Online Student Support Services for STEM Courses in New Mexico: A Cross-Institutional Approach

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I. Introduction

The NSF program for Transforming Undergraduate Education in STEM (NSF-TUES), which has been implemented at the University of New Mexico (UNM) from 2012 to 2013, shares services and resources between academic institutions in the state of New Mexico. It is intended to combine the strengths of a Research University with the student support systems and local resources of educational institutions who primarily serve academically underprepared students. Through the improvement of online instruction of engineering courses at UNM, and the development of an engagement model that integrates instruction, student support and peer interaction, this project is aimed at further strengthening the educational expertise and content that UNM shares with partner schools.

Through the development of a shared-curriculum and joint-instruction model, the NSF-TUES project will empower New Mexico to leverage the strengths of multiple educational institutions to better serve rural and low-income students. It makes available high quality online tutorials, online courses, and student support systems that would not be available at all institutions statewide due to budget limitations, isolation and lack of physical resources.

Based on the 2011 reports, 37.3% and 72% of the student population at UNM and Northern New Mexico College (NNMC) respectively, belong to Hispanic communities. Moreover, 8% of the student population at NNMC comes from Native American Communities in contrast to the 0.2% of Native American students at UNM. Therefore, the potential improvements in educational access for underserved populations and professional networking among faculty and students statewide are promising.

This program is designed to create a sustainable model for sharing the expertise and resources of a Carnegie Research University (classification: Very High) with educational institutions in New Mexico who serve academically underprepared students. New Mexico ranks 43rd in the nation in the percentage of the population who complete high school, and 35th in the nation in percentage of the population who earn bachelor's degrees or higher. It ranks 48th in percentage of teens who are not in school and who are not high school graduates. Seventeen percent of New Mexico's population lives in poverty, including an alarming one in four children. Thirty seven percent of jobs in New Mexico pay below the poverty rate (49th in the nation)[1].

Reversing these trends has become a major emphasis for higher education in New Mexico. The statewide funding formula for colleges and universities in New Mexico has focused on improving course completion rates, college graduation rates, graduation rates among low-income students and graduation rates in STEM fields. Chief among the challenges in this endeavor are the rural nature and high poverty of New Mexico's residents. While UNM has a strong reputation for producing outstanding research and a dedication to STEM achievement, colleges and high schools across New Mexico do not have access to these same resources or expertise. However, these institutions do understand the needs of their various student populations, and they continue to build strong support systems to assist them in their educational pursuits.

Over the past two years, UNM and NNMC shared online and hybrid courses taught by instructors of both institutions. This made possible not only the offering of courses that otherwise would require a higher investment in resources and instructors from both sides, but it offered different teaching perspectives to enhance the cross-institutional interaction and the design of the course material. The development of high quality educational material to fit the needs of both institutions was one of the main accomplishments of this program.

This paper focuses on the main lessons we have learned from the perspective of the students. We have gathered and quantified the impressions of the students participating in this study. Moreover, we carried out interviews to the Teaching Assistants (TAs) who interacted with the students to complement and support our findings. Finally, we carried out a systematic analysis of the online communications between the instructors of record, the TAs, the Supplemental Instructors (SIs), and the students looking for evidence to support our conclusions. The review of these data provided us with lessons that would allow us to improve the teaching and learning practices for this specific environment while we were planning and building the infrastructure to share and support online classes in three different institutions in New Mexico. The paper is organized as follows. In Section II we introduce the main features of our model for cross-institutional collaboration including a brief description of the mechanisms for course sharing and course design improvement, as well as the description of the main personnel involved in the project and the courses implemented online. In Section III, we present a qualitative evaluation of the classes supported by data obtained by surveying the students. In Section IV, we present a qualitative assessment of the communication channels that the students had available to contact the personnel of the project. In Section V, we provide the conclusions.

II. Cross-Institutional STEM Course Offering and Support

This program has focused on two primary initiatives: (1) expand the delivery of online engineering courses to remote and/or two-year institutions using a shared-curriculum and joint-instruction model, and (2) improve student success in these courses by strengthening course content, instructional delivery and student support systems.

A. Course Sharing

In expanding the delivery of engineering courses, UNM worked with NNMC and Central New Mexico Community College (CNM) to establish a manual method for registering students at multiple institutions. This project was piloted between UNM and NNMC, and scaled up to include CNM sections in the second year.

Students at all three institutions were provided access to the UNM course content via the UNM Blackboard Learning Management System. Course content and primary instruction and assessment for courses were developed and provided to NNMC and CNM students online by faculty members at UNM. Supplemental content and secondary instruction were developed and provided by faculty members at NNMC and CNM.

B. Course Design Improvement

In strengthening instruction, UNM instructional designers collaborated with faculty members in the online courses to increase the quantity and quality of multi-media learning modules and to restructure assignments and assessments for the online environment. These improvements were made based on the best practices established by the Quality Matters Program[2].

C. Project Personnel

In order to strengthen student support in UNM, NNMC and CNM, it was necessary to use the following staff with the corresponding tasks.

