# AC 2010-2005: INCREASING STUDENT ACCESS, RETENTION, AND GRADUATION THROUGH AN INTEGRATED STEM PATHWAYS SUPPORT INITIATIVE FOR THE RIO SOUTH TEXAS REGION – YEAR ONE ACTIVITIES AND RESULTS


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# Increasing Student Access, Retention, and Graduation Through an Integrated STEM Pathways Support Initiative for the Rio South Texas Region – Year One Activities and Results


## Abstract

This paper discusses in general the first year activities and results of an integrated STEM pathways support initiative for the Rio South Texas Region that was described last year. This initiative is a collaboration between The University of Texas-Pan American (UTPA) and South Texas College (STC), both Hispanic Serving Institutions (HSIs), to facilitate student engagement and success in STEM areas. With a recently funded College Cost Reduction and Access Act (CCRAA) grant from the Department of Education, both institutions are developing and supporting strategies that will facilitate the success of Hispanics and other low income students in STEM areas. The efforts supported by the initiative focus on four activities. The first activity enhances student services to foster success in Calculus I as it is a mathematics course known to be a roadblock for student success in STEM fields. The second activity supports the implementation of Challenge-Based Instruction (CBI) in selected key courses. CBI, a form of inductive learning, has previously been shown to be a more effective approach to the learning process than the traditional deductive pedagogy. The third activity supports faculty development workshops on CBI techniques and on other locally developed teaching tools with a focus on increasing student success. Finally the fourth activity develops and supports pathways to STEM fields between STC and UTPA. This paper discusses the results and modifications of the activities after the first year of implementation. Ultimately, we hope that this project will provide a model that will have a significant impact on the number of STEM graduates and that will be simple to replicate in other higher-education institutions.


## Introduction

This paper discusses the first year grant activities and results of a College Cost Reduction and Access Act (CCRAA) grant designed to implement a series of activities that will, ultimately, increase student performance and retention at colleges and university in the South Texas region. This initiative is a collaboration between The University of Texas-Pan American (UTPA) and South Texas College (STC), a two-year community college, to facilitate student engagement and success in STEM areas. Both UTPA and STC are Hispanic Serving Institutions (HSIs). The CCRAA grant funded four specific activities:

- Activity 1: Enhanced Student Services – STEM Advisement and Mentoring Program and STEM Calculus I Student Assistant Support Program;
- Activity 2: Curriculum Reform– Curriculum development based on Challenge-Based Instruction (CBI);
- Activity 3: Faculty Development – Faculty development seminars and workshops on CBI; and
- Activity 4: STEM Pathways Growth and Support – Dual enrollment programs at STC.

These four activities, which were described and justified in a previous paper in the proceedings of the 2009 ASEE National conference[1], have already impacted several hundred students and the impact is measurable. The following sections briefly described the four specific activities and the preliminary results obtained as well as the necessary adjustments that are currently taking place.

**Activity 1: Enhanced Student Services**

Activity 1 identified a strong need for student support services in the primary mathematics gateway course for STEM majors: Calculus I. The project implemented a system of student assistants and a series of mentoring sessions to better guide students to success in Calculus I classes. From the initiation of the project in Spring 2009 to Fall 2009, there were interventions in 19 Calculus I classes at UTPA. At STC-McAllen campus, there were interventions in 8 Calculus I classes and 5 Precalculus classes. The new interventions in Calculus I included the addition of Student Assistants (SAs), undergraduate STEM majors, who were assigned to a Calculus I instructor at UTPA and to a Precalculus or Calculus I instructor at STC. The SAs attended all 4 weekly class lectures during the entire semester, took lecture notes using the Cornell note-taking style and posted them online, graded homework or quizzes, posted assignments, solutions, and tutored students.

Precalculus and Calculus I students were surveyed since the initiation of the grant in Spring 2009 regarding the interventions in Precalculus and Calculus I. Preliminary data suggest that the SAs have a positive effect on the students. In particular, student surveys show that there has been an increase in the combined "Very Helpful" and "Helpful" category ratings given to Student Assistants in the classroom and in their tutoring from Summer 2009 to Fall 2009 (see Table 1 and 2).

