Engineering Math Development at CBU Utilizing the WSU Model

(First Six Years Results*)

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6th Annual National Engineering Math Consortium

Indianapolis, Indiana

June 2014

*Partially Funded by NSF Grant DUE 0817332

Overall Context for this work is somewhat unique

- CBU is a Private University (8000+ students in Riverside California – 32% minority, semester based) 3200 when we started!
- College of Engineering **Started** in 2006 (first classes Fall 2007)
  - 9 Degrees now offered: BmE, ChE, CE, CM, CS, ECE, ME, SwE and Engineering (pre law, pre med, bioengineering, business and global applications) Added BS BmE and BS CS this last year.
  - Incoming class size (55, 67, 81, 111, 152, 175, 210+?(est)) Total 438 last fall. Over 530 anticipated this fall.
    - ~35% ethnic minority,
    - ~15% female
    - ~10% international
    - ~20+% of incoming students involved in athletics
  - Cohorts of students on presidential scholarship from Rwanda (11/12, 16/19, 14/16, 3/7, 2/7,3/7)
  - Full time Faculty (1,2,5,8,13, 18, 22, 26, 30,?) Currently 3 of 26 faculty are women

Our NSF team has diverse and complimentary backgrounds

- **Dr. Grace Ni** – PhD ECE preparing new labs
- **Dr. Matt Rickard** – PhD ME preparing new lab
- **Dr. Mark Gordon** – PhD ME preparing new lab/and or demonstration device
- **Dr. Jae Kim** – PhD BME preparing demonstration
- **Dr. Mark Anklam** – PhD Chemical Engineering preparing to teach in fall
- **Dr. Francois Jacobs** – PhD Construction Management preparing new lab
- **Dr. Helen Jung** – PhD in CE, involved in K-12 outreach (*new faculty* (taught EGR "100" and developed new labs. Preparing new lab
- Dr. Elizabeth Morris – PhD Mathematics Education (School of Education) – mentored Dr. Jung for EGR "100"
- Dr. Xuping Xu -Masters in Applied Math and PhD in EE from Notre Dame (School of Engineering) (taught 2 sections of EGR "101" including follow on to EGR "100".
- Dr. Anthony Donaldson – PhD in EE, innovative curriculum work at TTU, SPU and CBU (College of Engineering)… intuitive lab for calculus.
- Dr. Ziliang Zhou – PhD in ME, MBA, *(taught multiple sections* of EGR "101".
- Dr. Rod Foist – *PhD in CpE, new faculty, taught EGR 101 in fall and spring, teaching labs only next year…. FPGA expert, will introduce them in the lab for the course.*
- Dr. Alex Chediak – PhD Material science Cal Berkeley – responsible for teaching and implementing a new inquiry based physics curriculum for our engineering program (joint appointment COE and College of NMS)

Outstanding undergraduate curriculum is a focus and thus a fit for this model

- One of four articulated areas of focus for the College's research activities
- One of ten distinctives desired for our programs
- Faithfulness in using vocational gifts for service is seen as a primary way we worship God and thus curriculum development is seen as directly tied to our College of Engineering's mission statement and its guiding verse ("For we are Christ's workmanship created in Christ Jesus for good works that God prepared in advance for us to do."Ephesians 2:10)

History of CBU adaptation of WSU model shows continual development

- **2013-2014 –Continued development and utilization of our intuitive calculus labs, developed and tested new NAO robots for use in engineering trig labs.**
- 2007-2008 – algebra, precal or calculus entry points (WSU 100 1.0 introduced in fall, WSU 101 1.0 introduced for first two groups in spring 2008.)
- 2008-2009 – WSU 100 2.0 (labs added), WSU 101 2.0, Math anxiety assessment begun for 100.
- 2009-2010 – WSU 100 3.0 (EGR faculty and vertical integration "VI") WSU 101 3.0 (required course, VI and customized text started) Assessment using WSU questions was conducted.
- 2010-2011 – WSU 100 & 101 4.0 (Recitation sections and new labs-closing feedback loop. Adding additional VI feedback from Mathematics dept.), Optional labs for those placing out of Calc I and II. Math anxiety assessment for 101 started.
- 2011-2012 – WSU 100 and 101 continued to be refined and assessed.
- 2012-2013 - Lab section only of WSU 101 was added for those students we wanted to have the lab experience but placed out of or transferred in Calculus credits, intuitive calculus labs piloted. Use of WSU official textbook started. Developed beta version of our own lab notebook.