Instructor of Record. The instructor of record was the person with the required expertise to prepare the contents of the classes, as well as the mechanisms for assessment of the students. For the NSF-TUES project, we required the instructor of record to be a professional in Engineering with a Doctoral degree in areas closely related to the offered courses. The instructor of record should have taught the class in previous years and was responsible for the design and provision of the online material.

For students at NNMC, synchronous weekly problem-solving sessions were offered by the NNMC instructor. During these sessions, students received additional content support, peer interaction, supplemental learning resources and encouragement.

Supplemental Instructor. For students at all three institutions, an SI was assigned in each improved course. The SIs were graduate students with extensive training in the offered courses. Their main task was to keep students on top of the classes by providing further explanation of the material and preparing personalized problem solving sessions. This tutoring would be carried out through the Blackboard learning system, through email or in person if required. The SIs were appointed by the Center for Academic Program Support (CAPS) at UNM. It is worth mentioning that the analysis of the role and impact of the SIs in this cross-institutional collaboration is out of the scope of this paper.

Teaching Assistants. In addition, each course was also assigned a specially selected and trained TA. These TAs were charged with developing and implementing a series of online engagement activities to help students connect to their course content, to their fellow students and to their instructors of record. In addition, TAs were responsible for providing academic interventions and academic coaching for their students throughout the course of the semester. At the end of the semester, the TAs also provided quantitative and qualitative feedback to project organizers to improve program effectiveness.

For students at UNM, an early-alert academic intervention system was piloted. This system involved UNM professional staff and mostly TAs contacting students who were underperforming in their engineering course(s) to assist them in accessing support resources and developing strategies for improvement.

Academic Adviser. The Electrical Engineering Department at UNM provided the service of academic advisement. There were online and face-to-face sessions where the students involved

in the NSF-TUES project received professional orientation to help them choose the courses and other curricular activities to satisfy their professional interests and goals. Furthermore, the Academic Adviser (AA) provided information about additional services that students might find useful, such as student health, counseling and tutoring.

Instructional Media Specialist. The New Media and Extended Learning (NMEL) unit at UNM provided a team of Instructional Media Specialists to customize the online platform used to make the online material available to the students. They supplied support to attend the needs of the instructors of record whenever required and were in charge of keeping the online infrastructure up and running.

D. Shared Courses

In year one and two of this grant, UNM strengthened online instruction and student support through the development of an engagement model for five courses. This model created stronger student engagement with content, instructors of record, peers and student support services through strategies that wove these elements together.

Among the primary goals of this model is the development of stronger interpersonal relationships between students, instructors and support professionals. This model included the use of group projects that counted towards students' final grades. These projects required students: to develop their own understanding and application of course content to real-world problems; to work collaboratively with other students using electronic communication and document-sharing platforms; to work with embedded tutors and TAs; and to work with instructors to link group projects to lectures, modules and assessments. The following is the list of courses covered by the NSF-TUES project complemented with a brief description of the contents:

ECE 101: Introduction to Electrical and Computer Engineering (1 credit). Insight into electrical engineering is gained through videos, hands-on experiments, use of computer software to learn basic problem-solving skills and a team-oriented design project.

ECE 131: Programming Fundamentals (3 credits). This class covers fundamental programming concepts including consideration of abstract machine models with emphasis on the memory hierarchy, basic programming constructs, functions, parameter passing, pointers and arrays. Furthermore, the students learn how to carry out file management, as well as bit-level operations and interfacing to external devices.

ECE 203: Circuit Analysis I (3 credits). This course starts with basic electrical elements and sources involving the concepts of energy and power, Ohm's and Kirchhoff's laws. It covers the mathematical analysis of resistive networks, as well as the node and loop analyses. Furthermore, the class covers network theorems and introduces the analysis of first-order and second-order circuits. The course wraps up with sinusoidal sources and complex representations impedance, phasors, complex power and analysis of three phase circuits.

ECE 231: Intermediate Programming and Engineering Problem Solving (3 credits). This class introduces elementary data structures, program design and computer-based solution of engineering problems. Topics include use of pointers, stacks, queues, linked lists, trees, graphs, systems and device-level programming and software design methodology.

ECE 238: Computer Logic Design (4 credits). This course was offered as part of the NSF-TUES project on Fall 2012 only. The class covers binary number systems and Boolean algebra. It follows up with the study of combinational, sequential, and register transfer logic. Implementations of the system are done using VHDL. The last part of the course focuses on the design and implementation of devices such as Arithmetic/Logic units and Memories. The students should develop more complex circuits involving computer organization, input-output blocks, culminating with the study of Microprocessors.

A more detailed description of the contents, methodology, and structures followed in the project's classes is described in [3]. Other best practices and recent research have been shared between project participants via email and through a SharePoint website, including journal articles, books and reports. Among the most significant see [4,5,6].

III. Qualitative Student Evaluation of Shared Courses

To capture the impressions of the students participating in this research, voluntary and anonymous surveys were carried out by the end of the semester. Such surveys allowed to gather some information about institutional participation, students' previous education as well as their opinions about the online courses.

A. About the Participants

The number of students per institution are presented in Table 1 for the Fall 2012 and the Spring 2013 semesters. Notice that in both semesters UNM students formed the majority of the population, followed by the NNMC students.

Table 1. Number of participants per institutions for the Fall 2012 and Spring 2013 semesters.