Table 1. "Very Helpful" and "Helpful" Combined
Ratings of the Student Assistant in the Classroom in Calculus I

| | UTPA | STC |
|---|---|---|
| Summer 2009 | 51% | 77% |
| Fall 2009 | 65% | 72% |

Table 2. "Very Helpful" and "Helpful" Combined
Ratings of the Tutoring done by Student Assistants in Calculus I

| | UTPA | STC |
|---|---|---|
| Summer 2009 | 45% | 57% |
| Fall 2009 | 47% | 69% |

Preliminary assessment results of Activity 1 are included below. A different cohort of faculty members teach Calculus I each semester; therefore instructor grading and teaching also played a critical part in the retention of students and delineating this variable from the data is difficult to extract. Since UTPA and STC are commuter schools with a large percentage of students working off-campus and being first-generation students (76%), challenges to having students use the services provided by this activity also arose. Formative assessment was conducted to determine how best to utilize the Student Assistants, the interventions, and resources to help students succeed in Calculus I, and adjustments in services were made as the project evolved.

Some preliminary results are the following:

- At UTPA, the average ABC pass rate in Calculus 1 for the past two years from Spring 2007-Fall 2008 was 74% with a total of 905 students (62% if we count withdrawals for a total of 1085 students). These percentages were the basis for further comparisons. This percentage was compared to the average ABC pass rate in Calculus 1 during the period the grant was implemented, Spring 2009-Fall 2009. The average pass rate was 70% with a total of 510 students (58.5% if withdrawals are counted for a total of 658 students).

- At STC, the average ABC pass rate in Calculus 1 for the past two years from Spring 2007-Fall 2008 was 81% with 271 students (66% with 338 students counting withdrawals). During the implementation of the grant from Spring 2009-Fall 2009, the average pass rate was 60.3% with 170 students (47% with 217 students counting withdrawals).

We note that the average pass rate at UTPA decreased slightly if we include in the total count the number of students who withdrew from Calculus 1. Some factors accounting for the decrease include individual instructor teaching and quizzes or homework accounting for 10-20% of the course grade. Prior to the grant, during the Spring 2007-Fall 2008 terms, not all instructors required homework or quizzes to be part of the course grade. With the implementation of the grant, it was suggested that assessments other than exams be included in the course. Thus, instructors assigned quizzes or homeworks as part of the course grade. By all means, having these additional assessments provides students the opportunity to continually assess themselves throughout the semester and in preparation for exams.

At STC the decrease in the average pass rate in Calculus 1 was significant. During the implementation of the grant, quizzes were introduced in the classes. Instructors noted that they planned to become more involved in the development of quizzes to align them better to material being taught.

Additional adjustments were made to enhance the tutoring done by the Student Assistants and to work more closely with them. In addition, a more closely monitored system was implemented to determine the students who were at-risk of failing Calculus 1 and referring them for advisement and tutoring. Furthermore, beginning with Spring 2010, the Calculus I Student Assistant Support Program was presented to entering students at Freshmen Orientation so that they would be aware of the importance of passing Calculus 1 initially.

In addition, limited formal mentoring was being done for some STEM disciplines. Therefore, as part of the STEM Advisement and Mentoring Program, a faculty member from each STEM department participates as a STEM Faculty Mentor. The Faculty Mentor intervenes by advising students who are at-risk of failing Calculus and discusses the consequences in the student's degree plan if the student fails/drops Calculus since this math course is the foundation for additional STEM courses and a prerequisite for subsequent STEM courses. The STEM Faculty Mentors also give two presentations on the Applications of Calculus during the semester. In all, students who are at risk of failing Calculus I during the semester are advised to speak with their

Calculus I instructor and their STEM Faculty Mentor. During the spring, summer and fall of 2009, about 250 students attended mentoring sessions, while 240 students at UTPA and STC made use of the student assistant in the classroom. Of the students who were advised to speak with their STEM Faculty Mentor, only a small percentage met with their mentor. For the Spring 2010 semester, the program was enhanced to better keep track of students who are not seeking advisement through their Faculty Mentor and to encourage them to seek advisement.