Curriculum was added to two more new majors this past year!

- This brings our total number of majors where the this approach is now required in its curriculum to nine!
- Two new majors in 2013-14 (computer science and biomedical engineering) went through curriculum with shared EGR core (i.e. required EGR 182)
- Two more majors under consideration for the future: IE and PE, as well as a PhD in Engineering Education.
- We anticipate new lab and demonstration modules for these majors as well.

NSF WSU curriculum implementation

Example: BS Electrical and Computer Engineering
We also have BS CE, ME and general Engineering degrees

	Fall			Spring			Summer	
	Course #	CR	Description					
Year 1								
	EGR 182	4	Engineering Math II	MAT 245	4	Calc I		
	EGR 101	3	Engineering from a Ch	EGR 102	4	Intro to Engineering Design		
	EGR 121	3	Problem Solving and P	PHY 201	4	Mechanics/Waves		
	ENG 113	3	Composition I	EGR 122	3	Visualization Languages I		
	EGR 103	1	Engineering Service I	EGR 192	1	Freshman Seminar		
	GST 100	1	Focus					
		15			16			
Alternative	EGR 181	4	Intro to Egr Math I	EGR 182	4		MAT 245	Calc I
Year 2								
	PHY 203	4	E/M Optics	EGR 202	0	Worldview Reflection		
	EGR 231	4	Circuit Theory I	EGR 232	4	Circuit Theory II +Design		
	MAT 255	4	Calculus II	EGR 234	4	Digital Logic Design		
	ENG 123	3	Composition II		4	Science Elective*		
		3	GE#3		3	Upper Division Math**		
				EGR 221	3	Data Structures		
		18			18			

* BIO 146 or 153 or CHE 115
** preferred MAT 403, 413

Note: EGR 181 is similar to WSU 100 but with a lab. EGR 182 is Wright State's 101
3 hours lecture, 1.5 hours lab 15 weeks.

We added a one unit lab to allow the hands on lab for those testing/placing/transferring out of the lecture.

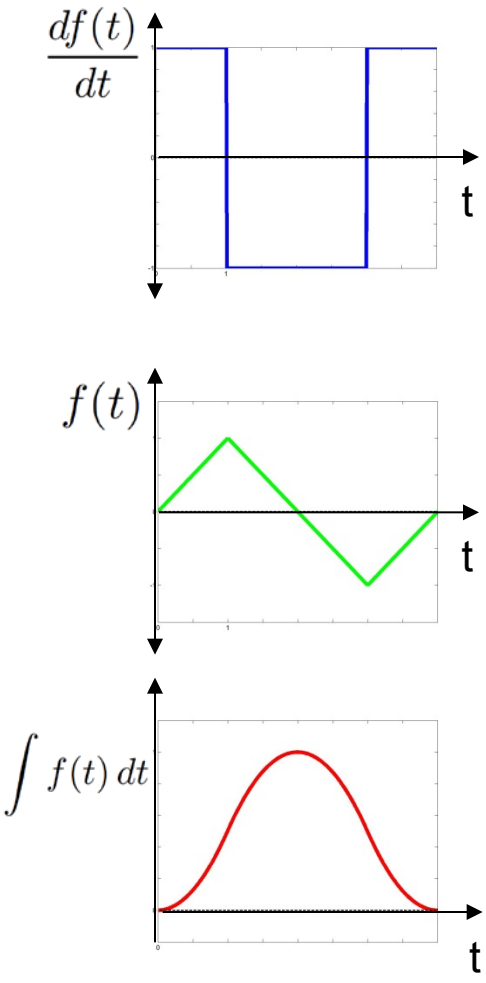
- New pathways are:
  - Fall: EGR 182L (1) or lab exam, and MAT 343 (4) Calc III or science course (Assumes placed out of or took lecture equivalent through Calc II at another school with a B or better.)
  - Fall EGR 182L (1) or lab exam, and MAT 255 (4) Calc II (Assumes placed out of or took lecture equivalent of Calc I at another school with B or better.

Intuitive Calculus Lab beta tested last year were further developed.

- The next two slides show the new calculus lab we beta tested this year. (Introduced to this group last summer).
- We have some refinements to do with the hardware (new FPGA etc) this summer in order to roll out for all students in the fall.

