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WIP: Creating a Framework for Upper-Level Project-Based Courses in Electrical and Computer Engineering

Dr. Rohit Dua, Missouri University of Science and Technology

ROHIT DUA, Ph.D is an Associate Teaching Professor in the Department of Electrical and Computer Engineering at the Missouri University of Science and Technology and Missouri State University's Cooperative Engineering Program. His research interests include engineering education.

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Abstract

Past research has demonstrated that project-based exercises allow students to build valuable skills, and retain knowledge, which will help them navigate and excel in industry after graduation. Many courses incorporate small projects to keep the courses interesting while reducing the burden of executing extensive projects. Unfortunately, such endeavors, even though valuable, fall short in developing skills needed for the industry and knowledge retention. This paper proposes a basic and broad framework, strategies, pros, and cons, including challenges, for creating project-based courses in which majority of the course assessments are projects, which are either pure hardware, pure software or a mix of hardware and software design components. The Missouri University of Science and Technology's (S&T) Electrical and Computer Engineering (ECE) Cooperative Engineering Program (CEP) serves as a testbed for the project-based instruction implementation in multiple sequential courses.

Keywords

Electrical and Computer Engineering, Project-Based Instruction.

Introduction

Course projects allow students to gain valuable engineering design and analysis skills that aim to prepare them for their chosen career path [1-4]. Past research has repeatedly demonstrated the need for active project-based learning, which involves significant hands-on projects for deeper learning and knowledge retention [3-4]. The goal of this paper is to suggest a basic framework to implement project-based learning for multiple and sequential upper-level courses in the S&T's Bachelor of Science (BS) Electrical Engineering (EE) undergraduate degree program. Moreover, the paper proposes basic strategies, pros, cons, and challenges of implementing project-based courses. The implementation structure is limited to upper-level Electrical and Computer Engineering (ECE) undergraduate/graduate courses taught in the S&T's ECE department and executed in their Cooperative Engineering Program (CEP) (BS EE and undergraduate minor in Computer Engineering (CpE) [5].

Targeted Courses and Reasoning

The EE degree program requirements include a set of elective courses [6], which have the potential to be implemented as project-based courses which include more than 75% of assessments as hands-on projects. The elective requirements and the chosen courses include:

- Electives A, B, C: Students are required to take three upper-level EE courses that allow focused education in one of the ECE emphasis areas. This set includes undergraduate courses such as EE 3120: Electronics 2, EE 3410: Digital Signal Processing (DSP), and CpE 3150: Introduction to Microcontrollers and Embedded Systems. Note that there is a bigger list of courses that can satisfy these electives [6]. Only those courses with suggested project-based instruction implementation are included and discussed in this paper.

- Elective D: Students are required to take one graduate level ECE course. CpE 5610: Real-Time DSP, CpE 5220: Digital Signal Modeling, CpE 5450: Digital Image Processing, and CpE 5410: Introduction to Computer Communication Networks are typical chosen graduate-level courses that can satisfy this requirement.

- Elective E: Students are required to take an additional undergraduate/graduate ECE course. This requirement can be satisfied by taking any EE/CpE undergraduate/graduate course. In addition to typical courses including CpE 3110: Computer Organization and Design, and EE 4099: Fun With Electronics (FWE), any of the courses mentioned for electives A-D can be used to satisfy this requirement.

- Free Electives: Students are required to take 6 credit hours of free electives. The above-mentioned courses can count towards this requirement.

The above-mentioned elective requirements provide a suitable platform to implement sequential hands-on project-based courses for enhanced learning and skill building. While Sophomore and Junior-level courses can incorporate project-based instruction, this paper emphasizes project-based instruction implementation for elective courses for the following observed reasons:

- Most of the Sophomore and Junior-level courses have a laboratory course associated with the lecture course [6]. Substantial project work, if any, is implemented in the lab setting. Elective courses usually do not have a required laboratory course attached to it.

