Cross-institutional Collaboration on Hybrid Engineering Courses among Institutions in New Mexico

Dr. Jorge Crichigno, Northern New Mexico College

Dr. Jorge Crichigno received a B.Sc. degree in Electrical Engineering from the Catholic University of Asuncion, Paraguay, in 2004, and M.Sc. and Ph.D. degrees in Computer Engineering from the University of New Mexico, Albuquerque, NM, in 2008 and 2009 respectively. In 2007, he was visiting the School of Electronic, Information and Electrical Engineering at Shanghai Jiao Tong University as a research assistant. Dr. Crichigno is currently an Associate Professor in the Engineering Department at Northern New Mexico College, Espanola, NM. His research interests include wireless and optical networks, graph theory, mathematical optimization, network security and undergraduate STEM education. He has served as reviewer and TPC member of journals and conferences such as IEEE Transactions on Mobile Computing and IEEE Globecom, and as panelist for NSF STEM undergraduate education initiatives. He is a member of the IEEE Computer Society.

Prof. Gregory L Heileman, University of New Mexico

Gregory L. Heileman received the BA degree from Wake Forest University in 1982, the MS degree in Biomedical Engineering and Mathematics from the University of North Carolina-Chapel Hill in 1986, and the PhD degree in Computer Engineering from the University of Central Florida in 1989. In 1990 he joined the Department of Electrical and Computer Engineering at the University of New Mexico, Albuquerque, NM, where he is currently a Professor. Since 2011 he has served as the Associate Provost for Curriculum at the University of New Mexico. During 1998 he held a research fellowship at the Universidad Carlos III de Madrid, and in 2005 he held a similar position at the Universidad Politénica de Madrid. His research interests are in information security, the theory of computing and information, machine learning, and data structures and algorithmic analysis. He is the author of the text Data Structures, Algorithms and Object-Oriented Programming, published by McGraw-Hill in 1996.

Dr. Ivan Lopez Hurtado, Northern New Mexico College

IVAN LOPEZ HURTADO received his B.S. degree in Industrial Physics Engineering from Tec de Monterrey, Monterrey, Mexico, 1995. M.S. degree in Automation from Tec de Monterrey, Monterrey, Mexico, 1998 and Ph.D. in Electrical Engineering from the University of New Mexico, Albuquerque, NM, USA in 2008. He is currently the Chair of the Department of Engineering at Northern New Mexico College.

Alfredo J. Perez, Northern New Mexico College

Alfredo J. Perez received his M.S. degree in Computer Science and Ph.D. degree in Computer Science and Engineering from the University of South Florida, in 2009 and 2011 respectively. Since 2011, he has been with Northern New Mexico College, Espanola (NM), where he is currently an Assistant Professor in the Department of Engineering. Prior to coming to USA to pursue graduate studies, he obtained a B.S degree in Systems Engineering from Universidad del Norte in Barranquilla Colombia (2006). His research interests are in the area of Ubiquitous Systems, Mobile Computing, Data mining, Distributed Systems and STEM education. He has coauthored several journal and conference papers as well as the book "Location Aware Information Systems - Developing Real-time Tracking Systems", published by CRC Press. Dr. Perez is Co-PI of the NSF NOYCE program at NNMC and he is PI for the Google CS4HS 2012/2013 site at NNMC.

Ramiro Jordan, University of New Mexico

Ramiro Jordan is a faculty member of the Electrical and Computer Engineering department at the University of New Mexico. He is currently the Associate Chair of the Undergraduate Program, and Associate Dean of Engineering for International Programs. He obtained his PhD from Kansas State University in

the area of Spectral Estimation. He holds a faculty position at the Universidad Nacional de La Plata, Argentina, and has served as visiting and resident professor at universities in Brazil, and many other countries in Ibero-America. He is the Executive Vice President and Founder in 1990 of the Ibero-American Science and Technology Education Consortium (ISTEC), a successful non-profit organization with the mission to accelerate STEM education, R&D and entrepreneurship in Latin America and the Iberian Peninsula. He serves on the Board of Directors of several industrial and professional organizations. He served as Vice President for the Americas Region and Executive Committee in the International Federation of Engineering Education Societies. He is on the Board of the Engineering for the Americas Initiative, an initiative hosted by the Organization of American States involving all Heads of State in the Americas Region. He has been involved in the creation and enhancement of several international Technology Parks and has fostered entrepreneurial activities worldwide. He serves on the editorial board of Computers and Software Engineering, is editor of Journal of Computer Science and Technology, and is editor and advisor to The Ibero American Journal on Technology in Education and Education in Technology. He has received many national and international Honors and Awards including two Silver Quilt Awards, Motorola; International Excellence Award, University of New Mexico; Growing with Technology Award, Cisco Systems; Professional Progress Award, Kansas State University; Award for Contributions in Higher Education and Science and Technology, Organization of American States; Achievement Award for Innovations and Accomplishments in Multilingual IT Infrastructure in Engineering Education, iNEER-ICEE; and Award for Meritorious Work in Engineering and Computer Education, International Conference on Engineering and Computer Education. He is bestowed with the Order of Rio Branco, in the rank of Officer, by the Brazilian Government.

