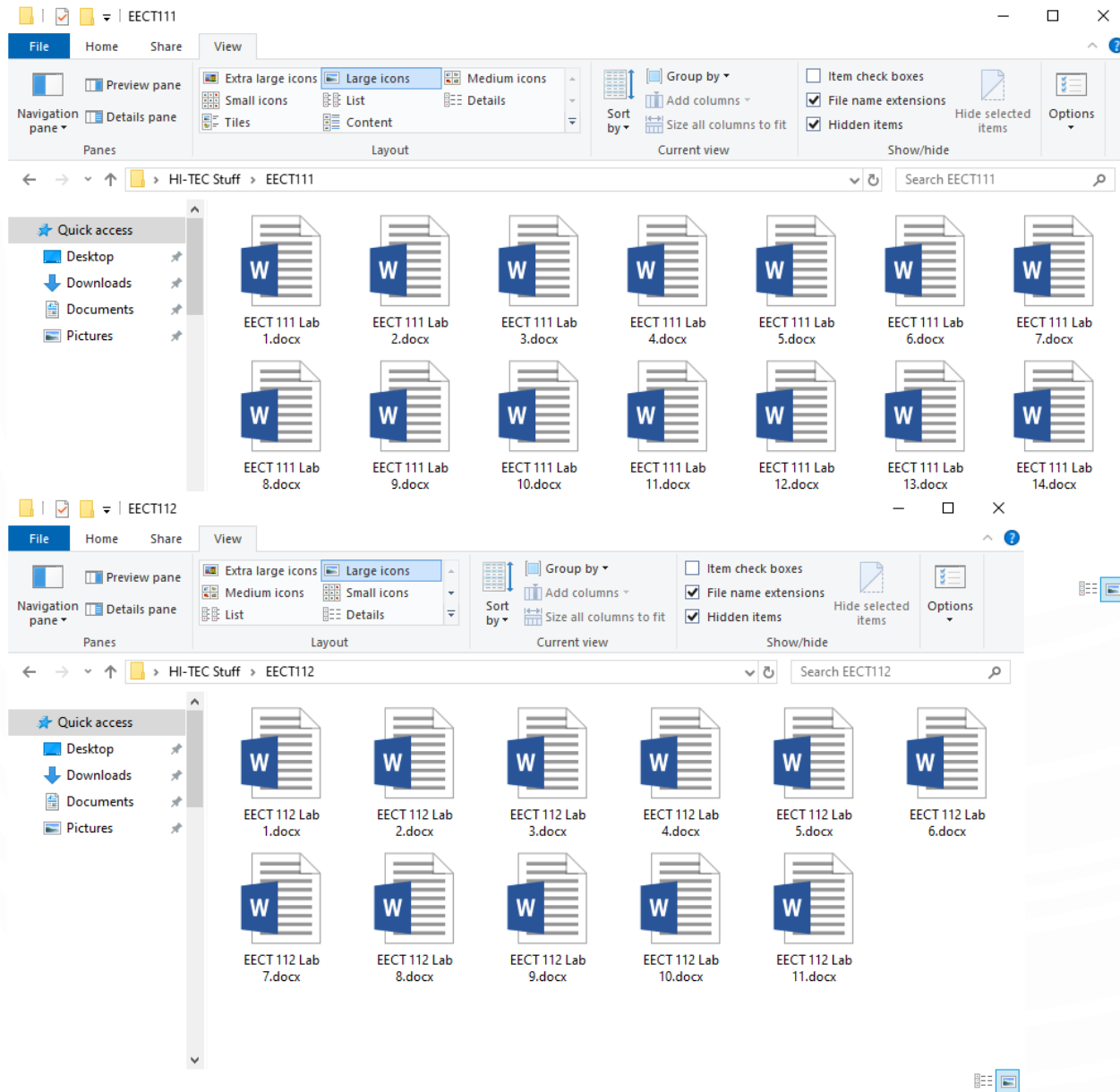
Two kits were developed for EECT 111 Intro To Circuits Analysis and EECT 112 Digital Fundamentals. Parts from two vendors (Electronix Express and Jameco) were selected based on the ~ 20 labs that we typically do for these two courses. Quotes were provided and we selected Electronix Express. The new kits received part numbers and the bookstore could order and stock the kits in the bookstore.

Our reasons are

- 1.) Need for social distance
- 2.) Reduce cost to department budget
- 3.) Put electronics in the hands of students to own
- 4.) Emphasize the need for “hands on learning”



Kit info – the labs



Students access the lab instructions via Canvas (Ivy Learn). Software is provided via NI as part of our site license agreement and the kits are what the students can buy in the bookstore.