Semester/Institution	UNM	NNMC	CNM
Fall 2012	129	48	6
Spring 2013	123	39	5

In order to capture the impressions of the students about the offered classes, we carried out an anonymous online survey. The number of participants in the survey was 38 out of 85 invitations for Fall 2012, and 47 out of 64 invitations for Spring 2013. The distribution among the institutions is shown in Figure 1. Notice that the participation of students from NNMC and CNM is low with respect to UNM students; however, it is coherent with the student population per institutions shown in Table 1.

Less than 71.79% of the participants said they were taking only one class in both periods but less than 28.21% were taking two or three classes. Most of the respondents are first and second year students of Engineering.

B. Survey Results

The participants were able to assign a grade to the different services and resources provided by this project, namely, *very good*, *good*, *fair* and *weak*. Besides that, the students had the option to choose *No answer*.

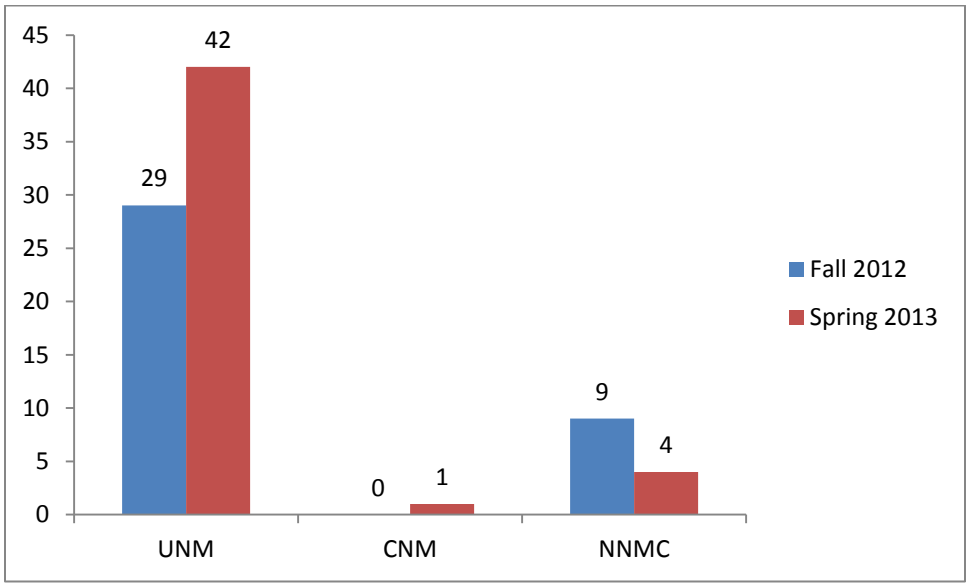

Figure 1. Number of participants of assessment survey per institution

The participants were asked about the quality of the online material. During Fall 2012, 27.03% graded the material as very good and 27.03% as good as shown in Figure 2. However, based on the results obtained from the evaluation of communications between TAs and students, the implementation of the online versions of classes ECE 231 and ECE 238 presented difficulties in Fall 2012. The main issues had to do with complexity of the covered topics and the required laboratories and projects to be submitted by the students. We will refer to these classes which had problems to be adapted to an online environment as *transition courses* from now on. By removing the participants of the transition courses from the results 42.11% considered the online material very good and 15.79% considered it good in Fall 2012. Furthermore, given the improvements in the organization of the online material during Spring 2013, 75% of the participants found all classes to be good or very good.

Similarly, the students were asked about the responsiveness of the instructors of record when required. During Fall 2012, 29.73% of the participants found it very good while 27.03% found it good as shown in Figure 3. However, after ruling out the responses of the students in the transition courses, 31.58% graded it as very good, while 36.84% as good in Fall 2012. Besides, it is clear that the students found the responsiveness of the instructor of record during Spring 2013 better than the previous semester.