Mr. Timothy L Schroeder
José Marcio Luna, Department of Electrical and Computer Engineering at the University of New Mexico

José Marcio Luna received his B.Sc. in Electronics Engineering from the Universidad Distrital Francisco José de Cáldas in 2004. He received a M.Sc. degree in Electrical Engineering from The University of New Mexico in 2009 where he currently is a Ph.D. student in Electrical Engineering with a Ph.D. Minor in Applied Mathematics. His been actively participating in the design of methods for cross-institutional educational collaborations between higher education institutions in the State of New Mexico.

Cross-institutional Collaboration on Hybrid Engineering Courses among Institutions in New Mexico

Abstract

This paper presents a two-year pilot project involving cross-institutional collaborations among the University of New Mexico (UNM), Northern New Mexico College (NNMC), and Central New Mexico Community College (CNM). The primary objective of this project is to leverage the limited resources available in New Mexico (NM) to provide quality STEM undergraduate education to a large student population. The immediate goal is to develop a pedagogy that allows for demonstrable and repeatable success in this environment using a few targeted courses, with the longer-term goal of expanding the results of this research across all higher education institutions in NM and to any STEM-related discipline. The project focuses on the creation of online instructional materials and pedagogy related to existing lower-division courses in computing disciplines including Electrical Engineering, Computer Engineering, Computer Science and Information Engineering Technology. Historically, these computer disciplines have mostly been taught independently from each other, at different departments and institutions. The fact that they all have overlap in content results in duplicated offerings. Moreover, this duplication of offerings can be seen at a larger scale through the whole state of New Mexico, where curricula at distant schools in the same state share significant knowledge units such as computer programming, logic design, etc. This project consolidates course offerings across the state of New Mexico in computing disciplines. The project includes instructional online lecture materials, support structures, and a virtual lab model that ensure the same or better quality of learning than face-to-face offerings. A detailed description of the pilot project including student learning outcomes, rubrics, labs, and activities is presented.

Index Terms

Curriculum development, online and hybrid courses, cross-institutional collaboration, engineering education, computing disciplines.

I. Introduction

New Mexico has a number of remote community colleges and colleges that serve students who are distinctly under-represented in computing disciplines such as Electrical Engineering, Computer Engineering, Computer Science and Information Engineering Technology. A large percentage of these students are also first-generation college students and therefore in many cases they lack of a role model for success in rigorous STEM undergraduate learning environments. In this context, this paper describes an cross-institutional initiative among three higher education institutions to create online instructional materials and pedagogy related to existing lower-division courses in computing disciplines. The initiative includes curriculum development for lab-intensive online and hybrid courses, support structure in the form of advisement and tutoring which are essential for first-generation students, and student outcomes and articulation among institutions. Further motivations for this project include:

1. Students across New Mexico, one of the largest state in the US in terms of mass land, attend colleges that may be remotely located from their local community. This characteristic is typical in NM, where remote communities may be distant from one to another by tens or hundreds of miles. Online and hybrid courses are appealing for the state because they may allow students to physically attend college fewer times per semester or per week (e.g., for hands-on lab hours or recitation hours). Figure 1 shows part of the NM map with some locations served by UNM, NNMC and CNM. Located in Espanola, NNMC mostly serves Northern New Mexico mountainous communities such as Taos, Penasco, Abiqui, and Ojo Caliente. These remote towns are of difficult access during winter months. UNM and CNM are located in Albuquerque and serve the largest city of the state and its metropolitan area.