Kit info – what's in the EECT 111 Intro To Circuits Analysis kit?

Students can buy kits from the bookstore and use their financial aid.

EECT111 ELEC.KIT-32IVTFWEECT111 by 550218717 (2818440022630)

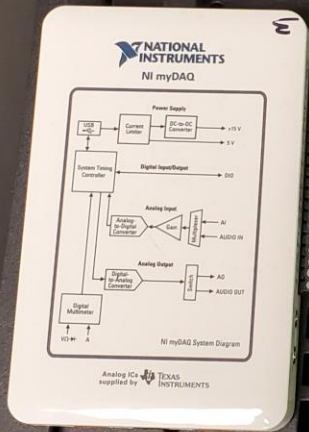
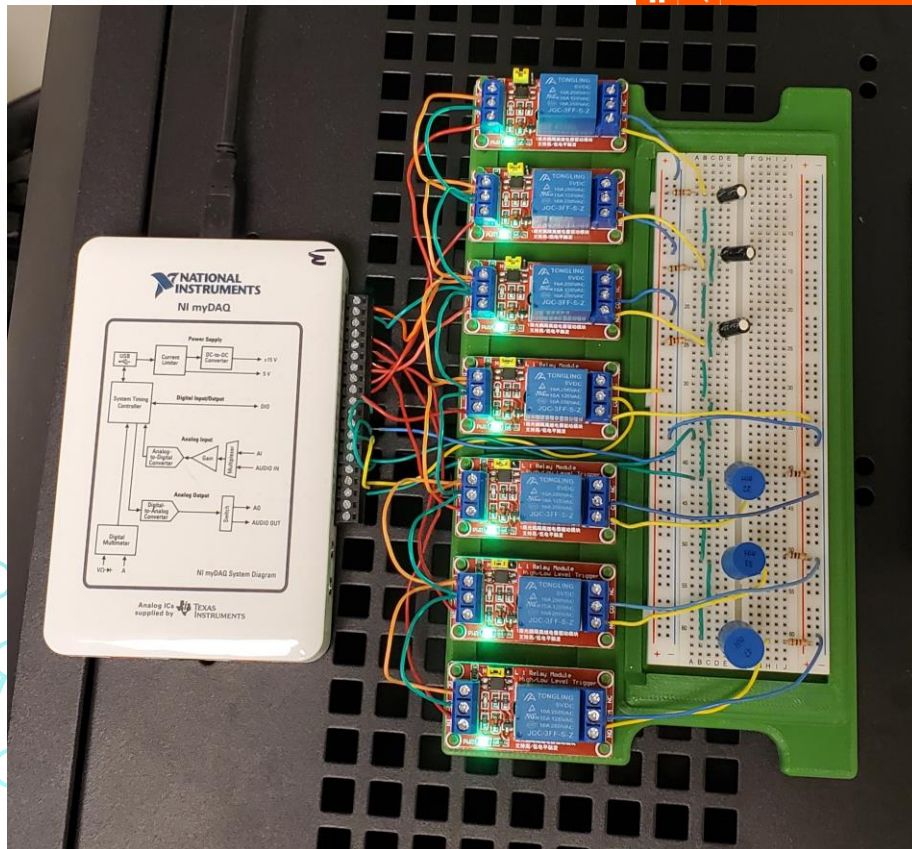
Item	Description	Part Number	Qty	Cost	Total
1	Carbon Film Resistors 5% 1/4 W 100 Ohms	13005100	2	\$0.06	\$0.12
2	Carbon Film Resistors 5% 1/4 W 220 Ohms	13005220	2	\$0.06	\$0.12
3	Carbon Film Resistors 5% 1/4 W 330 Ohms	13005330	2	\$0.06	\$0.12
4	Carbon Film Resistors 5% 1/4 W 470 Ohms	13005470	2	\$0.06	\$0.12
5	Carbon Film Resistors 5% 1/4 W 560 Ohms	13005560	2	\$0.06	\$0.12
6	Carbon Film Resistors 5% 1/4 W 680 Ohms	13005680	2	\$0.06	\$0.12
7	Carbon Film Resistors 5% 1/4 W 910 Ohms	13005910	2	\$0.06	\$0.12
8	Carbon Film Resistors 5% 1/4 W 1K Ohms	130051K	20	\$0.06	\$1.20
9	Carbon Film Resistors 5% 1/4 W 2.2K Ohms	130052.2K	2	\$0.06	\$0.12
10	Carbon Film Resistors 5% 1/4 W 3.3K Ohms	130053.3K	2	\$0.06	\$0.12
11	Carbon Film Resistors 5% 1/4 W 4.7K Ohms	130054.7K	2	\$0.06	\$0.12
12	Carbon Film Resistors 5% 1/4 W 5.6K Ohms	130055.6K	2	\$0.06	\$0.12
13	Carbon Film Resistors 5% 1/4 W 6.8K Ohms	130056.8K	2	\$0.06	\$0.12
14	Carbon Film Resistors 5% 1/4 W 10K Ohms	1300510K	2	\$0.06	\$0.12
15	Carbon Film Resistors 5% 1/4 W 22K Ohms	1300522K	2	\$0.06	\$0.12
16	Carbon Film Resistors 5% 1/4 W 33K Ohms	1300533K	2	\$0.06	\$0.12