- Not all students are interested in taking project-based courses since projects are usually time-consuming affairs. Past course execution observation has shown that most students dislike project-based courses that are time consuming and challenging resulting in reduced learning and semester-end instructor evaluation scores! Elective courses offer a way to allow desiring students, who dislike standard exam-based courses, to take project-based courses. There are plenty of other exam-based courses available for students who prefer exam-based courses [6].

Dual Advantage

Carefully choosing EE electives can also help an EE student earn a minor degree in CpE at S&T [7]. Following are the CpE minor degree requirements, which will also satisfy EE electives:

- CpE 3150: Introduction to Microcontrollers and Embedded System: Will also satisfy EE electives A, B or C.

- CpE 3110: Computer Organization and Design: Will also satisfy EE elective E or free elective.

- CpE 5410: Introduction to Computer Communications Networks: This course will also satisfy EE elective D.

- Any additional EE/CpE 4xxx or higher 3-credit hour course: Several graduate courses mentioned above may be used to satisfy this requirement.

As seen above, the suggested elective courses offer EE students a path towards earning a CPE minor degree while building hands-on project development skills.

Basic Project-Based Sequential Course Framework

Course Recruitment: To ensure that students understand the intensive course expectations, students are regularly informed, before the start of the semester, about rigorous project-based courses assessments that will be a great learning experience but will be time consuming and challenging. This regular communication will ensure that only those students enroll in a project-base course who are truly interested in learning via hands-on projects. One con to this process is the resulting low enrollment numbers in rigorous project-based courses.

Basic Course Structure and Framework Suggestions for project-based implementation: Note that the goal here is to mold the course into a project-based course in which majority of the courses assessment modules are project-oriented. The project suggestions below can be implemented in similar courses at other universities depending on desire and available teaching support resources.

- *EE 3410: Digital Signal Processing (DSP)*: In a nutshell, DSP involves significant mathematical treatment to understand signal processing, in the time and frequency domain, and digital filter designs including FIR and IIR filters. A higher-level programming language platform, such as Matlab, serves as a perfect stage to learn DSP concepts. Broad course goals include:

    - Analysis methods for discrete-time signals and systems in the time and frequency-domains.
    - Frequency domain analysis algorithms such as DTFS, DTFT and ZT.
    - Digital filter design and analysis including IIR and FIR filters.

  Typical project-based learning components/assessments can include:

    - Math oriented analytical analysis coupled with programming-based exercises, which will form the bulk of the course assignments as mini-projects.
    - In depth understanding of sampling, aliasing, and signal analysis via a programming-based comprehensive and major project 1. Note, this project also includes significant analytical analysis.
    - Comprehensive FIR filter design and analysis as the major project 2.

- *EE 3120: Electronics 2*: Since several of the active electronic components are non-linear, design and analysis learning must involve significant circuit simulation and/or hardware circuit building and testing. This course has an associated and recommended laboratory course [6]. Unfortunately, most enrolled students do not take this laboratory course. Therefore, an important goal, and challenge, is to bring some of hardware laboratory components into the lecture course. Broad course goals include:

- Frequency domain analysis of discrete amplifier circuits
- Power amplifiers and heat sink design and analysis
- Positive feedback Op-Amp circuits including comparators and Schmitt-Triggers
- A-D and D-A circuits
- Digital logic circuits including CMOS and ECL logic families.
- Oscillator circuits design and analysis

Each covered theoretical module has an associated hardware laboratory exercise, which requires, design, analysis, and demonstration [8-9].

- *EE 4099: Fun With Electronics (FWE)*: This 3-credit hour lab course concentrates on building and testing of practical electronics to better understand the concepts covered in lower-level electronics lecture courses [10-12]. This course is currently taught via undergraduate research.

- *CpE 3150: Introduction to Microcontrollers and Embedded Systems*: This first course in the realm of embedded systems concentrates on 3 main skills via a chosen microcontroller family including basic computer organization, ASM programming and C-based application development with an external interfaced device such as a sensor or an actuator. In addition to basic homework exercises for general understanding of the covered concepts, typical project-based learning components/assessments can include:
    - Create your own mini-processor version for enhanced understanding of computer organization [3, 13-16]. This project includes hardware design on an IDE such as Quartus and hardware test on an FPGA board.
    - ASM-based application development on the provided microcontroller development board [17-18].
    - C-based application development on the provided microcontroller development board including interfacing to external peripherals such as sensors and actuators [19].