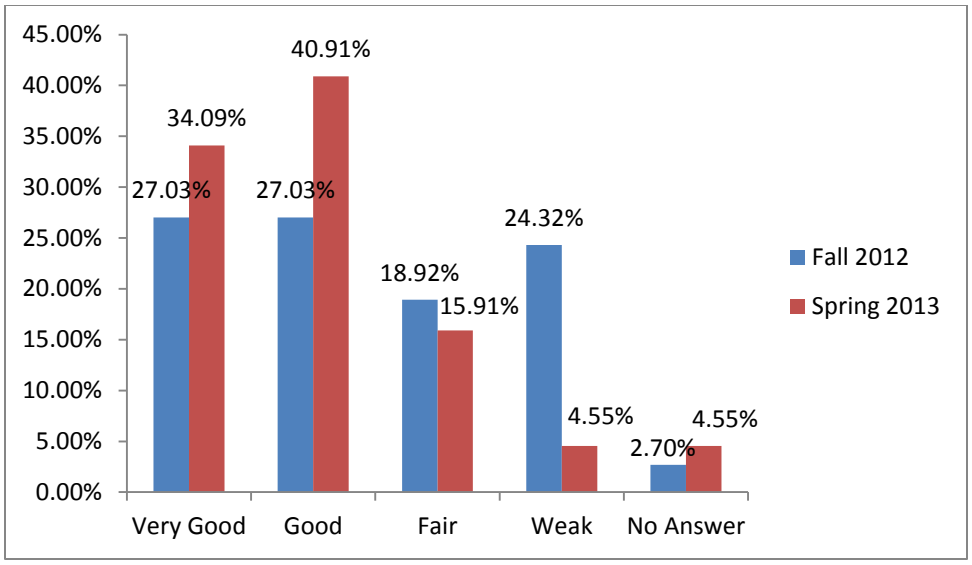

Figure 2. Qualitative assessment of online material

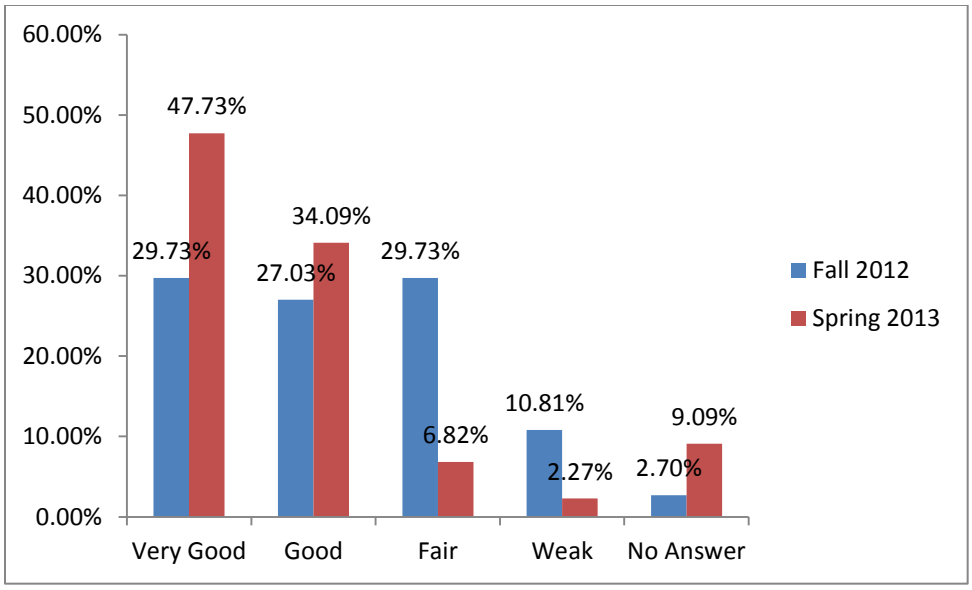

Figure 3. Qualitative assessment of instructors of record's responsiveness

Instructors of record's material encompasses notes, files, presentations and other resources that the instructor of record provided other than computing or laboratory resources. In Fall 2012 65.79% of the participants found the materials to be good or very good as shown in Figure 4. By ruling out the responses of the students who took the transition courses in Fall 2012, the number of students who answered that the instructor of record's material was good or very good increased to 75%.

The students were asked about their impressions of the role of the TAs tracking their performance. As mentioned before, the TAs were in charge of carrying out the early alerts to help students catch up to the class by referencing them to resources and people who would be able to provide assistance. The TAs were not aimed to provide academic support such as

grading, assisting with class contents or lecturing. As shown in Figure 5, in Fall 2012 only 50% of the participants found the role of the TAs good or very good. However, the TAs informed that they had difficulties keeping regular communication with the instructors of record of the transition courses and, due to technical problems, had limited access to the grades and submissions of the students so it was difficult to keep track of the students' performance. By ruling out the responses of the participants who were taking the transition courses in Fall 2012, the students who graded the role of the TAs as good or very good increased to 61.11%.