17	Carbon Film Resistors 5% 1/4 W 47K Ohms	1300547K	2	\$0.06	\$0.12
18	Carbon Film Resistors 5% 1/4 W 100K Ohms	13005100K	2	\$0.06	\$0.12
19	Carbon Film Resistors 5% 1/4 W 1M Ohms	130051M	2	\$0.06	\$0.12
20	Carbon Film Resistors 5% 1/4 W 10M Ohms	1300510M	2	\$0.06	\$0.12
21	Electrolytic Radial Lead Capacitor 50V 0.47 μ F	14ER050.47U	1	\$0.15	\$0.15
22	Electrolytic Radial Lead Capacitor 50V 1 μ F	14ER0501U	1	\$0.14	\$0.14
23	Electrolytic Radial Lead Capacitor 50V 2.2 μ F	14ER0502.2U	1	\$0.15	\$0.15
24	Electrolytic Radial Lead Capacitor 50V 10 μ F	14ER05010U	1	\$0.15	\$0.15
25	Electrolytic Radial Lead Capacitor 35V 22 μ F	14ER03522U	1	\$0.16	\$0.16
26	Electrolytic Radial Lead Capacitor 50V 47 μ F	14ER05047U	1	\$0.16	\$0.16
27	Encapsulated R.F. Chokes 150 mA 5 Ohms 1 mH	1501M	1	\$0.95	\$0.95
28	Encapsulated R.F. Chokes 100 mA 9 Ohms 2.2 mH	1502.2M	1	\$0.85	\$0.85
29	Encapsulated R.F. Chokes 80 mA 18 Ohms 4.7 mH	1504.7M	1	\$0.85	\$0.85
30	Multiturn Potentiometers Top Adjust - 5K Ohm (Square)	18MPT5K	1	0.65	\$0.65
31	Digital Multimeter MS8360E	01DMMS8360E	1	\$34.95	\$34.95
32	RSR Solderless Breadboard Model MB801400 Tie-Points	03MB801	1	\$3.40	\$3.40
33	RSR Jumper Wire Kits for Breadboarding -140 Pieces	2700MJW70	1	\$4.90	\$4.90
34	CBL ASM ALG-ALG 10pc ALS 1	32VPTALS1	1	\$3.75	\$3.75
35	9V Battery Holder Plastic Case with Leads	28019PWR	1	\$0.75	\$0.75
					\$55.44