- *CpE 5220: Digital Systems Modeling*: This course concentrates on modeling of computer engineering hardware using Hardware Descriptive Languages (HDL). Typical instruction includes teaching VHDL, Verilog and SystemC HDL to model computer hardware systems ranging from basic gates to Register Transfer Logic (RTL) design. Design verifications include extensive simulations. Project components include:

    - Broad design modules from simple gates, combinational and sequential circuits to an RTL system design.

    - An RTL system design using the HDL of choice for a typical comprehensive application.

- *CpE 3110: Computer Organization and Design*: This first course aims to introduce design methodologies used in modern computer systems and processors. In addition to basic homework exercises for general understanding of the covered concepts, typical project-based learning components/assessments can include:

    - An HDL-based processor sub-system design, testing and timing analysis on a chosen FPGA board.

    - Simulation of sub-systems using Modelsim or similar hardware simulation software.

- *CpE 5450: Digital Image Processing*: This course concentrates on understanding and programming algorithms created from the developed math for image processing. Matlab is the preferred programming platform for all project components including:

    - Programming the discussed algorithms and mathematical treatment, for image processing, that will form the bulk of the course assessments.

    - Comprehensive image processing application design, programming, and testing. A typical project includes video compression implementation, from scratch, testing and analysis.

- *CpE 5610: Real-Time Digital Signal Processing*: This course is broken into two parts: learning advanced DSP techniques and implementing DSP systems for audio signal processing on a DSP processor board. Project components include:

    - Math oriented analytical analysis coupled with Matlab programming-based exercises on advanced DSP concepts.

    - C++ based hardware programming and testing of audio DSP algorithms.

- *CpE 5410: Introduction to Computer Communication Networks*: This first course in the realm of computer networking aims to provide a strong foundation on computer communication and networking concepts. Since this course is open to non ECE majors, significant project-based instruction implementation has proved to be challenging! Current projects include data packet capture and analysis using the Wireshark software.

Broad Institution Adoption

The above-mentioned implemented projects and examples provide a basic framework that can be used by other instructors to implement project-based instruction in similar courses under their purview. Here are some suggestions, on broad project-based learning adoption, and observational opinions:

- For a stand-alone course, it is easy for an instructor to implement project-based instruction. The above-mentioned project examples can be implemented depending on the instructor's desire and the availability of instruction resources.

- For sequential courses, such as in signal processing or embedded systems, if all the courses in sequence are taught by the same instructor, then implementing project-based instruction is straightforward. If multiple instructors are involved in teaching sequential courses, then consensus will have to be reached between the involved instructors on implementing project-based learning in their course, which can be challenging! With department support and mutual agreement, project-based learning can be implemented if the skill building is an important department and institution student learning outcome.

- The discussed framework and strategies are perfect for implementing project-based skill development for a CpE minor program, as discussed above, or an undergraduate/graduate certificate program.

Pros, Cons and Challenges

The advantages, cautions, and tribulations mentioned in this section can provide a course planner some guidance on creating a project-based course under their purview. Note that the below-mentioned points and discussions are observational!

- *Sequential skill building*: The above-mentioned ECE courses were carefully chosen to create a structured mechanism in which students continually build skills, enhancing their understanding of topics sequentially, while simultaneously pursuing increasingly difficult projects from one course to the next. Typical course sequences include:

    - CpE 3150 → CpE 3110 → CpE 5410 & CpE 5220

    - EE 3410 → CpE 5450 & CpE 5610

    - FWE → EE 3120

  Students were able to use the learnt skills to implement capstone experiential learning and senior design projects [10, 11, 14, 15, 20, 21]. This culmination of skill building endeavor is by far the biggest pro feedback for executing project-based courses. For the student, an obvious drawback of this undertaking is the limited availability of such project-based course sequences.