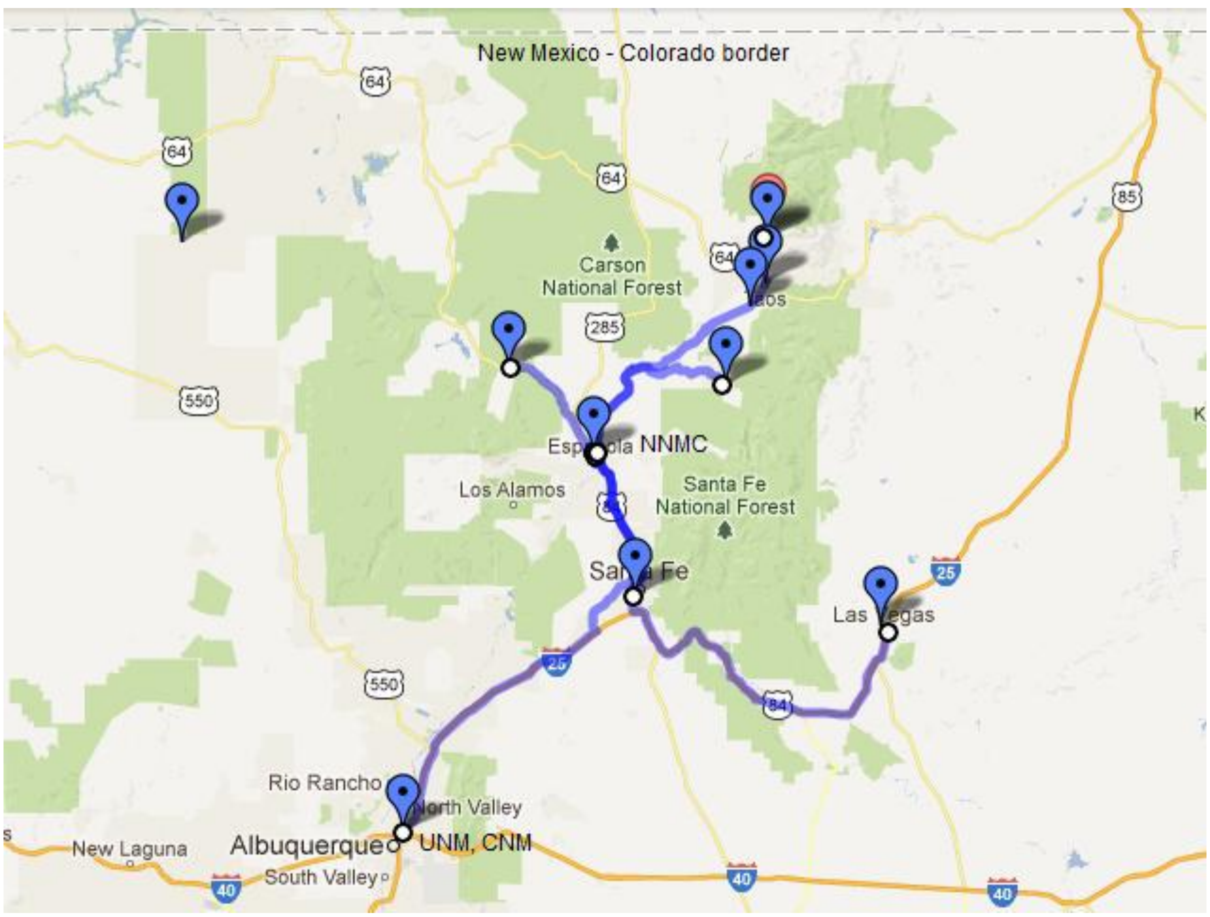

Figure 1. Main areas served by UNM, NNMC, and CNM.

2. The need for standardization of courses on the same subject taught at different institutions. While the state of New Mexico has a state transfer module for general

education courses, this project addresses the need for standardization of lower division courses in engineering. With this project, engineering students at different institutions receive the same lectures, lab experiences, and examinations thereby ensuring that student learning outcomes are the same at different institutions. Thus the project not only helps in the assessment of student learning outcomes but also facilitates the transfer of credits as students decide to enroll in other institutions. This fact is particularly useful in New Mexico where a great percentage of students take credits from peer institutions other than their home institutions.

3. Local students who currently have non-engineering jobs or family commitments that preclude them for taking courses at their local institution can exploit the advantage of the support infrastructure provided by UNM, NNMC or CNM. The reason for segmenting out the students that are currently employed in an engineering-related field is that these students have a high probability of success within the current online framework.

To address the above items, the courses in hybrid format combine online weekly lectures, online tutoring, lab experiments (with the option for students for either online or face-to-face labs) and recitation hours (non-mandatory). The latter refers to face-to-face hours with assistance in areas such as problem solving, lab exercises and theoretical concepts.

The rest of this paper is organized as follows. Section II presents course information. Section III describes the infrastructure support deployed for the project. Section IV discusses preliminary results, and Section V presents concluding remarks.

II. Course Information

In the first year of the pilot project, the institutions have already developed and implemented curricula for three courses: ECE 131 Computer Programming, ECE 203 Circuit Analysis, and ECE 238 Computer Logic Design. Topics in these courses are considered core for computing disciplines as listed by the ACM/IEEE joint committee[1, 2, 3], as shown in Table 1. The three courses are four-credit courses because of the substantial lab components. Officially, the courses have three credits of theory hours and one credit of lab hour. Only few courses of the entire programs at UNM, NNMC, and CNM are four-credit courses; most of the courses are three-credit courses. The organization of the three courses is discussed next.

Table 1. Courses implemented by the cross-institutional pilot project.

Course	Core Topics	Lab Component
ECE 131 Computer Programming	Primitive variable types, data representation in memory, control structures, sub-routines and functions.	Programming in the C Language.
ECE 203 Circuit Analysis	Ohm's law, polarity and power, parallel circuit, Kirchoff's laws, loop analysis, Thevenin and Norton theorems, AC, phasors, impedance, AC circuit analysis and three-phase systems.	Analog circuit design with passive (resistors and capacitors) and active (operation amplifiers) components.
ECE 238 Computer Logic Design	Number systems, basic gates, Boolean algebra, arithmetic functions, sequential circuits, VHDL language construct, processes, description of sequential systems, finite state machines.	Digital hardware design and implementation on FPGA boards using VHDL.

A. Description of Courses

The courses are part of the Computer Engineering, Electrical Engineering, Computer Science (UNM) and Information Engineering Technology (NNMC) programs. At CNM, the courses are part of the pre-engineering program.

ECE 238 Computer Logic Design introduces the student to digital systems and information, combinational logic circuits and design techniques, arithmetic functions, sequential circuits, registers and register transfers. The course also covers systematic digital circuit design using the VHDL hardware description language and implementations using ISE, ModelsimXE and Spartan 3 FPGA from Xilinx.

ECE 131 Computer Programming introduces students to the basics of programming using the C Language, including basic syntax and semantics of a higher-level language, variables, types, expressions, and assignments. The course also covers simple Input/Output, conditional and iterative control structures, functions and parameter passing, and structured decomposition.