Calculus Made Fun With EE Hardware

or, "Intuitive Integrals & Derivatives"



Math Operation, $\int$

Math Operation, $\frac{d}{dt}$

8th-grade language

"smoother"

Engineering language

"Low-pass filter"

8th-grade language

"rougher"

Engineering language

"High-pass filter"

Applications: Audio and video signal processing!! – Cool stuff!!!

New "WSU EGR 101" Lab

(Analog & Digital Implementations of Calculus)

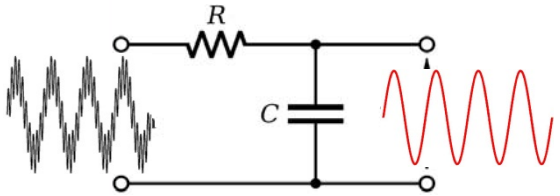
Math Operations

"Signal" Operations

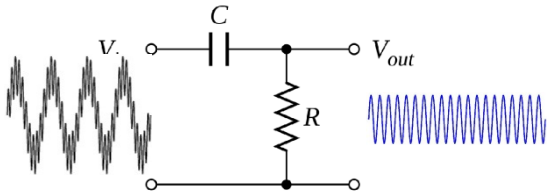
Analog

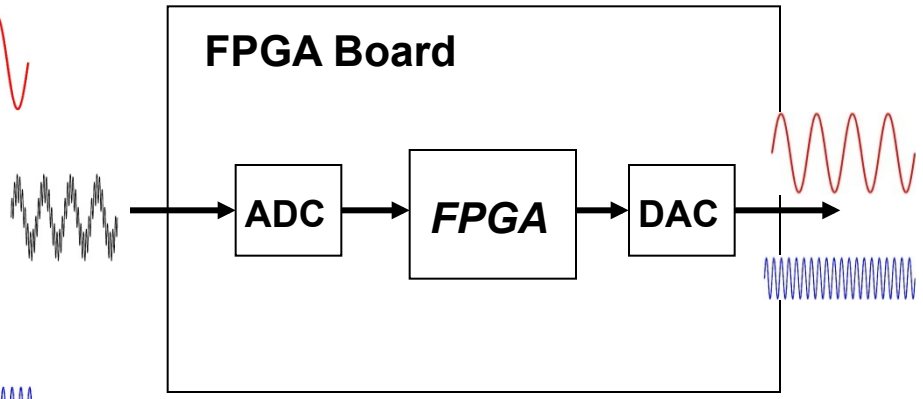
Digital

$\int$ **Low-pass Filter**



$\frac{d}{dt}$ **High-pass Filter**





(Low-pass & High-pass Filters)

FPGA = Field Programmable Gate Array

ADC = Analog-to-Digital Converter

DAC = Digital-to-Analog Converter

New labs and demonstrations were developed this year!

- Dr. Grace Ni and Dr. Rod Foist (ECE) used NAO robots to illustrate trigonometry.
  - Paper planned to be given at 6th First Year Engineering Experience Conference, August 7-8, 2014, College Station, Texas



- Dr. Rod Foist and Dr. Anthony Donaldson (ECE) used Electronic Filters (Analog and Digital(FPGA)) to illustrate derivatives and integrals.
  - Paper planned to be given at 6th First Year Engineering Experience Conference, August 7-8, 2014, College Station, Texas

Longitudinal results are encouraging!

- 58% of ‘at risk’ students entering ‘100’ since inception (85/146) were still in the program after 1 year (Note: WSU (MPL3) went from 26 to 48 %)
- Over 2/3rds of those not in engineering where still in the university in other majors.

Overall impact has been very good for a new college of engineering!

- This fall we will surpass over 1000 students that have been positively impacted by our versions of WSU's 100 and 101!!
- Provided mechanism to continually improve critical starting math classes for our students
- Provided mechanism for many faculty to contribute and in some cases innovate.

Future Plans involve expanded impact of this type of curriculum.

- We are in the middle of a campaign for a new 100,000 ft^2 engineering building with utilization for STEM education year round for the entire Southern CA region.
- We are planning to begin a PhD in Engineering Education in Fall 2017 with an emphasis on undergraduate engineering education in different cultures/countries of the world.