In Spring 2009, three meetings were held with the STEM Faculty Mentors and Calculus 1 students. These sessions dealt with having students and mentors meeting each other, advising students on their degree plan, and providing a presentation on "Applications of Calculus" given by STEM Faculty Mentors with the goal of exposing Calculus I students to applications of science and engineering in Calculus I. In the next fall 2009 semester, the meetings were enhanced to initially include a session on "Tutoring Services" in STEM disciplines and two presentations on "Applications of Derivatives" and "Applications of Integrals" given by STEM Faculty Mentors; these two presentations were given about one month apart during the time students were covering the content. Surveys were conducted after each session beginning with Spring 2009. At UTPA, from Spring 2009-Fall 2009, 172 students attended the "Applications of Calculus" or "Applications of Derivatives" presentations out of a total of 510 students who did not withdraw from the class. These numbers pertain to a 34% attendance; on average about 1/3 of the students attended a presentation. STC was planning similar activities for later in the year. In particular the cumulative results for the "Application of Derivatives" and the "Applications of Integrals" presentations are given in the Figure 1 and student comments on the presentations are given subsequently.

**Presentations on "Applications of Integrals/Derivatives"**

For Questions 1-4, please answer "Strongly Agree", "Agree", "Neither Agree nor Disagree", "Disagree" or "Strongly Disagree". *Only circle one choice.*

1. "From this presentation, I learned about applications of calculus in science and engineering".

Strongly Agree
Agree
Neither Agree not Disagree
Disagree
Strongly Disagree

Combined "Strongly Agree and Agree" Average for all presentations given from Spring 2009, Summer 2009, and Fall 2009: **97.6%**

2. "The majority of the applications given in this session were interesting".

Strongly Agree
Agree
Neither Agree not Disagree
Disagree
Strongly Disagree

Combined "Strongly Agree and Agree" Average for all presentations given from Spring 2009, Summer 2009, and Fall 2009: **88.3%**

3. "After attending this session, I have a better understanding of how calculus is used in science and engineering applications. "

Strongly Agree
Agree
Neither Agree not Disagree
Disagree
Strongly Disagree

Combined "Strongly Agree and Agree" Average for all presentations given from Spring 2009, Summer 2009, and Fall 2009: **92.3%**

4. Overall, one a scale of 1 to 100 where 1 is the worst possible evaluation and 100 the best possible, how do you rate this session that you attended?_____________

The Average for all presentations given from Spring 2009, Summer 2009, and Fall 2009: **89**

5. Please provide additional comments or feedback on the session for further improvement.

Figure 1. Assessment Instrument and Cumulative Results for Presentations

Comments by Calculus I students on the presentations included the following:

- I learned more about Physics. At first I hated physics, now it makes more sense, so I like it more.

- It's good to see how this fits in to every day life. More of this is good
- I really enjoyed the second (biology) presentation. I would like to see more 'real world' applications. zeno's paradox [math presentation] is super interesting
- The Computer Science presentation was most interesting.
- I suggest having the topics to be presented printed on the postings. Elliptic functions talk was interesting.
- Very good Presentations. Informational on how derivatives are utilized in different fields. Actually, the biology presentation helped me figure out a homework problem from calculus as for as population growth. Should have these presentations more often that way students are aware of the real way or process of how these different fields use derivatives on a daily bases.

More data is being collected and assessed to determine the impact of the Activity 1 interventions on the enrollment and retention of STEM majors. At this time, the trend suggests enrollment is increasing at UTPA and STC student (STEM) transfers to UTPA are increasing as well.