ECE 203 Circuit Analysis prepares students for analysis and design of analog systems. Topics include basic electrical elements and sources, energy and power, Ohm's and Kirchoff Law's, resistive networks, node and loop analysis, network theorems, first and second order circuits, sinusoidal sources and complex representations, impedance, phasors, complex power, and three-phase circuits.

B. Student Learning Outcomes

Multiple student learning outcomes are assessed in the three courses. Outcomes belong to both ABET Engineering Accreditation Commission (EAC) and ABET Engineering Technology Accreditation Commission (ETAC). At UNM, ECE 131, ECE 203 and ECE 238 are part of the Electrical Engineering and Computer Engineering programs (under EAC); at NNMC, the same courses are part of the Information Engineering Technology program (under ETAC). Most of student learning outcomes are assessed through lab experiments and associated rubrics. Tables 2-4 show the outcomes associated with ECE 238, ECE 131, and ECE 203. Since most of the outcomes are measured with lab or project experiments, we have designed a "Project Rubric" that captures the essential performance criteria. The rubric is shown in Figure 2.

Project Rubric

Course:______________________________ Team Members:__________________

Date:________________________________ Evaluator:__________ Overall score: __/20

Objective	5 High Proficiency	4 Proficiency	2 Some Proficiency	0 No/Limited Proficiency	Score
Defining the Problem	Student states the problem clearly and identifies underlying issues.	Student adequately defines the problem.	Student fails to define the problem adequately.	Student does not identify the problem.	
Developing a Plan to Solve the Problem	Student develops a clear and concise plan to solve the problem, with alternative strategies.	Student develops an adequate plan.	Student develops a marginal plan.	Student does not develop a coherent plan to solve the problem.	
Specifications	Student follows the specifications, and includes additional features.	Student follows the specifications.	Student changes some specifications.	Student does not follow the specifications.	
Interpreting Findings and Solving the Problem	Student provides a logical interpretation of the simulation and findings, and clearly solves the problem.	Student provides a logical but incomplete interpretation of the simulations and findings, but solves the problem.	Student does not provide an interpretation of the simulations and findings, but solves the problem.	Student does not interpret the findings/reach a conclusion.	

Figure 2. Rubric used to assess lab experiments.

Table 2. Student learning outcomes assessed in ECE 238 Computer Logic Design.

Specific knowledge and skills demonstrated in ECE 238 Labs	**ABET student outcome**	
Students must model digital systems using knowledge, techniques and skills learned during the course, such as state diagram, state table, and excitation equations. Students must apply modern tools to design digital circuits such as VHDL hardware description language, Modelsim software package, and Spartan 3 FPGA development kit.	**1**	An appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines.
Students must write synthesizable VHDL code for a given project, and compile, simulate and synthesize it. Students must write a VHDL testbench to test their design. Students must analyze and interpret the test results in terms of resources and performance used by their design such as flip-flops and maximum frequency, and improve the design using a different technique.	**3**	An ability to conduct, analyze and interpret experiments, and apply experimental results to improve processes.
Students must write a written report considering the different criteria including Lower and Higher Order concerns: clarity, organization, support/reasoning, writing conventions, and presentation.	**7**	Ability to communicate effectively.
Students must write synthesizable VHDL code for a given project, and compile, simulate and synthesize it. Students must write a VHDL testbench to test the devised system using Modelsim. Students must implement their design in a Spartan 3 FPGA development kit.	**12**	Application of computer and network hardware, operating systems, system and network administration, programming languages, application software, and databases in the building, testing, operation, and maintenance of hardware and software

		systems.
Students must verify their design using simulation software (Modelsim) before implementing it in hardware (Modelsim generates timing charts of the electrical signals and the propagation of them). Students must implement and test their design in a Spartan 3 FPGA development kit.	**13**	Application of electrical, electronic, telecommunications, and digital signal propagation fundamentals in the building, testing, operation, and maintenance of hardware and software systems.

Table 3. Student learning outcomes assessed in ECE 131 Computer Programming.

Specific knowledge and skills demonstrated in ECE 131	**ABET student outcome**	
Students must apply structured decomposition to build medium-size software systems. Students must write, compile, link, and debug programs written in the C Language using tools such as debugger and linker.	**1**	An appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines.
Students must apply structured decomposition to build medium-size software systems.	**12**	The application of computer and network hardware, operating systems, system and network administration, programming languages, applications software, and databases in the building, testing, operation, and maintenance of hardware and software systems.

Table 4. Student learning outcomes assessed in ECE 203 Circuit Analysis.

Specific knowledge and skills demonstrated in ECE 203	ABET student outcome	
Students must apply matrix theory to solve engineering problems (analysis of DC and AC circuits) modeled by systems of equations.	**1**	An ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology.
Students must apply electrical fundamentals in building, testing and operating on analog circuits.	**13**	The application of electrical, electronic, telecommunications, and digital signal propagation fundamentals in the building, testing, operation and maintenance of hardware and software systems.