- *Enjoyable and fun learning experiences?*: While the amount of experienced fun, in a course, is subjective, overall students found the learning experience enjoyable and fruitful

[10-12]. In some projects, allowing students to be creative in project-building help enhance the learning experience [10-12]. While some enrolled students found the hardware-oriented projects to be more enjoyable, other enrolled students found the programming-oriented projects to be more enjoyable. This observation supported the initial hypothesis that some students prefer hardware-oriented projects, while some other students prefer programming-based projects. Though, by the end of a course students found that they had improved skills in lacking experiences.

- *"I wish, I had more time"*: Time, time and more time is the biggest issue encountered while implementing project-based courses. Iterative programming, hardware design and testing are time consuming tasks which require students to work long hours, many times outside business hours and weekends, to complete the required project tasks. Now, it is possible to water-down the projects to make the tasks easy and less time consuming. Though, this route results in less skill building as past observation has shown that students learnt more from making mistakes and figuring out solutions while working on challenging projects. Past implemented solutions to mitigate this con included:

    - Bigger and comprehensive projects were broken into phases, requiring students to demonstrate regular project progress. This structured project implementation allowed the instructor to observe the muddiest portions of projects and adapt the project execution accordingly. This technique was executed in most of the courses mentioned above.

    - Based on student feedback, some of the busy-work parts of the projects were minimized or eliminated to streamline project execution.

    - Provided frequent technical support, which is discussed next.

- *"I am working long hours"*: A major caveat to this endeavor is the large amount of time spent, by the instructor, outside class hours providing valuable technical support to enrolled students. This time exponentially increases as enrollment increases, especially in individual project implementations. Group project work (maximum of two students per group) can help lower the required amount of interaction time. Moreover, hiring a Teaching Assistant (TA) can help lower the interaction time if hiring funds are available, which can be a challenge. Of course, finding a good TA for the job is also a challenge!

- *Continuous creativity*: To keep projects challenging and minimize cheating and copying past executed projects, creating new and varied project specifications can be challenging and time consuming. This issue is especially observed in courses that are offered frequently.

- *Threat from AI*: To ensure students are not using AI tools, such as ChatGPT, to find solutions for programming-based projects, projects are required to implemented at grassroots level including setting very specific project goals or requiring the implementation of specific programming strategies or covered mathematical equations so that such acts are minimized.

- *Hardware and software access*: Past observation has shown that access to university supplied and supported software is clunky especially on a student's personal computer! One example is Matlab, which is difficult for a student to access on their personal computer. This issue is exacerbated for distance students who are not on campus. Students must either buy their own license or use the free online platform such as GNU Octave, which may not have all the features as available in Matlab. Moreover, a bigger challenge is providing access to hardware in elective courses. Sufficient resources are needed to allow students to check out the required hardware if it is not bulky. Holding an in-person class in a laboratory room is also a solution to this issue. Distance students must buy their own hardware and/or get access to laboratory equipment, which may not be easy or economical.

Student Feedback

Course execution successes and shortcomings were judged based on the semester end feedback received. Here are some typical samples of the comments received from students:

EE 4099: Fun With Electronics

Instructor:	**Dua,Rohit**	Title:	**Undergraduate Research**
Section(s):	**ELEC ENG 4099 607**	Term:	**FS2022**

Number Responding: **6** Number Enrolled: **6** Percent Responding: **100.00%** Effectiveness: **4.00**

Student Comments

With regards to teaching, what are the strengths of the instructor?

I am not speaking in hyperbole when I say this is the most impactful class I have taken to date. It cemented several years of instruction through practical application. It is my belief that the subject matter was so incredibly important and helpful that it should be mandatory for any student passing through the program. On top of that, I don't think I've ever had more fun in a class. Not only did I learn, but Dr. Dua made it fun and engaging.

Extremely in depth understanding of the material at hand

Dr. Dua has a complete fundamental understanding of the material that was presented during the semester. It is very beneficial to the quality of the course when the professor is able to concisely and accurately answer questions pertaining to the material.