**Activity 2: Curriculum Reform**

Activity 2 focuses on STEM undergraduate curriculum reform. One important goal of this activity is to initiate a systemic change in the way STEM faculty teach and in the way our STEM students perceive their role as a learner. The basic methodology of curriculum reform was to systematically and deliberately enrich instruction in key STEM classes with Challenge Based Instruction (CBI). CBI is a form of inductive learning, which has been shown to be a more effective approach to the learning process than the traditional deductive pedagogy[1-3] and incorporates cognitive and affective elements recommended for retaining underrepresented students[4-6]. CBI provides a real life learning environment where the problem/challenge is introduced first and the supporting theory/principles second (i.e. traditional teaching backwards). The implementation of CBI was built around the How People Learn (HPL) framework as realized by the STAR Legacy cycle (VaNTH). The steps in this cycle are: 0. Look Ahead (the learning tasks and desired knowledge outcomes are presented – allows for pre-assessment and serves as a benchmark for self-assessment in the Reflect Back step), 1. Presentation of Challenge (the student is provided with information needed to understand the challenge), 2. Generate Ideas (the students work alone and/or in teams to express what concepts or knowledge they think is important in solving the challenge – learner and community centered), 3. Multiple Perspectives (thoughts of various experts and/or simulations are presented to the students – community and knowledge centered), 4. Research and Revise (reference materials and formative assessment articles are presented to assist the student in exploring the challenge – knowledge and learner centered), 5. Test your mettle (summative instructional events are presented – knowledge and learner centered), 6. Go Public (a high stakes motivating activity such as a presentation is undertaken – learner and community centered), and 7. Reflect Back (the student revisits their initial thoughts concerning the challenge that they expressed in the Generate Ideas phase – learner centered)[2,7-9]. Figure 2 shows the Legacy Cycle and its relationship with the engineering design process[10]. The Legacy Cycle aligns itself well with key phases of the engineering design cycle. Steps 0 and 7 of the STAR Legacy cycle are not shown in Figure 2.


Figure 2. Legacy Cycle and Engineering Design Process

The implementation of CBI is addressing the needs of attracting and retaining talented minority students and developing in them a solid understanding of the fundamental principles as well as developing adaptive expertise skills. These goals were identified as significant current engineering educational challenges[1]. The project promotes student attraction and retention by addressing students' need to see relevance of studies to the real world. The project is also addressing the need to develop student adaptive expertise. As discussed in the literature[1], STEM professionals need not only a solid understanding of the fundamental principles and knowledge in their discipline, but they also need to be able to adapt as opportunities and applications in these fields evolve. The project is achieving its goals via Challenge-Based Instruction by introducing the Legacy Cycle to STEM students early and often.

Table 3 shows the selected STEM key courses where CBI was implemented in the first and second year of the project. Among the selected STEM key courses, Calculus I, Calculus II, and Physics I are early career science courses that most STEM students have to take. A significant number of engineering courses were also selected since mechanical engineering faculty at UTPA were already participating and/or interested in doing extensive curriculum reform starting with the freshman course of Introduction to Engineering. While Statics and Dynamics are key courses for all engineering majors, the remaining selected engineering courses are significant CBI areas of opportunity because of these courses are exploratory in nature.

Table 3. Selected Key Courses

| First Year (2008-2009) | Second Year (2009-2010) |
|---|---|
| Calculus I | Calculus II |
| Physics I | Engineering Graphics |
| Introduction to Engineering | Mechanics of Solids |
| Statics | Measurement and Instrumentation |
| Dynamics | Interdisciplinary STEM Course (TBD) |

After attending the CBI faculty development workshop and workdays (see more details in the next section-Activity 3) the five CBI development teams for Year 1 met regularly in summer 2009 to develop CBI modules, with associated documentation, for their respective courses. The Calculus I team developed 15 modules covering the entire course content, the Physics I team developed 12 modules covering the entire course content, the Introduction to Engineering team developed 6 modules covering the intended course content, the Statics team developed 4 modules covering approximately 80% of course content, and the Dynamics team developed 4 modules covering approximately 50% course content. Additional modules will be developed by the Statics and Dynamics team to completely cover content of respective courses by the end of May 2010.