C. Organization of the Courses

The three courses that belong to the pilot project have learning activities that can be classified in three categories: online lecture, lab session, and recitation hour. Online lectures cover traditional lectures where topics are explained theoretically and include exercises. Lab sessions require students to implement hands-on assignments with appropriate equipment. Recitation hours are scheduled once per week and are intended for questions and answers and exercises solved face-to-face to reinforce concepts. Recitation hours are not mandatory; however, most of the students come during these hours. For those students who do not attend recitation hours, all material discussed in class is captured by the smartboard and posted online. The organization of the courses is intended to accommodate extensive hands-on hardware/software assignments and problem-solving activities. As such, the courses are strongly supported by the literature on how students learn[7, 8, 9].

Lectures

Lectures are given online. During the first year of the pilot project, lectures were prepared by UNM's instructors and delivered to the other institutions through UNM's Blackboard System. Students from NNMC and CNM were enrolled locally at their institutions but had access to UNM's Blackboard System. Figure 3 shows a snapshot of the online system used in the pilot project. The three courses follow a similar format for the online lecture videos.

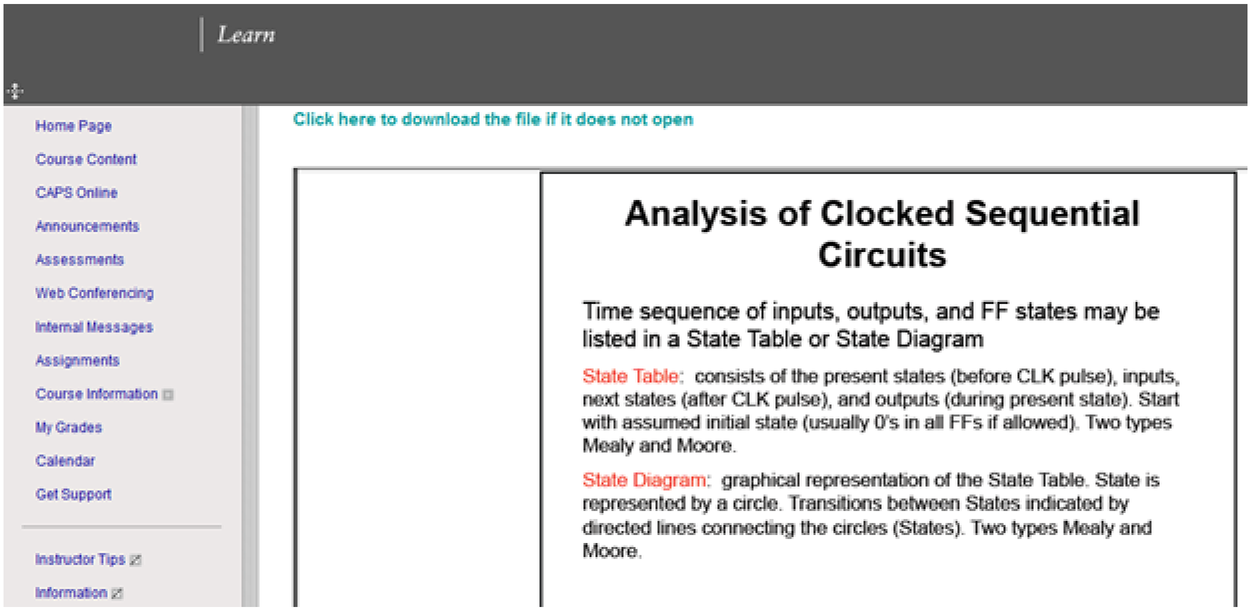

Figure 3. Snapshot of the online system used by students of the three institutions.

Lab Sessions

The lab component is intended to reinforce theoretical concepts and to apply them to hands-on activities. A lab experiment requires students to follow a lab manual that describes step by step the design of a system aligned with the theory developed in the week the lab must be completed. Students then must extend the design according to some given specifications. A lab experiment may require 1 to 3 hours. Students can perform lab sessions either by using the lab facilities in their local institution or by using the equipment that is lent to them by their local institution. The second option does not require students to come to lab sessions.

Lab equipment for ECE 238. The equipment needed for lab sessions is shown in Figure 4. It consists of a Xilinx Spartan 3 FPGA development kit. The board includes input and output modules such as switches, buttons, LEDs and a display. The description of the hardware is written in VHDL. The software tools to write, synthesize, simulate, and program the FPGA board are included in the Xilinx ISE WebPACK Design Software[4]. This package is free and meets all the requirements for the size and type of designs taught at ECE 238. Labs fully equipped are deployed at UNM and NNMC. Online students who are not able to come to lab hours at their institutions can borrow the FPGA board and install the ISE WebPACK Design Software on their respective personal computers. For each assignment, students must also submit a video showing the operation of their implemented assignment and a report. Students who come to lab hours must implement the lab assignments which are checked by a teaching assistant. There are at least five lab sessions during a semester as shown in Table 5.

Figure 4. FPGA board used for lab experiments in ECE 238 Computer Logic Design.

Table 5. Examples of laboratory assignments for ECE 238 Computer Logic Design.

	Laboratory Assignment
1	Introduction to ISE, Modelsim, VHDL and FPGAs with simple basic gates project.
2	Components and subsystems, structural description, code reuse and concurrent signal assignments in VHDL.
3	Combinational logic circuits including multiplexers and decoders with VHDL processes.
4	Arithmetic functions and iterative combinational circuits.
5	Sequential circuits, state machines, and sequence detectors.