I really liked that the experiments were often modeled around practical uses. I also liked how the focus was not necessary on the precise values of all the components used or the operating conditions of the transistors, but rather how the circuit worked in general and how modifying any of those components would effect it's performance

Incredibly effective teacher, understands what he needs us to do and communicates it clearly.

Very passionate about his electronics, and that passion bleeds into the class!

What suggestions do you have for improving the quality of instruction?

I honestly can't think of anything. All the projects were incredibly practical and useful. I've built a few on my own for home use. Please give Dr. Dua a raise. He's the best professor in the program and this class is one of the most important.

None

No recommendations. The quality of instruction was exceptional.

Class was very BJT heavy. Should incorporate more vacuum tubes for sure. Or not, those are expensive.

CpE 3150: Introduction to Microcontrollers and Embedded Systems

Instructor:	**Dua,Rohit**	Title:	**Intro Micro Embed Design**
Section(s):	**COMP ENG 3150 104**	Term:	**SP2023**

Number Responding: **5** Number Enrolled: **9** Percent Responding: **55.56%** Effectiveness: **4.00**

Student Comments

ID	With regards to teaching, what are the strengths of the instructor?
72715	He has the answer for any question.
72721	Dr. Dua is truly the pinnacle of professors in the field of Electrical Engineering. With his exceptionally deep understanding of the subject matter, he is always prepared to answer any question a student might have. His genuine interest in the success of his students and their career development in Electrical Engineering is truly inspiring. Attending Dr. Dua's classes feels like experiencing an Ivy League engineering course, as he consistently sparks students' interest in the fascinating aspects of electronics, rather than simply providing information and testing knowledge. His encouragement for students to further their understanding and promoting curiosity creates an engaging and supportive learning environment. Dr. Dua frequently checks in with phrases such as "are you with me" and "please review this," ensuring that every student stays engaged and comprehends the material being discussed. As his responsibilities continue to grow each semester, his engagement and support for students has only increased, which is just remarkable. I don't know how he does it. He is generating 10's of millions of dollars in industry skills. It is always an absolute pleasure to study under Dr. Dua, a truly remarkable educator in his field.
72724	Dr. Dua for president. His courses are hard but they're always fun and you always learn.
72727	Very informative, and provides great projects and lectures to help understand topics and how they can be used in applications. Completing projects provided more insight into applied engineering and gives confidence for future design processes.

ID	What suggestions do you have for improving the quality of instruction?
72736	Nothing. He just improves before I can think of it.

EE 3410: Digital Signal Processing

Instructor:	**Dua,Rohit**	Title:	**DSP**
Section(s):	**ELEC ENG 3410 104**	Term:	**SP2023**

Number Responding: **5** Number Enrolled: **9** Percent Responding: **55.56%** Effectiveness: **4.00**

Student Comments

ID	With regards to teaching, what are the strengths of the instructor?
70345	The depth of his understanding of course material, and willingness to help students.
70348	He knows his stuff.
70351	Dr. Dua's main strength is that he really cares about his students. While his course material is hard (extremely so at times), he is always one email away. He dedicates himself to answering your questions effectively and thoroughly, so much so that he feels like more of a personal mentor in a one-on-one class than an instructor of 15-20 people. He is a rare gem among professors!
70354	Rapid email response, kind responses to my stupid questions, plenty of office hours, always goes farther into detail in the lecture than we need for exams so that we have the option to learn more.
70357	The instructor always encourage students to get done the assignments, help and respond questions. Maintains a good communication with students.

ID	What suggestions do you have for improving the quality of instruction?
70360	none
70369	None. Dr. Dua always sets the bar for the highest quality of education of any professor both in and outside of this program.
70372	N/A

CpE 3110: Computer Organization and Design

Instructor:	**Dua,Rohit**	Title:	**Computer Org and Design**
Section(s):	**COMP ENG 3110 103**	Term:	**SP2024**

Number Responding: **3** Number Enrolled: **8** Percent Responding: **37.50%** Effectiveness: **4.00**

Student Comments

ID	With regards to teaching, what are the strengths of the instructor?
246416	His willingness to delve into the unknown with his students on their quest for knowledge
246419	Dr. D also definitely knows his stuff!
246422	Dr. Dua was very effective at communicating the concepts of the course. The way that he explained the 'why' behind organization of components was clear and made sense. His drawings on the diagrams were especially helpful.