Each team is in the process of producing three documents including a single project profile for their course, module design templates, and an instructor's manual describing the modules at increasing levels of detail, respectively. At the time of this paper, 5 basic STEM classes have been implemented with CBI modules. While assessment of all the classes is not complete, the assessment that has been completed indicates that CBI instructed students appear to acquire better adaptive expertise skills. For example, the CBI Calculus I classes tended to have a (statistically significant) higher course grade expectation than the non-CBI classes taught at UTPA. This expectation was supported in that the CBI class had a statistically significant higher course grade than the non-CBI classes (e.g., 61.3% of the CBI students received either an A, B or C grade compared to 39.9% of non-CBI students). In addition, the CBI students tended to be more willing to make use of the classroom resources (student assistants and posted notes) than the non-CBI group. As noted below, a more complete evaluation will be done over a larger number of classes and a longer period of time. However the preliminary results are strongly suggestive of success.

Full implementation of the CBI modules occurred in the following 5 CBI 1 course sections: Physics I at UTPA, Calculus I at UTPA, Introduction to Engineering at both UTPA and STC, and Statics at STC. Partial implementation occurred in the following 3 course sections; Statics at UTPA, and Dynamics at UTPA and STC. Only 2 course sections did not have any CBI implementation in Fall 2009; Physics I and Calculus I at STC. This was due to not having CBI 1 faculty teaching the courses. The plan is to have the 5 CBI 1 course sections that did not receive full implementation in Fall 2009 receive full implementation this coming Spring 2010. It has been observed that this style of instruction has a high overhead in terms of both initial time and effort. To date, the assessment activities are lagging the module development activity so only a limited comparison of CBI with the "standard" pedagogical approach has been completed.

Conclusive data on the effectiveness of our integrated and systematic implementation of CBI throughout the curriculum will be presented in future publications.

**Activity 3: Faculty Development**

The need for instructors versed in the techniques and methodology of CBI requires faculty training. Activity 3 has supported faculty development workshops on CBI techniques and other locally developed teaching tools with a focus on increasing student success. The grant provides for a series of 4 two-day workshops along with associated work days for some 20 faculty each, for a total of 80 faculty members trained in CBI instruction in the 2 years of the grant. As of the time of this paper, we have completed three of these workshops with associated workdays and have trained 60 faculty members. This progress indicates that the grant activities are well on course to create a cadre of UTPA and STC faculty members trained in CBI.

The first group of faculty participating in Activity 3 consisted of 20 STEM faculty members from STC and UTPA. The five faculty members from STC represented three different STEM fields (2-Math, 2-Physics, and 1 Engineering). The 15 faculty from UTPA represented six different STEM fields (2-Chemistry, 1-Electrical Engineering, 2-Manufacturing Engineering, 2-Math, and 7 Mechanical Engineering). The two hour pre-workshop training was offered in February 2009 at UTPA and was led by the Activity 3 director, Dr. Crown. During the pre-workshop meeting faculty were introduced to several examples of CBI as used in various courses at UTPA and other institutions. The faculty members were also presented with instructional content using CBI to get a hands-on experience with CBI. Finally, the materials for the two-day workshop were given to faculty including a pre-workshop section that was assigned as homework. The workshop presenters, a team of faculty and staff from Vanderbilt University, commented repeatedly in subsequent workshops that the preparedness of the faculty for the workshops was noticeable and it had a positive impact on the overall effectiveness of the workshops.

The first of four two-day workshops was offered in March 2009. Eighteen STEM faculty attended the workshop led by a team of faculty and staff from Vanderbilt University. The team of CBI specialists were led by A. H. Harris, Ph.D., the director of Educational Programs of VaNTH ERC at Vanderbilt University. The agenda of the two-day workshop is shown in the Table 4 below. Following the workshop, the first group of faculty members returned for two faculty workdays. The first group attended two workdays in April and May 2009. The objective of the workdays is to provide faculty with time and resources to implement what was learned in the CBI workshop. Specifically, faculty began development of CBI lecture content for at least one STEM course that they teach. At the workdays faculty members were provided with additional examples, group development activities, student assistants, and technical resources to aid in the development of a CBI lecture. One of the resources provided to the faculty was a CBI development template, which also serves as the template for the CBI "Teaching Toolbox" online repository. The first group of faculty participating in the workshops and workdays were also selected to participate in the course development activity of the grant, Activity 2. Involvement of subsequent groups of faculty was opened to all STEM faculty at the two partner institutions through emails to faculty and by word of mouth from former participants.