For each lab, students are given one week to implement and demonstrate the operation of the system. Students either work individually or in groups of two. Besides the mandatory demonstration of the operation of the system, students submit a report that is graded using the report rubric shown in Figure 2. Students are expected to achieve at least a level of *Proficiency* in 3 out of 4 performance criteria, and at least *Some Proficiency* in the remaining criterion.

Lab equipment for ECE 131. This course focuses on the fundamentals of computer programming where the main lab requirements are software components. The computer language used is C and the main tool is the MinGW development environment[5]. MinGW provides a complete open-source programming tool set that includes:

- A port of the GNU Compiler Collection (GCC), including C, C++, ADA and Fortran compilers;

- GNU Binutils for Windows (assembler, linker, archive manager);
- A command-line installer (mingw-get) for MinGW and MSYS deployment on MS-Windows;
- A GUI wrapper (mingw-get-inst) for the command line installer.

While there are specific lab rooms with MinGW and other programming tools at UNM, NNMC and CNM, most students install MinGW in their personal computers and fulfill the lab requirements remotely. Table 6 lists the lab assignments for ECE 131 Computer Programming.

Table 6. Examples of laboratory assignments for ECE 131 Computer Programming.

Laboratory Assignment	
1	Setting up the development environment and introduction to compilers and debuggers.
2	Variables and selection statements: finding the greater of several numbers.
3	Loops exercises: inverting numbers, calculating arithmetic series and applying Euclidean algorithm.
4	Functional decomposition and arrays: implementing sets and set operations.
5	Strings: counting words and characters in files.

Lab equipment for ECE 203. Circuit Analysis includes lab experiences on analog circuits with passive and active components. Passive components are resistors and capacitors and active components are operational amplifiers used for the construction of basic filters. UNM and NNMC have specialized lab rooms with PC computers and instrumentation hardware, multi-meters, and waveform generators embedded in ELVIS II[6] boards. CNM does not offer this course yet; thus, if a student plans to transfer to UNM or NNMC, he/she can either take this class at the time of the transfer or enroll at UNM or NNMC while studying at CNM. It is expected that ECE 203 will be scheduled at CNM in a near future. ELVIS boards are integrated suites of 12 of the most commonly used instruments in the lab, including the oscilloscope, digital multi-meter, function generator, variable power supply, and Bode analyzer. Based on NI LabVIEW graphical software, NI ELVIS, with USB plug-and-play capabilities, offers the flexibility of virtual instrumentation and allows for quick and easy measurement acquisition and display. Figure 5 shows an ELVIS II board.

Figure 5. Elvis II station used for ECE 203 Circuit Analysis.

Table 7 lists the lab assignments for ECE 203 Circuit Analysis.

Table 7. Examples of laboratory assignments for ECE 203 Circuit Analysis.

Laboratory Assignment	
1	Introduction to Multisim.
2	Voltage and current measurement and Ohm's law.
3	Internal resistance of voltage sources.
4	Series-Parallel DC circuits.
5	Thevenin's and Norton's theorem applications.
6	Capacitors.
7	Basic AC measurements: period, frequency and amplitude.

Recitation Hours

Students have a non-mandatory meeting once per week (two hours) with the instructor or teaching assistant for extra help during recitation hours. Recitation hours are intended to reinforce learning through solving problems in class. Questions may be related to theoretical topics from the online lecture. Theoretical questions are answered accompanied with problems or exercises. Thus, recitation hours are driven by problem-based learning. All material covered during recitation hours is captured by a smartboard and posted online. Figure 6 shows a snapshot of a capture of a recitation hour on priority encoders on ECE 238 Computer Logic Design.