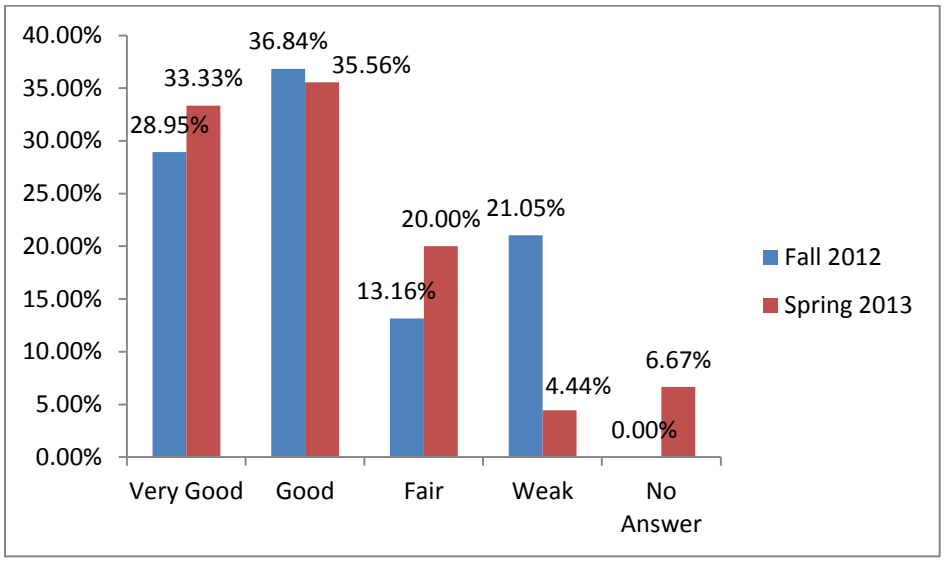

Figure 4. Qualitative assessment of instructors of record's material

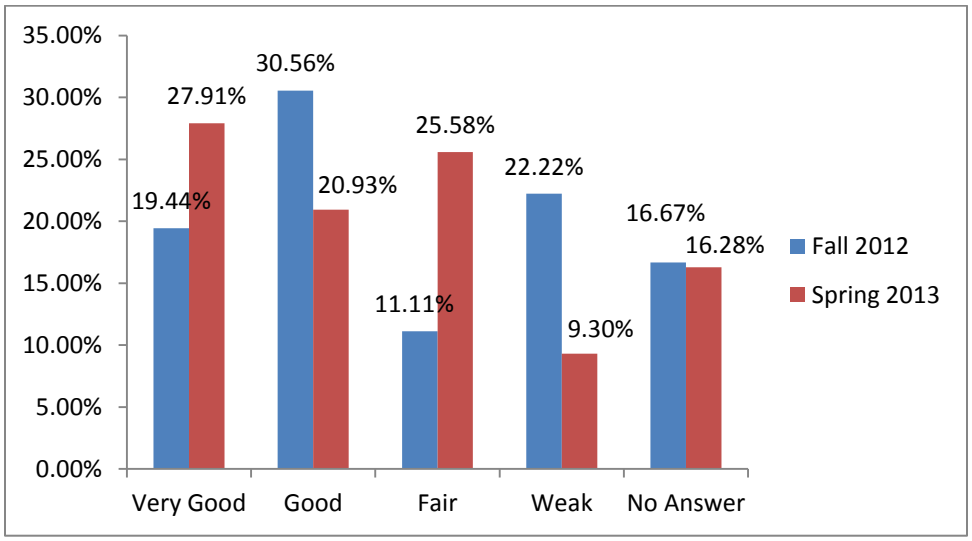

Figure 5. Qualitative assessment of performance tracking and personal assistance by the TAs

To assess the success of the project at encouraging students to take online classes, we asked the students whether they would take an online class in the future. In Fall 2012, Only 50% of the participants responded they would take an online class in the future. In Spring 2013, that number

changed to 82.22%, which could be due to the improvements that were carried out during Spring 2013. These improvements consisted of the redesign of the contents of some classes, the correction of technical problems in the online platform and, in some cases, the reassignment of instructors of record.

IV. ASSESSMENT OF COMMUNICATION CHANNELS WITH STUDENTS

In this section we carry out the analysis of statistical information related to the e-mail communications between TAs and students, instructors of record, SIs and AAs.

A. Classification of Messages

We have classified the observed messages into the following categories.

- ***Announcment:*** Announcements provided by the instructor of record, the TAs, the SI or the AAs to the entire population of students or a subset of the population.
- ***Comm.w/Instr:*** Communications student-instructors or TA-instructors.
- ***Comm.w/SI/AA/Othr:*** Communications between the TAs and people different than the instructor such as SIs or AAs.
- ***Erly.Alrt:*** It consists on preventive messages where the TA asks the students the reasons why they have not been able to accomplish short term goals in the course (*e.g.*, homework, quizzes and project submissions).
- ***Fdbk/Assmnt:*** Communications where the students provide some critical feedback or qualitative assessment of the course which could potentially improve the quality of the online courses.
- ***Hwk/Proj/Quiz Submssn:*** Messages used to submit homework, projects, quizzes or tests through the TAs.
- ***Org.Questn Hmk/Proj/Quiz:*** Messages used by the students or TAs to ask questions about the format, templates, support files and presentations related to a homework, project, quiz or test submission.
- ***Prblms w/IT:*** Messages where students, instructors of record, SIs and TAs report issues associated with the online platform.
- ***Tech.Questn:*** Messages where students, SIs or TAs ask technical questions about solutions of homework, laboratory, quiz or assessments.
- ***Undergrd.Advismnt:*** Messages where students discuss about their future career plans based on their individual professional interests.

B. Assessment of Messages

Next, we describe the parameters used to grade the quality of the communications with the TAs. The grades and their description are given below.

- ***Successful:*** Grade assigned when the communications reflect that the main objective was carried out as required.
- ***Apparently Successful:*** Grade assigned when the communications reflect that the action of the TAs and SIs has been correct and efficient, however, from the communication only is difficult to tell if the final outcome was the desired one.

- ***Unsuccessful:*** Grade assigned when the communications reflect that the final outcome is not quite the required one.
- ***Undetermined:*** Grade assigned when nothing about the quality of the communications can be concluded out of the messages.

For the classes offered during Fall 2012 we analyzed 369 communication threads between the TA and other entities, namely, students, instructors of record, SIs, AAs and instructional media specialists. During Spring 2013, the number of analyzed threads was 76. Possible explanations of why the number of messages decreased at that extend will be provided in the conclusions section.

