A Synchronous Distance Education Hybrid Model of College-level Credits for High-school Students

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***Abstract*—Impacting college readiness and reinforcing recruitment and retention methods are objectives shared by virtually all engineering schools. This paper describes a dual enrollment program for high-school students that supports a recruitment, retention, and college readiness improvement plan initiated by the UPRM College of Engineering. Elements of synchronicity, hybrid populations, and assisted teaching are combined with a distance learning modality to define the backbone of this initiative. A small sample provides preliminary statistics on the potential results of this model, while yielding valuable feedback and insight for driving its scaled implementation.**

I. Introduction

The level of proficiency achieved in math and science by high-school (HS) students by the time they reach their senior year is one of the key factors determining their chances of entering into an engineering program. Moreover, for those who are actually accepted into such disciplines, this factor also becomes determinant for their early success in science, math, engineering, and technology (STEM) study programs, and largely determine their progress and their chances of persisting until completing their degrees.

The Recruitment, Retention and Distance Engineering Education Project (R2DEEP) in the College of Engineering (CoE) of the University of Puerto Rico at Mayaguez (UPRM) has established as part of its objectives, reinforcing high school (HS) students college readiness in math and engineering-related areas by offering them the opportunity of earning college-level credits during their senior HS year. This strategy aims, among other things, at creating engineering awareness and moving students with high potential of success to applying and entering into our degree programs, reducing the number of students dropping out in the first and second year of study, reducing their time to graduation, and impacting college-level on-time completion rates.

The approach of offering college-level credits to high-school students has long been recognized as a powerful mechanism for boosting their college readiness [1]. The mounting evidence of effectiveness of this strategy has led the US Department of Education to establish an experimental program to provide Federal Pell Grants funds to HS students taking college courses for credit [2].

Multiple modalities have been used for offering such credits, including on-campus courses along regular students, in-school with specialized teachers, and the increasingly popular form of online courses [3], [4]. Each of these approaches has their unique benefits and limitations. On-campus courses are often limited by the requirement of students physically attending university. In-school specialized teachers require just that, specialized teachers; while online courses usually rely on student self discipline and commitment.

In the light of all the above limitations, the R2DEEP program has established a pilot *Synchronous, Hybrid, Assisted Distance Education* (SHADE) model that combines elements of all the above modalities.

This paper describes the academic setting where the experiment was conducted, providing insight into course structures, student profiles, lecturing strategies, and preliminary results.

II. Academic Setting

The University of Puerto Rico at Mayagüez (UPRM) is one of the eleven campuses of the state supported university system in the island of Puerto Rico. With 12,226 students (21.2% of the entire UPR student body), the UPRM is the second largest unit in the UPR System, and the only system unit offering engineering degrees. The College of Engineering (CoE) of the UPRM serves 4,462 students distributed in nine academic programs at the BS-level, most of them awarding degrees at the master's, and Ph.D. levels as well [5]. The CoE has for many years maintained a position as the largest provider of Hispanic engineers in the US, graduating around 600 new engineers each year, from which approximately one third of them are females [6].

A. Program Structure & Profiles

With the exception of the Surveying and Topography, all UPRM engineering programs are five-year-long, a structure that benefits student formation by enabling academic programs that provide both breadth and depth. This strong formation has always been praised by employers who recruit our graduates. The benefits of such a structure however do not come without a price. Five-year long programs prolong completion time when compared to the four-year standard used by most universities in the mainland. This characteristic sets the standard 150% program length metric used to estimate graduation rates at 7.5 years for CoE students, producing interesting statistics.

1) Retention & Graduation Rates: UPRM engineering programs enjoy a modest first-year retention rate of 92.8%. By the fourth year of study, an average of 81.3% of the first-year cohorts are still retained (10-year average, 3.8% Std. Dev.). Despite these statistics, only 7.8% graduate on-time. The graduation rate at the standard 150% time has declined from 61.9% in year 2000 to an all-time low of 48.0% for the 2008 cohort (Class of 2016), with 56.5% average during that period (4.1% Std. Dev.). Moreover, beyond the 7.5-year window, an additional 6.1% ever graduate, yielding a total graduation rate of 62.6% [5].

2) Readiness Indicators: When we look at college readiness among incoming freshmen, two metrics become of interest: standard test scores and performance levels in portal courses. In this study we particularly looked at math aptitude scores in the College Entrance Examination Board (CEEB), a key admission index variable; and performance levels in math portal courses pre-basic (remedial) Math (MATE066), Precalculus I (MATE3171), and Calculus I (MATE3031) taken by roughly 83% of all engineering freshmen as their first math (the remaining 17% enter through up to ten different, more advanced math courses) [7].