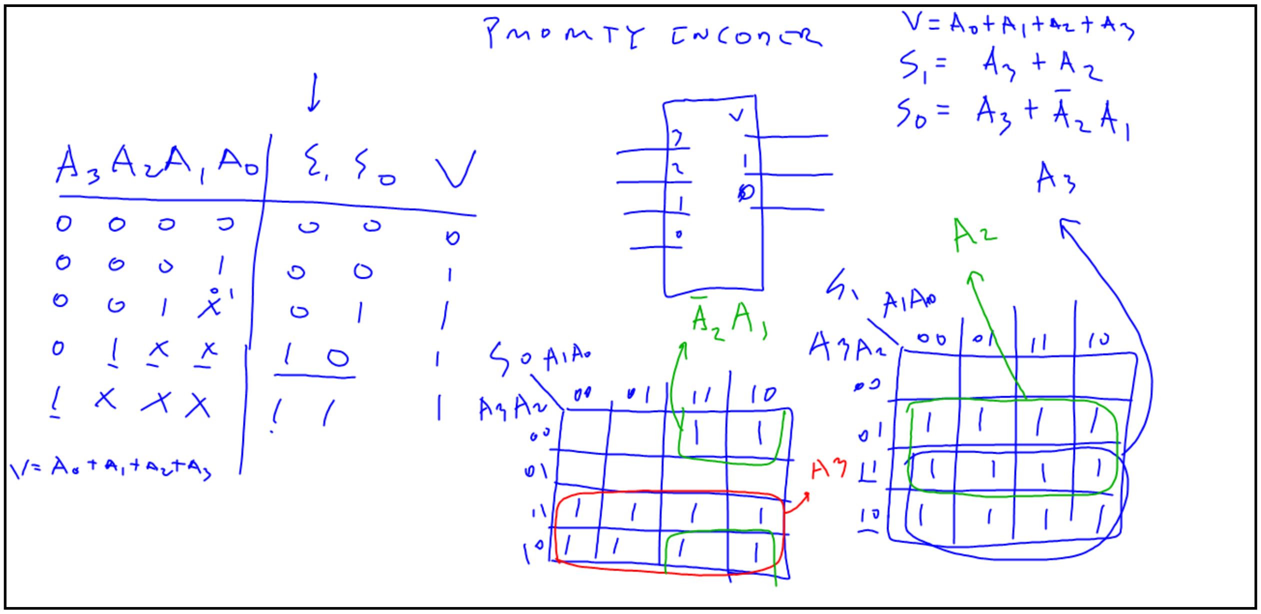

Figure 6. Snapshot of a topic covered during recitation hours and captured by a smartboard.

III. Support Infrastructure

Courses belonging to the pilot project are led by one instructor who prepares the videos for online lectures. Students from all institutions have access to the online infrastructure. In this first year, the online infrastructure was set by UNM. Students from NNMC and CNM are given an UNM's ID to access UNM's Blackboard System. The online support infrastructure also includes online tutoring with tutors available at certain *online office hours*.

UNM already had a state-of-the-art information technology infrastructure for distance learning programs. All students who have taken the three courses of this pilot project have reasonable access to the Internet. The pilot project extended the logistics, administrative, instructional and support framework to use these available resources to deliver effective engineering education to a broader student population throughout the state. Online services have made the student interaction with the instructors, teaching assistants and demonstrators more seamless. As an example, course tools now include functionality such as CAPS online which stands for Center for Academic Program Support. CAPS is an online learning assistance that provides tutoring. Students can contact tutors through email or live chat during online office hours. Figure 7 depicts the CAPS online interface.

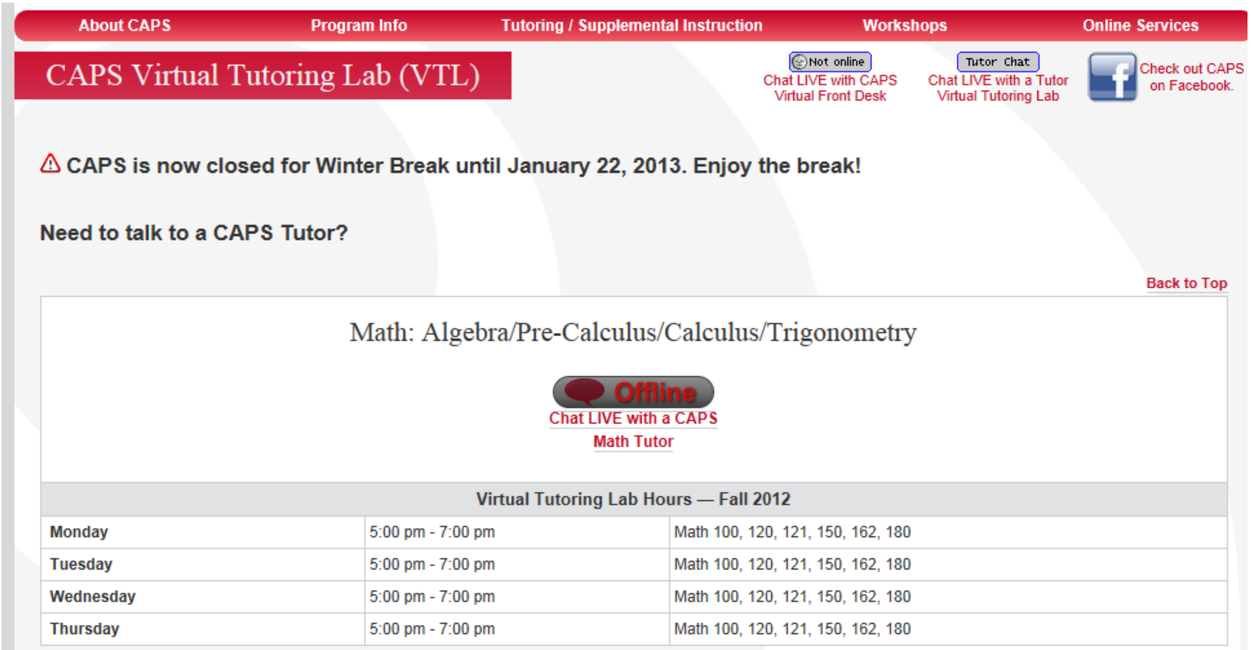

Figure 7. CAPS online interface.

IV. Preliminary Results

Table 8 shows the results of an offering using the pilot project of each course. These courses have been offered during the year 2012. Table 8 also includes results of the same courses offered before the pilot project was implemented. Results correspond to students from NNMC only.

Table 8. Preliminary results of the pilot project implementation at NNMC. Results correspond to one offering of the course using the pilot project (under the column "After") and one offering of the course before the pilot project (under the column "Before").