The percentage of messages per class is shown in Figure 6. Although among the original tasks of the TAs was not grading tests or projects, this changed by request of the instructor of record of ECE 203. Therefore, the amount of communications in that specific class is larger.

Based on the classification of messages by topic described in the previous section, we present the percentage of messages per topic in Figure 7. We decided not to include the announcements in the following analysis since they are unidirectional and their assessment would be most likely successful skewing the responses toward a positive evaluation. Notice that organizational questions about submission of homework, quizzes and projects take at least the 25.24% in both periods. Announcements take a big portion as well but it has been ruled out in this paper as explained before.

Based on the previous description of the grades, we show the percentage of messages per grade in Figure 8. Notice that given that the TAs did much of the requested work, the majority of communications were graded as successful and apparently successful. It is worth mentioning that apparently successful does not guarantee that the final goal was fulfilled, but it rather means that the TAs did the right thing based on their duties.

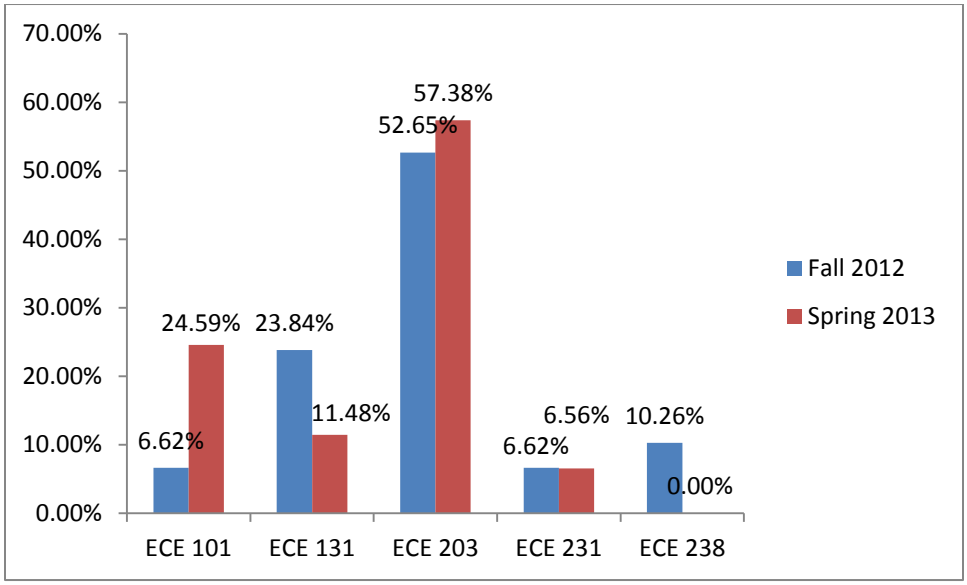

Figure 6. Percentage of messages per class.