ID	What suggestions do you have for improving the quality of instruction?
246425	N/A
246428	NA
246431	Although I feel that I had a good handle on the concepts of the course, I often struggled to turn it into Verilog. Much of the time spent on this course was just trying to learn the Verilog skills that I needed in order to complete the projects. I realize that there is not enough time to teach good Verilog skills during the course, so I would have loved to have links on Canvas to external resources that would aid in translating computer organization designs from block diagrams into Verilog code.

CpE 5220: Digital Systems Modeling

Instructor:	**Dua,Rohit**	Title:	**Digital System Modeling**
Section(s):	**COMP ENG 5220 1DIS**	Term:	**SP2019**

Number Responding: **1** Number Enrolled: **2** Percent Responding: **50.00%** Effectiveness: **4.00**

Student Comments

What are the strengths and weaknesses of the instructor?

Rohit is very well organized and throughly explains course material during lectures. The course involves a lot of well thought out projects and Rohit makes sure we each can demonstrate that we have full understanding of the material and works with us on any issues we might have.

What suggestions do you have for improving the quality of instruction?

It seemed like a slow start in the beginning and a lot of content and work towards the end. More even work load and pace throughout the semester would improve the quality.

What are the strengths and weaknesses of the course?

By far the greatest strength is developing a working knowledge of hardware description languages VHDL, Verilog and SystemC. A weakness would be that a lot of the work is done alone and with the professor. It would be nice to work with other classmates and know how we all are progressing and not in the sense of group projects but more sharing things that stood out in people's assignments and presenting that so we each and learn from each other. A good idea would be to have someone in the class present their project for the whole class after each project is complete.

What suggestions do you have for course improvement?

See the strengths and weaknesses response.

CpE 5610: Real-Time Digital Signal Processing

Instructor:	**Dua,Rohit**	Title:	**Real-Time Digit Sign Pro**
Section(s):	**COMP ENG 5610 3MSU**	Term:	**SP2019**

Number Responding: **1** Number Enrolled: **3** Percent Responding: **33.33%** Effectiveness: **4.00**

Student Comments

What are the strengths and weaknesses of the instructor?

Instructor worked with students to help projects get done, and answered questions, and helped students get hardware to make progress on their own, and gave feedback to questions. A weakness is that the instructor had limited experience with the specific DSP hardware board that was used in the lab, and so it took significant time to troubleshoot everything.

What suggestions do you have for improving the quality of instruction?

The instructor could become more familiar with the hardware so that some of the bugs could be resolved more quickly.

What are the strengths and weaknesses of the course?

The course allowed me to apply what I learned in theoretical DSP to a physical DSP board. I was able to see in real time how and FIR and IIR filter changed the signals. I learned how interrupts limit the amount of taps and processing that can be performed before the next sample comes in, and general debugging strategies. A weakness is the shear amount of time loss from running into little computer bugs. There was limited progress in this course in part due to the little computer bugs that showed up.

What suggestions do you have for course improvement?

It would be useful to have some discussion of common bugs that show up, and how to quickly get around them. That way, more time can be spent on learning the affects of DSP algorithms to real signals and systems, rather than fixing bugs in CCS code.

CpE 5450: Digital Image Processing

Instructor:	**Dua,Rohit**	Title:	**Digital Image Processing**
Section(s):	**COMP ENG 5450 1MSU**	Term:	**FS2018**

Number Responding: **3** Number Enrolled: **4** Percent Responding: **75.00%** Effectiveness: **4.00**

Student Comments

What are the strengths and weaknesses of the instructor?

The professor knows the material well and is usually available for assistance, but sometimes the assignments becomes excessive. This is especially true when this professor assigns major projects in all of his other classes. This can become frustrating when I, as student, need assistance, but the professor becomes too busy at the end of semesters.