Results from the CEEB math achievement test taken by engineering freshmen cohorts in a decade (2004-2013) has exhibited a tendency to decline, dropping 34 and 22 points, respectively for students coming from public and private schools [7]. It deserves to mention that the CoE has the highest admission indices in the entire UPR system and such criteria has not suffered significant changes in decades.

During the same decade, incoming freshmen have been averagely distributed with 17% taking MATE066, 18% in MATE3031, and 48% in MATE3171 with approval rates of 84.7%, 62.8%, and 63.3%, respectively. These statistic denote that at least 65% of engineering freshmen are not ready to enter college taking Calculus I. Moreover, nearly 40% fail their first math, being a common denominator from these two situations a delay of one to three semesters for incoming students, significantly affecting graduation times.

3) Early Approaches: Through the years, different strategies have been attempted to impact first math success statistics. Several alternatives of portal math courses have been attempted with different content and credit count, with the aim of offering alternatives able to accommodate different levels of readiness among incoming students and shortening the path to Calculus I to those better prepared.

Two notable initiatives were launched in 2008 in the UPRM Math Department to improve student performance in pre-calculus courses. The first, named in Spanish *"Talleres en Blanco y Negro"* (Black and White Workshops) promoted students success in the first MATE3171 exam via an intervention program of workshops conducted as co-curricular activities. The workshops were coordinated during university established no-class periods, and sought to develop an environment for students to develop effective study habits [8]. The outcome of this approach found limited success as it did not reach widespread adoption.

A second initiative named the *Pre-Calculus Mega Section Project* was launched within the Math Dept [9]. It aimed at improving pre-calculus performance of large student groups (up to 150 members) by integrating technologies and practice time with TA support. This strategy helped improving withdrawal and failure rates in a 21.8% with respect to the general student population taking the same courses, course while providing a cost-efficient mechanism for offering on-campus remedial courses.

B. Open Challenges

The approaches discussed above, despite having different levels of success, are all addressing readiness problems via remedial courses after students have already entered college. While such an approach has undeniable merits, an earlier intervention, when students are still in high school, would provide for multiple advantages that include:

1) *Cost effectiveness* – It results less expensive addressing deficiencies while students are still in school, rather than doing it when they are already in college.
2) *Broader impact* – All high school students could be potentially impacted and not only those who were able to enter college.
3) *Access opportunities* – Improving high-school students proficiency also increases their chances to enter college, offering more accessibility to higher education.

The achievement of such objectives were part of the hypotheses for the establishment of the R2DEEP initiative, described in the next section.

III. The R2DEEP Educational Approach

The R2DEEP initiative began as a set of intertwined strategies to support the UPRM strategic plan. Its objectives included boosting recruitment strategies for CoE programs among HS students, establishing strategies for improving the readiness level of incoming engineering freshmen, and a set of retention strategies to support first- and second-year CoE students.

The strategies for improving the readiness level of incoming freshmen were centered around offering dual enrollment opportunities in first-year math and engineering courses to eleventh and twelve grade HS students via on-line, distance education. This approach was entwined with the recruitment and retention objectives as HS students not only acquired knowledge in college-level math and engineering subjects, but also got them in early hands-on contact with the discipline, supporting recruitment efforts and allowed them to earn college-level credits with the potential of enabling for earlier college completion paths.

In an attempt to avoid known pitfalls of on-line education, several characteristics were embedded into this on-line dual enrollment offer. First, to limit the high reliance on self-discipline, characteristic of asynchronous on-line material, courses were set for synchronous delivery, requiring HS students to connect via video-conference for each lecture. Courses were scheduled during afternoon hours, from 3:30PM

to 5:30PM two days a week each, allowing for live interaction with college professors and providing a structured environment that aimed at facilitating high-schoolers transitioning into college-level lecturing styles.

Second, to provide for the accessibility of asynchronous material, the entire class discussions were also recorded and made available on-line to all students for study at their own pace after the synchronous lecture was over.

Third, to develop a sense of belonging for remote students, courses were simultaneously offered to remote and live in-the-classroom on-campus students, creating with this hybrid modality virtual extensions of the college classroom in every participating school. This approach aimed at providing an environment to foster class participation and creating a sense of belonging to both on-campus and remote students. Moreover, in-school groups had an assisting math or science teacher that served as facilitator to moderate the discussion, providing with local help, and serving as liaison for the interaction with the on-campus classroom. To avoid distractions to the college professor, a designated in-class teaching assistant (TA) served as moderator for the participation of remote students, among other chores.