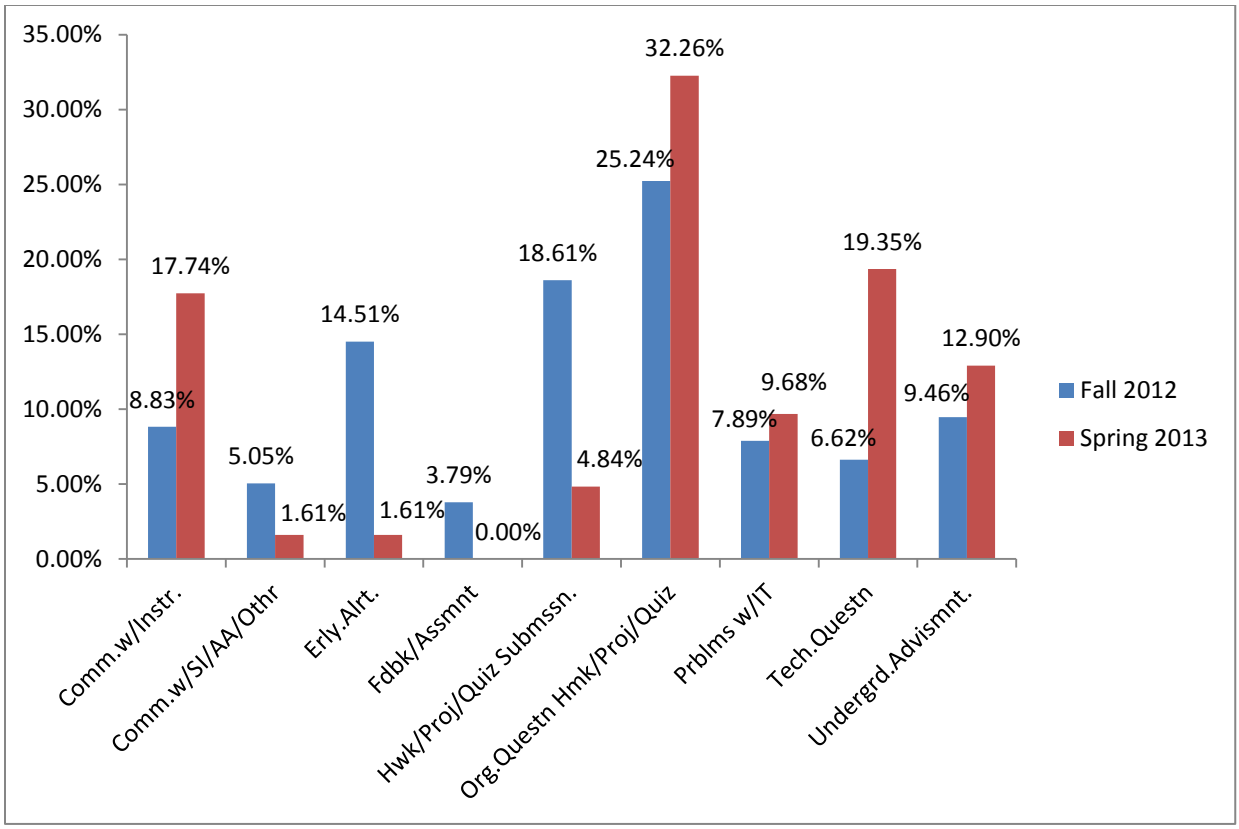

Figure 7. Percentage of messages per topic

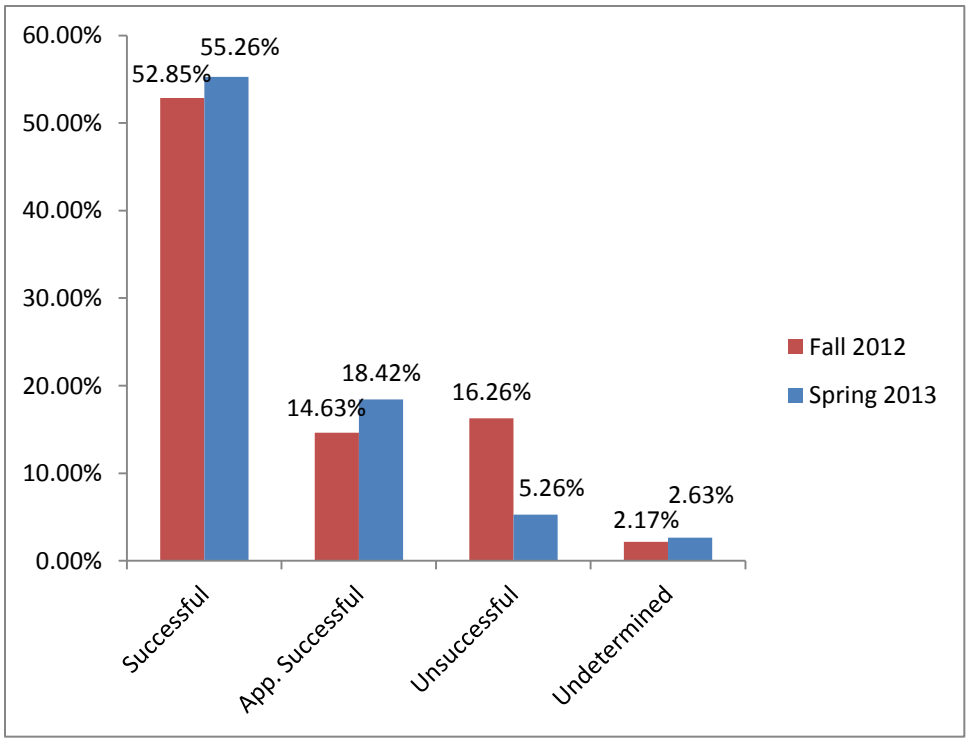

Figure 8. Percentage of messages per grade

In Table 2, we illustrate the number of messages corresponding to a specific topic and class during the Fall 2012 and Spring 2013 semesters. It is worth recalling that ECE 238 was not offered in Spring 2013 as evidenced in Table 2.

Table 2. Number of messages belonging to a specific topic and class Fall 2012

Topic\Class	ECE 101		ECE 131		ECE 203		ECE 231		ECE 238	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Comm.w/Instr.	4	0	3	2	15	9	6	0	0	N/A
Comm.w/SI/AA/Othr	0	0	0	0	6	0	3	0	0	N/A
Erly.Alrt.	10	0	15	1	18	0	0	0	3	N/A
Fdbk/Assmnt	0	0	7	0	0	0	2	0	3	N/A
Hwk/Proj/Quiz Submssn.	0	0	0	0	59	3	0	0	0	N/A
Org.Questn Hmk/Proj/Quiz	2	6	30	2	22	11	6	1	17	N/A
Prblms w/IT	2	3	4	1	8	1	3	1	6	N/A
Tech.Questn	2	1	12	1	5	8	0	2	2	N/A
Undergrd.Advismnt.	0	5	1	0	26	3	0	0	0	N/A

In Table 3, we show the number of messages corresponding to a specific topic and a grade for the Fall 2012 and Spring 2013 semesters.

V. Conclusions

The main sources of data are the surveys of the students, the reports of the TAs, meetings with the TAs and the analysis of the online communications between students, TAs and instructors of record. Based on the quantitative data we have reached the following conclusions.