EECT 111 Kit



Kit info – What is missing can be supplemented with remote labs using MyDAQs and ELVIS IIs

If necessary, kits can be supplemented with remote labs.
Labs 11 and 13 for the EECT 111 class use remote labs



A screenshot of a remote lab interface. The browser window shows a URL "access.ivytech.edu/console#". The interface displays several LabVIEW windows: "Function Generator - NI ELVISmx" showing a sine wave at "1.000 kHz", "Digital Writer - NI ELVISmx" showing a numeric value of "2", and "Oscilloscope - NI ELVISmx" showing a sine wave. The oscilloscope window has settings for Channel 0 (Source: AI 0, Scale: 200 mV, Timebase: 500 us) and Channel 1 (Source: AI 1, Scale: 200 mV). The device is identified as "myDAQ1 (NI myDAQ)". The interface also shows a Windows taskbar at the bottom with the date "6/23/2021" and time "2:52 PM".

Kit info – what's in the EECT 112 Digital Fundamentals kit?

Students can buy kits from the bookstore and use their financial aid.

EECT112 ELEC.KIT-32IVFTWEECT112 by 550218725 (2818440022647)

Item	Description	Part Number	Qty	Cost	Total
1	Carbon Film Resistors 5% 1/4 W 1K Ohms	130051K	4	\$0.06	\$0.24
2	Carbon Film Resistors 5% 1/4 W 10K Ohms	1300510K	4	\$0.06	\$0.24
3	DIP Switch 4 Switches 16-Pin Greyhill	17DIP4SDGRE	1	\$3.50	\$3.50
4	74LS00 Quad NAND	1074LS00	2	\$0.79	\$1.58
5	74LS04 Hex Inverter	1074LS04	2	\$0.60	\$1.20
6	74LS08 Quad AND	1074LS08	2	\$0.60	\$1.20
7	74LS11 Triple 3 input AND	1074LS11	2	\$0.55	\$1.10
8	74LS32 Quad OR	1074LS32	2	\$0.55	\$1.10
9	74LS73 Dual JK flip flop with clear	1074LS73	2	\$1.40	\$2.80
10	74LS86 Quad XOR	1074LS86	2	\$0.65	\$1.30
11	555 Timer	10555	2	\$0.22	\$0.44
12	Logic Probe with Beeper	01LP610	1	\$16.50	\$16.50
13	Jumper Wire Kits 140 PIECES	2700MJW70	1	\$3.90	\$3.90
14	Solderless Breadboard 830 6.5" x 2.1"	03MB102WWK	1	\$7.95	\$7.95
15	Carbon Film Resistors 5% 1/4 W 470K Ohms	13005470K	2	\$0.06	\$0.12
16	Mylar Radial Capacitor 10% 100 Volt 0.1 μ F	14MR100.1U	1	\$0.15	\$0.15
17	Electrolytic Radial Lead Capacitor 50V 1 μ F	14ER0501U	1	\$0.14	\$0.14
					\$43.46