An important goal of this pilot was to provide a scalable scheme that allowed bringing this opportunity to virtually any interested school in the island. Of particular interest was reaching those in geographically difficult to access locations, where local studies have found marked levels of under-representation in engineering [10]. This was a main drive for adopting an on-line delivery method. Aligned with this objective was also the consideration of impacting students outside the typical classroom setting. To this end, remote participants were divided among two groups that included in-school, teacher-assisted, and independent students taking the courses on their own. All were required to sign-in prior classes started, enabling attendance control and compliance with synchronous requirement. All students, including on-campus, in-school, and independent students were granted unrestricted access the online videos and resources after lectures were over.

These attributes define what we call the SHADE model, alluding to the acronym derived from the Synchronous, Hybrid, Assisted Distance Educational modality defining the approach. Below we describe the work currently in progress to assess the effectiveness of the model.

IV. Experiment Configuration

The pilot was set for its inaugural ride last fall 2015, with two courses: college-level Pre-calculus I (MATE 3171) and Engineering Graphics I (INGE 3011), both core courses for the majority of all first-year CoE students. Four public schools in the UPRM service area were engaged through an agreement with the PR Department of Education, and independent students from seven different private and public schools from equal number of municipalities in the island also participated. Students were enrolled in a first-come, first-served basis after the pilot was announced in schools and among summer camp goers prior to the delivery.

Participation criteria required students to have a minimum HS grade point average (GPA) of 3.50/4.00 and scored 625 or more in the CEEB math achievement test. Those scoring between 625 and 650 in the CEEB were required to pass a math proficiency test (MPT) offered by the UPRM Math Department. Those failing the MPT were offered the opportunity of completing a three-week math reinforcement workshop and re-taking the MPT during the summer.

A. Demographics and Distribution

Eighty-two students originally applied to the program. From those, only 24 had the requirements to directly enter the courses. The rest, although having the required GPA, did not satisfy the CEEB score requirement of 651 or more, and thus were recommended taking the MPT. Twenty-five of them took the test and they all scored below the 50% passing threshold, failing in their first attempt. None of them signed for the reinforcement workshop. Twenty students took the MPT in its second offer and four passed. In the end, twenty-eight students enrolled in the offered courses, 21 in MATE3171 and 16 in INGE3011. One third of them were enrolled in both courses.

The participants were distributed as 53.6% males and 46.4% females; 64.3% came from public schools, and all but one took the courses on-line. One local student enrolled in both courses opted to attend on-campus.

Only one of the four initially recruited public schools kept enough students to participate in the pilot. Eleven students participated from this school, and the rest took the courses independently.

V. Course Structures

The structures of the two courses offered in this part of the pilot are organized to build on top of the student HS preparation. Although engineering students in the UPRM enter from their first year in their chosen major, most courses taken in the first two years are common to all engineering disciplines. Below we provide a brief description of the organization of each course.

A. The Pre-calculus I Course

The three-credit MATE3171 course has as an objective providing students with fundamental knowledge on the properties and operations of real numbers; equations and inequalities; absolute value, polynomials; linear and quadratic equations; Cartesian coordinates and graphs; functions and their properties; algebraic, exponential and logarithmic functions.

The course is organized into three parts that include:

1) *Arithmetic and Algebraic Part*: Provides students with a review of algebra concepts, working with variables and symbols, and their properties.
2) *Constructive Part*: Focuses on functions, graphs, and their interpretation.
3) *Explorative Part*: Performing operations with functions, Cartesian dynamics, and transformations.

Students complete homework after each lecture, all of them to be individually completed. Course materials and delivery

emphasize the importance of understanding the fundamentals and how to apply them for solving problems.

Under the SHADE model, the course was offered in two weekly 75-minute sessions on Mondays and Wednesdays for 15 weeks, for a total of 45 contact hours. Each lecture was transmitted and recorded via Google Hangouts and made asynchronously available via YouTube. Office hours were offered by the college professor via email and live chat sessions, three hours per week. The support teacher offered in-school 1.5 office hours per week. A web page maintained by the TA provided lecture materials.

Each lecture was delivered with the professor greeting students facing the camera upon entrance, and afterwards the video streamed the screen of a tablet used as writing device, allowing students to follow the discussion and listen the professor's explanation. Student faces and classroom views were briefly projected when asking and responding questions.

Homework was turned-in on-line and midterm and exams were offered in writing, on-campus (no on-line exams) along with the general college student population, and proctored by the professor and TA. The UPRM Math Department offers departmental exams prepared by a team of professors other than the lecturer. A total of 1,441 students took MATE3171 that semester, including the R2DEEP students.