The teachers motivation to the course and getting it ready for this semester is incredible. I feel that the subject was too condensed and the workload was to large for a single semester course. But the teacher set me up like I feel like I can finish teaching and practicing the theory I wasn't able to get finished by the end of the semester.

Instructor gives students projects that are challenging and require students to study material intensively. A weakness is that instructor assigned significantly more work in second half of semester than in first half.

What suggestions do you have for improving the quality of instruction?

None, the instructions are fine, being online is a major plus.

If instructor could assign projects more evenly throughout the semester, then students would have more time to work on projects. It seemed that more of the projects were not assigned until later in the semester.

What are the strengths and weaknesses of the course?

Strength: theory and computation is taught. Weakness: no hardware.

What suggestions do you have for course improvement?

A couple of the examples could be expounded upon further.

Add hardware component.

EE 3120: Electronics 2

Instructor:	**Dua,Rohit**	Title:	**Electronics II**
Section(s):	**ELEC ENG 3120 1MSU**	Term:	**FS2017**

Number Responding: **3** Number Enrolled: **10** Percent Responding: **30.00%** Effectiveness: **4.00**

Student Comments

What are the strengths and weaknesses of the instructor?

Dr. Dua seems to have a great concern for his students education. The projects he assigns may be a little difficult but he will spend hours outside of class making sure anyone that seeks his help receives it. He is always offering to have help sessions or problem solving sessions outside of class time or on the weekends. This is greatly appreciated by the majority of his students. Dr. Dua also makes sure all of his notes and lectures are recorded and made available to his students.

Both my mother and my grandfather were teachers and over the course of my life and specifically my academic career, I've seen a lot of very good and very bad teaching. That said, Dua has perfected his teaching method. The dedication, commitment and fervor with which Dua teaches is very apparent as a student. He is always available for help no matter the time of day (or night) and he will work through any problem you have no matter how big or small. He's the ONLY teacher I have that I can count on a quick response to an email (even at 2am), and a helpful response at that. Dua has mastered the line between being tough and being forgiving. Informally, passing a Dua class is like beating the final boss in a video game without cheats. You might have to put in some serious work, but very few things feel so rewarding. While other teachers are mercilessly difficult or ridiculously easy (handing out A's), Dua's grades are accurate and well earned. I absolutely have never seen such a defined balance in a teaching method. And it works. While other classes have become hazy, my Dua courses from even my earliest classes with him are still fresh in my mind. I know when I sign up for a Dua class that while I'm going to have to work for it, by the end of the semester I'll actually understand it. Dua has become a definite legend among students and that title is well earned. I would proudly boast my good Dua grades above all others. It would be easy to say that Dua has been the pinnacle of my college career teaching wise. He has perfected his teaching method and I would highly recommend him to anyone, no contest.

What suggestions do you have for improving the quality of instruction?

None

None.

What are the strengths and weaknesses of the course?

The best part of this course is it is project based so even though there is no lab associated with it, you gain hands on experience in designing electronic circuits.

Currently, only semester end instructor feedback comments are used to gauge the effectiveness of project-based learning. Though, observations from individual project demonstrations, and discussions with students, provided valuable insight into potential changes to subsequent implementations. Future course executions will include extensive surveys to gauge individual project learning effectiveness.

Also, project-based course execution was implemented at the CEP, which is a small program with smaller student enrollment numbers as compared to the main campus enrollment numbers. Some of the above-mentioned courses have been offered to students on the main campus. But, as mentioned in the student recruitment strategy section, adding course execution clarity and honesty, to potential students, about project-based course expectations resulted in low enrollment numbers. Moreover, the suggested project-based course execution framework is preferred for elective courses as discussed earlier in the paper, further exacerbating the low enrolment number issue.

Conclusion

This paper provides a basic framework, which include suggestions for types of projects to execute, for implementing project-based courses for sustained skill building in upper-level EE curriculum. Broad course content, in the implemented courses, provides the reader with basic ideas on implementing their course as a project-based course. Mentioned observed successes and issues may provide some guidance on how to manage project-based courses. Overall, implementing a project-based course, let alone a string of sequential project-based courses, is a challenging task!

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