Grant and New Faculty Opportunities in Sunny Exciting CA

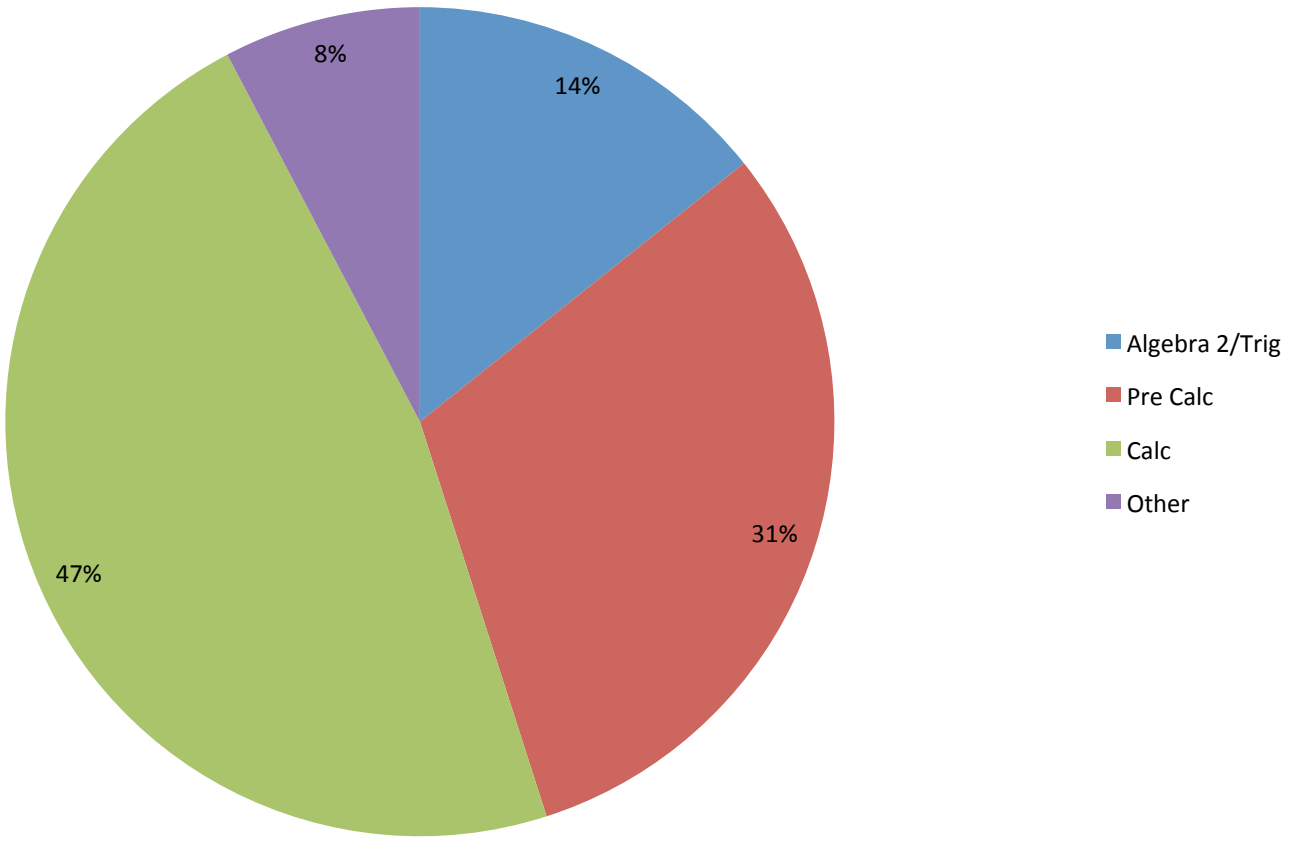
- We would delight in partnering with other institutions (K-12 and Universities) for Engineering and STEM education grants.
- We currently have an opening for a tenure track position in Computer Science starting this fall (Fa 2014).
- We will likely have openings in Industrial, Chemical, Computer Science and at least one another area (ECE, ME, CE, BmE, CM) next year.
- For more information contact Anthony Donaldson, Founding Dean of the California Baptist College of Engineering using LinkedIn or adonaldson@calbaptist.edu

Special Thanks

- Jeff Froyd (Head of Faculty development at Texas A&M) – suggesting to Dr. D to contact Nate in summer of 2007(ASEE- Hawaii)!
- Nate Klingbeil at Wright State University
  - Allowing us to be on the initial team and providing great leadership
- The National Science Foundation
  - For funding projects that make a difference!

Highest High School Math

(all 1st year EGR students for 2011-2012)



Additional assessment is being implemented

- Math anxiety (pre and post for 101 as well)
- Correlation for student performance in Calculus (w and w/o 101) is planned
- Correlation for student performance on National FCI for Physics is planned
- Specific new lab modules for intuitive learning of calculus.