	ECE 131		ECE 203		ECE 238	
	Before	After	Before	After	Before	After
Passing rate	71%	68%	72%	100%	29%	33%
Failing rate	23%	14%	28%	0%	42%	62%
Drop-out rate	6%	18%	0%	0%	29%	5%

For ECE 131 Computer Programming, in both offerings (after and before pilot project) the sizes of the classes were higher than 25 students. The passing rate changed from 71% (before) to 68% (after). This indicates that there was no substantial change on the number of students passing the course. However, the failing rate (those students who will have to repeat the class) decreased from 23% to 14% while the drop-out rate increased from 6% to 18%. What these results show is that students taking joint classes with a large online components may take their studies more seriously; if they cannot commit to the plan of the class, they dis-enroll. This could be the reason for the lower failing rate and the higher drop-out rate. These results correspond to the students at NNMC which is a small, rural institution that focuses on undergraduate education. Most students in this institution are first-generation under-represented students. We believe that another reason for the increase on drop-out rate and the decrease in failing rate is related with peer-pressure and the fact that students are now sharing a class across the state with other students enrolled in larger institutions. Additionally, the fact that most students in this course are first-year freshmen who have never taken an online class may have affected negatively. On the other hand, for those students who pass the class, the course was an important and encouraging experience because they feel they are successfully competing with students from the larger institutions. This is also valuable since many students from NNMC are expected to continue their master's degree education at UNM. For these students, having passed a shared class implies a smoother future transition from NNMC to UNM.

For ECE 203 Circuit Analysis, the sizes of the classes were approximately 10 students after and before the implementation of the pilot project. The passing rate changed from 72% to 100% after implementing the pilot project. The experience in this course was positive; according to the feedback from students, the online material served not only to present topics but to reinforce the learning experience in combination with the lab sessions listed in Table 7. Another important highlight is the fact that students from NNMC were not required to take Differential Equations as a prerequisite for ECE 203, while those students from UNM were required to do so. However, results showed that the students from NNMC were able to satisfactorily complete all assignments and exams.

For ECE 238 Computer Logic Design, the sizes of the classes were 20 students. Historically ECE 238 has been considered one of the most challenging courses for the students in the Information Engineering Technology program at NNMC. The introduction of the shared course helps in standardizing content that is considered core for Computer Engineering, Electrical Engineering, Computer Science and Information Engineering Technology. As such, the failing rate experienced both after and before the implementation of the pilot project was higher than those on ECE 131 and ECE 203. While the passing rate slightly increased from 29% to 33%, the failing rate also increased. However, we notice from students feedback that those who failed the class recognized that the level expected from them is not arbitrary and is the same as that for those students at UNM.

V. Concluding Remarks

We have described a two-year pilot project involving cross-institutional collaborations among three institutions in the state of New Mexico. We have described how courses are organized in the pilot project; e.g., the infrastructure used to share courses efficiently, the online tutoring support, the lab organization and the student outcomes. The project focuses on the creation of online instructional materials and pedagogy related to existing lower-division courses in computing disciplines including Electrical Engineering, Computer Engineering, Computer

Science and Information Engineering Technology. Among the main results of the project are the consolidation of course offerings across the state of New Mexico in computing disciplines. This consolidation may have a large impact in making the process of transferring students from one institution to another completely smooth. Additionally, by uniformly developing curricula across the state and by defining common student learning outcomes and performance metrics, we expect an easier transition of students from community colleges to colleges and to graduate programs. We have also presented a description of the pilot project including rubrics, labs, and the implementation of activities in hybrid and online environments.

Acknowledgement

NNMC would like to thank Mr. Craig Kief, Deputy Director of Configurable Space Microsystems Innovations and Applications Center (COSMIAC) at the University of New Mexico. COSMIAC has donated 20 FPGA development kits used in the course ECE 238 at NNMC. COSMIAC is focused on the advancement of reconfigurable systems for aerospace and defense applications.

References

1. Curriculum Guidelines for Undergraduate Degree Programs in Information Technology, Association for Computing Machinery (ACM) and IEEE Computer Society, 2008.

2. Curriculum Guidelines for Undergraduate Degree Programs in Computer Engineering, Association for Computing Machinery (ACM) and IEEE Computer Society, 2004.

3. Curriculum Guidelines for Undergraduate Degree Programs in Computer Science, Association for Computing Machinery (ACM) and IEEE Computer Society, 2008.

4. Xilinx ISE WebPACK Design Software. Available online: http://www.xilinx.com/products/design-tools/ise-design-suite/

5. MinGW development environment. Available online: www.mingw.org

6. NI ELVIS II Prototype platform. Available online: http://sine.ni.com/nips/cds/view/p/lang/en/nid/13137

7. N. Klingbeil, K. Rattan, M. Raymer, D. Reynolds, R. Mercer, The Wright State Model for Engineering Mathematics Education: A Nationwide Adoption, Assessment and Evaluation, ASEE Annual Conference & Exposition, Austin, TX, June, 2009.

8. Kerr, A.D., and Pipes, R.B., 1987. Why We Need Hands-On Engineering Education, The Journal of Technology Review, Vol. 90, No. 7, p. 38.

9. Sarasin, L., 1998, "Learning Style Perspectives: Impact in the Classroom." Madison, WI: Atwood.