A. Lessons about Communication

Based on Table 2 and 3, there is less communication related with ECE 101, ECE 231 and ECE 238 compared to ECE 131 and ECE 203. From the contents of the messages and the reflections of the TAs, ECE 131 and ECE 203 were well managed classes with clear contents and with active interaction between faculty, students and TAs. Besides, in the specific case of ECE 203, the TAs were given the specific task of grading the projects during the semester, which is reflected by an outstanding amount of communication threads, specifically in Table 2, in the intersection of Hwk/Proj/Quiz Submssn and ECE 203 for Fall 2012 (59 communication threads).

The online versions of the transition courses were characterized by lack of structure in the syllabus, as well as in the homework and online content. Students and TAs complained about technical difficulties in the communication with the instructor of record as well. All this is reflected in the fact that by ruling out the students from the transition courses we notice an improvement in the assessment of the online material and the instructor of record's responsiveness respectively.

ECE 101 does not present a remarkable flow of communication in spite of the good impressions provided by the students and TAs as shown in Table 2 and 3. The TAs are explicit in their reflections that the instructor of record had the class very well organized and because of that, they did not have much to do since almost everything was taken care of. Therefore, lack of communication threads does not necessarily imply low performance of the instructor of record or TAs of the class.

Table 3. Number of messages belonging to a specific topic and grade Fall 2012

Topic\Grade	Successful		App. Successful		Unsuccessful		Undetermined	
	2012	2013	2012	2013	2012	2013	2012	2013
Comm.w/Instr.	23	11	5	0	0	0	0	0
Comm.w/SI/AA/Othr	13	1	1	0	2	0	0	0
Erly.Alrt.	16	0	7	0	20	0	3	1
Fdbk/Assmnt	8	0	3	0	1	0	0	0
Hwk/Proj/Quiz Submssn.	57	2	0	1	2	0	0	0
Org.Questn Hmk/Proj/Quiz	52	13	15	4	9	3	4	0
Prblms w/IT	9	4	8	1	7	0	1	1
Tech.Questn	5	6	10	5	6	1	0	0
Undergrd.Advismnt.	12	5	5	3	13	0	0	0

As part of the solutions to improve the pedagogy and solve the technical problems with the transition courses, the instructor of record of ECE 231 was reassigned. Given the technical difficulties of ECE 238, we decided not to offer it online for Spring 2013. With all the classes instructed by the same standards, it turned out that the TAs did not have the amount of responses that were expected. From Table 2 and 3, it is clear that the communications with the students dropped dramatically from Fall 2012 to Spring 2013.

Based on the reports of the TAs and periodic project meetings, one of the possible reasons is that during Spring 2013 all the students had at least one or more semesters attending UNM, NNMC and CNM. Therefore, different than Fall 2012, the majority of them were used to the undergraduate education environment. Another possible reason is that a considerable amount of students had taken online courses in the previous semester; therefore, students already knew the dynamics of online classes and were more independent and self-motivated. Moreover, the instructors of record who had spent some time correcting their online material did not have the need to carry out so many modifications or corrections later on. Finally, the instructors of record were more experienced about how to handle the online classes, so in many cases they did not need to contact the TAs to carry out some tasks, such as, announcements and organization of classes.

B. Lessons about Early Alerts

In Table 2, in the row Erly.Alrt., it is easy to see that the transition courses present a low flow of communications on this matter. The main reason why this numbers are low is because the instructors of record were not able to manage submissions through the Blackboard learning

correctly. Therefore, the TAs did not have the necessary means to access the performance indexes of the class. In the end, it was not possible to determine the students who were having issues with the class ahead of time to activate the early alerts. Therefore, the communication channels between the instructor of record and the TAs is essential in order to keep all the parts involved in the project well informed, hence providing the best service possible to the students.

C. Lessons about the Tasks and Profiles of TAs

Based on the TAs reports and periodic project meetings, they were supposed to interact with students by facilitating communication channels in circumstances where the students would feel disoriented given the limitations of not having the instructor of record present in the class. They did not have to neither grade nor answer technical questions about homework, projects or quizzes since there were SIs and instructors to take care of it.

However, by direct request of the instructor of record of ECE 203 they became graders of the projects, which actually brought up some positive conclusions since the students became more prone to interact with the TAs as reflected in Figure 6. Based on the reflections of the TAs, the students seem to establish communication channels quicker if they recognize the TAs as experienced authorities, (*e.g.,* if the TA has a degree in Electrical or Computing Engineering), or if the student has a practical and specific reason to contact a TA, such as, submitting a project/homework.

Given the lack of responses from the students in classes other than ECE 203, the TAs reported lack of motivation since they believed that their work was not as useful as they thought. This was worsened by the fact that in most cases their technical abilities, given that they are graduate students in electrical engineering, were not useful for their specific tasks.

D. Lessons about Undergraduate Advisement

The role of the TAs in the undergraduate advisement was a very successful feature of this project for the class ECE 203. Based on the careful analysis of the communications between students and TAs, once the communication bridge was built through the grading of the projects, the TAs had the chance to ask questions about the students' plans for the future. In many cases the students showed a genuine interest in hearing the opinions of the TAs about classes, faculty, graduate school and research. In a couple of cases the TAs were very helpful putting students in contact with Professors that would provide special advice. It is clear that the students trusted the TAs because they were able to provide an opinion of the faculty based on experience and because of the grading of projects he/she had become a familiar figure for the students.

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