EECT 112 Kit

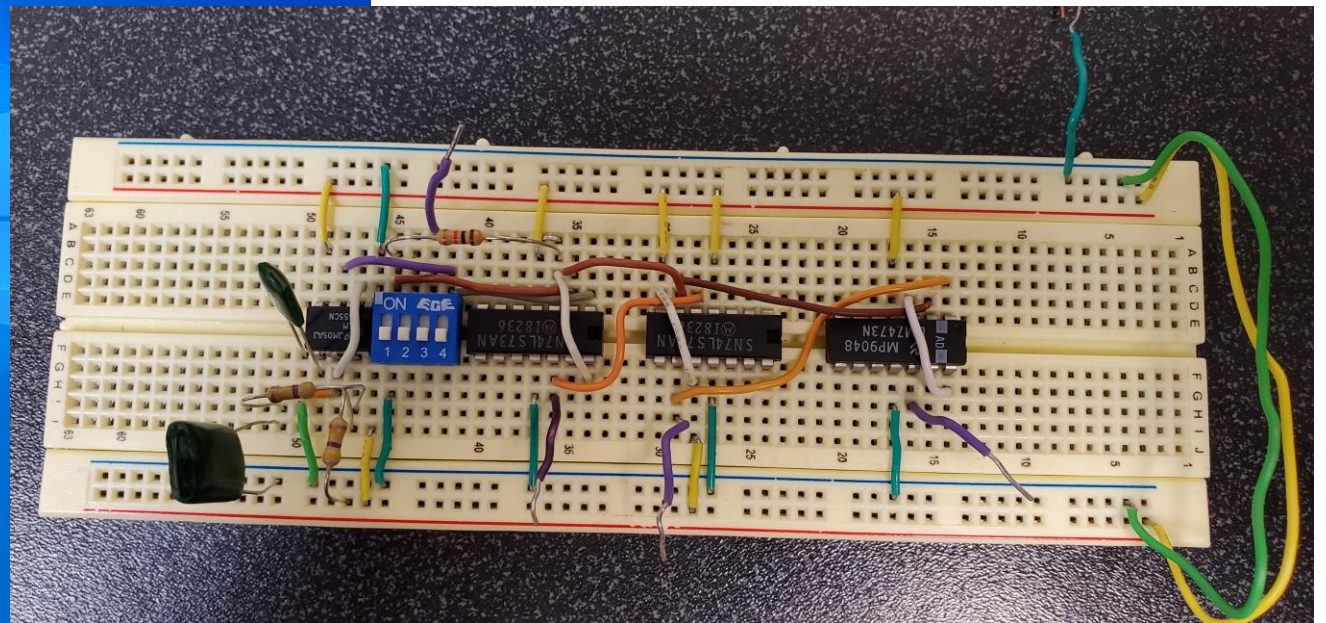
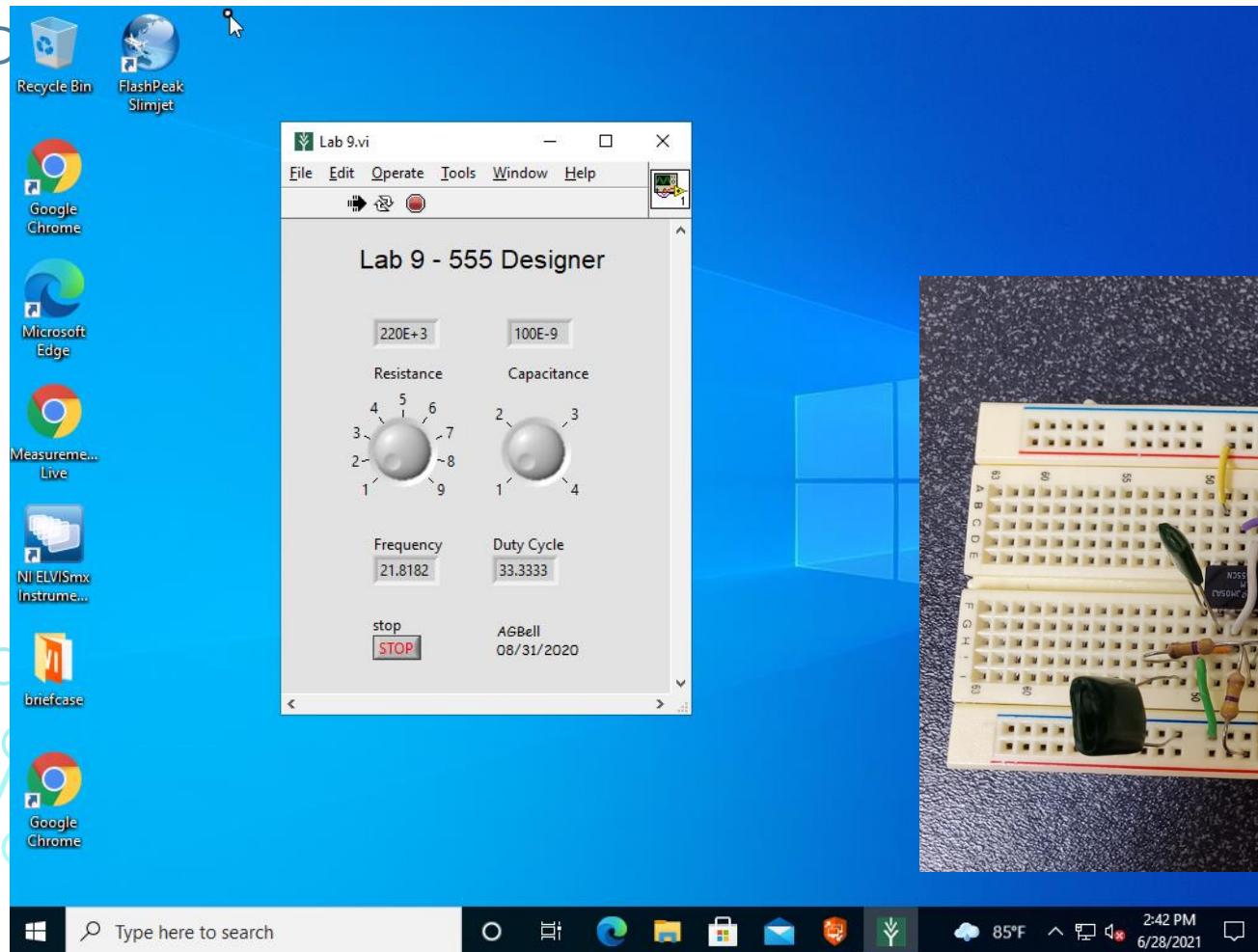


Also added by the department were items bought through Amazon:

- 3.3V 5V Power Supply Module for MB102 102 Prototype Breadboard DC 6.5-12V or USB Power Supply Module
- 9V Battery Clip with 2.1mm X 5.5mm Male DC Plug