B. The Engineering Graphics Course

The two-credit INGE3011 course has as an objective teaching students how to make sketches of conceptual products, develop graphic solutions to geometrical problems, making 2-D and 3-D drawings by hand and with a computer, and understanding engineering drawings. In addition students are expected to understand the engineering design process, communicate ideas using graphic language, and understand ethical considerations of engineering decisions.

The course is organized into three main units that cover fundamentals of delineation, descriptive geometry-based analysis and solution of space problems, and development of drawing and sketches. Ethical aspects of engineering decisions are integrated along the course. At the end of the course, students present a graphical solution to an engineering problem assigned at the middle of the semester and completed in teams of four or five students. Oral presentations and posters are used by the students to communicate their project progress and main results, enforcing the communication component of the course.

Like the pre-calculus course, homework are turned-in electronically and exams are offered on-campus in writing along with the rest of the student population. As the course includes lab hours, it meets four hours per week, (Tue/Thr 3:30PM - 5:30PM) with one third of the time devoted to lectures and the rest to laboratory activities.

Lecture delivery used one screen camera and an ELMO visual presenter to convey images of solid models and drawings. In addition, students used AutoCAD as the sketching software, with remote students accessing through a virtual license server. A total of 579 students took the INGE3011 course that semester, including those in the R2DEEP course.

VI. Results and Analysis

As an on-going pilot, the results presented in this section are preliminary. By the end of the fall semester, the approval rates in MATE 3171 and INGE 3011 showed that 83% and 86%, respectively approved the courses with grades C or higher. Two students withdrew from MATE3171 and one from INGE3011. Three students who stopped attending the courses, two in MATE 3171 one in INGE3011, failed the courses (F as grade) as they did not withdrew.

The performance reports of this reduced sample of students resulted very encouraging for this pilot, as approval rates in the case of pre-calculus was 32% higher than in the general population. For the Engineering Graphics course, the statistic was identical to that of the general population.

Although the sample population used in this initial run was small, the exercise provided us with valuable insight of practices that will allow us to improve the student experience for the continued offering of this course modality. Some of the most important lessons learned include:

- Developing empathy with students via a chat or email proved to be very challenging. Relations tend to be less personalized. Some students complained about this fact, while others considered it a benefit of this course modality.
- The system will benefit from providing professional counseling. Students requiring assistance for adjusting to the teaching style or coping with personal situations were referred to one of the campus counselors, but appropriate provisions are required to serve larger groups as the initiative scales.
- Economic assistance must be included as part of the program if true accessibility is expected for low-income students. In this initial run 25% of participants qualified and received financial aid to afford paying for the credits.
- For the school-based groups, forming working groups was relatively easy, when compared to the independent students, who had to use virtual means to interact with peers in their INGE3011 projects.
- The usage of support teachers resulted in an excellent mechanism to improve teacher preparation in schools. Sitting for one semester in a college course resulted in an excellent refresher for teachers. In the case of INGE3011, a college TA was used as supporting person in the classroom, but the teacher sat in the course with the student and for the next run he will be the in-school support person.
- Exam sites need to be established in strategic places over the island, as the requirement of physically coming to the UPRM campus results a burden to students and parents living in far away places.
- More information needs to be relayed to aspiring students on the importance of preparing for the MPT and taking the reinforcement workshop. Although a self-study

guide is available, an informal poll indicates that several students would have taken it if it had been available in SHADE mode.

- Students completed both courses while still having the opportunity of taking once more time the CEEB. This is a great plus for student confidence and preparation and is expected to impact test performance.
- Most students who completed the courses (93.4%) were highly satisfied with the experience and rated it as good (20%), very good (46.7%), or excellent (26.7%).

VII. Conclusion and Continuing Plans

The results from this run by no mean can be inferred to be representative of the student population at large, but provide encouraging results to continue its application, gather more data, and refine the SHADE model. Students from this pilot group are as we write this manuscript taking the second part of the pre-calculus course (MATE3172), and continue to exhibit a similar performance pattern as in the previous semester. This year, the model is expected to impact around one-hundred additional students in a dozen schools, allowing the collection of critical data to be able to estimate impact in more representative sample, and including additional courses with the expectation that similar results could be replicated. In the mean time, those who participated of the experience express great satisfaction with the experience and have become messengers onto other of the potential benefits of the R2DEEP course model.

Acknowledgment

The authors would like to thank Dr. Olgamary Rivera, Math Department Chair and Dr. Aidsa Santiago, Materials Science and Engineering Department Chair, as well as former chairs Omar Colón, Jeannette Santos, and Jaime Ramirez for their support in the execution of this pilot.

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