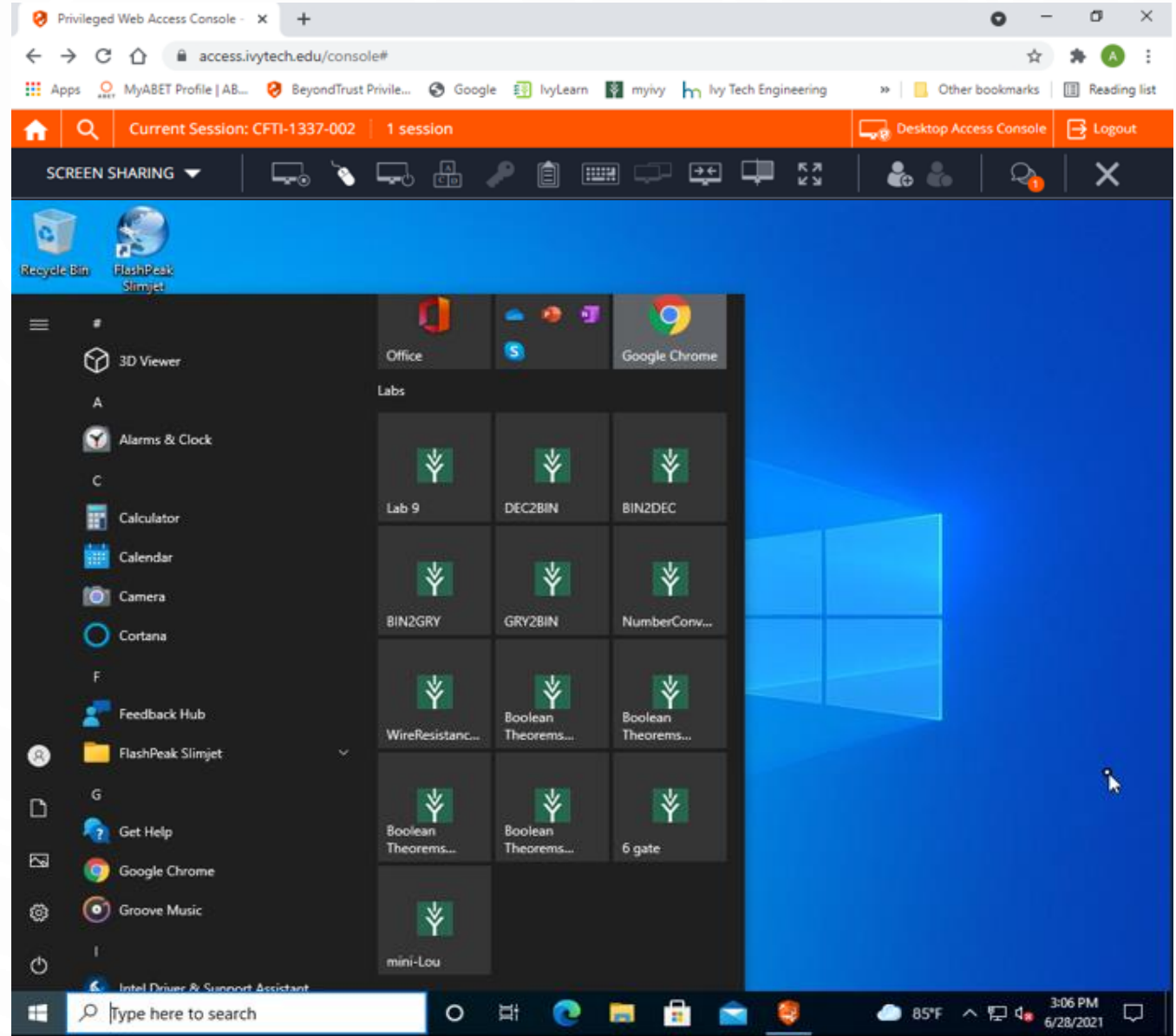
Kit info – What is missing can be supplemented with LabView programs and remote labs (under development)

Most challenging EECT 112 lab is lab 9, lab also supported with Custom LabView program for 555 Design.



Kit info – What is missing can be supplemented with LabView programs (continue)

Numerous custom LabView programs have been created and are easily deployed to the GRE computers. Admin rights are maintained by the department ...



Questions and References

<https://online.nvcc.edu/it/docs/sl/Virtual-Worlds-Teaching-Manual.pdf>

<https://www.ivytechengineering.com/abell118/references/SecondLifeInfo/>

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SL avatar = ivytechengineer

<http://maps.secondlife.com/secondlife/IvyTech%20Engineering%20Island/206/120/21>

<http://www.ivytechengineering.com>

<http://www.ivytechengineering.com/abell118>