Table 4. CBI Workshop Agenda

| "How People Learn" Engineering / CBI Workshop / Day 1 | |
|---|---|
| Morning Session | Afternoon Session |
| ▪ Introduce ourselves and discover in-workshop collaboration opportunities<br>▪ Examine personal goals for the workshop<br>▪ Review the history of HPL Legacy Cycle (LC) modules in VaNTH courses<br>▪ Examine the component parts of HPL learning theory and LC lesson design<br>▪ Work through an abbreviated bioengineering-based LC module<br>▪ o Review more examples of LC modules | ▪ Apply HPL design to selected course<br>▪ Revisit/refine course objectives to determine acceptable evidence and plan assessments to be used<br>▪ Design effective, real-world challenges to engage students with content<br>▪ Identify appropriate learning activities incorporating HPL elements<br>▪ Review LC lesson design for course<br>▪ Share some initial module ideas with fellow workshop participants for feedback |
| **"How People Learn" Engineering / CBI Workshop / Day 2** | |
| Morning Session | Afternoon Session |
| ▪ Understand how on-line courseware differs from a website<br>▪ Introduce the basic elements of CAPE - concepts and vocabulary<br>▪ Use existing web materials with CAPE<br>▪ Design activity flows in CAPE<br>▪ Author and use formative assessments in CAPE<br>▪ Represent knowledge in CAPE | ▪ Apply HPL design/CAPE technology to course<br>▪ Review LC lesson design for the selected course with CAPE in mind<br>▪ Revisit appropriate learning activities incorporating HPL elements with CAPE in mind<br>▪ Collaborate, design, and develop an LC module<br>▪ Present lesson module ideas to fellow workshop participants for feedback<br>▪ Make brief written commitments for module implementation and follow-up activities |

The second group of STEM faculty that attended the pre-workshop meeting on April 2009 numbered 19. To date, three of four faculty development workshops have been offered with the final group beginning in February 2010. The schedule and attendance at completed workshops and workdays is given in Table 5 below. The second and third columns represent numbers of faculty who attended some portion of the training. The final column of the table represents the total number of STEM faculty members (59) who have completed the workshops to date. In each of the groups, the faculty from both institutions were mixed during interactive activities to provide many opportunities for collaboration. A majority of the faculty have collaborated on other activities outside of the faculty development workshops following their participation especially in other activities funded by the grant. There has been a recent increase in the matriculation of students from the two-year STC to the four-year UTPA which may have in part been due to the relationships developed among faculty and the increased faculty awareness of each other's programs.

Table 5. CBI Workshop Attendance

| Group # | UTPA Faculty | STC Faculty | Pre-Workshop | Workshop | Workday #1 | Workday #2 | Completed Workshops |
|---|---|---|---|---|---|---|---|
| **1** | 15 | 5 | Feb. 27, 2009 | Mar. 6&7, 2009 | Apr. 24, 2009 | May 1, 2009 | 18 |
| **2** | 17 | 3 | | | | | 36 |
| **3** | 22 | 2 | Nov. 13, 2009 | Nov.20&21, 2009 | Spring 2010 | | 59 |
| **4** | Scheduled Spring 2010 | | | | | | |

As part of their participation in the CBI workshop and workdays, faculty members have agreed to develop an implementation of CBI for one of their STEM courses. As there are 80 faculty members who will participate in the workshops, there will be a minimum of 80 STEM courses impacted by STEM as the faculty members implement their developed content into their courses. As of November 2009, the first two groups (36 faculty members) have completed the workshop and CBI course development workdays. Each course is at different stages of development and implementation. Some faculty had begun implementation of CBI in their courses even before attending the workdays based on content developed in the workshops. Other faculty members have developed course content but have not delivered it in class as they are waiting for the next offering of the course. A faculty survey has been developed that will be sent out to all participants in the Spring semester of 2010. The survey is used to collect data about completed and anticipated implementation of CBI in STEM courses and preliminary assessment of the impact both on both the students and faculty. Results of the faculty survey will be presented in future publications.

During the two workdays, faculty members are given time and resources to develop course content for one of their STEM courses. The initial implementation is a single lecture using the CBI methods built on the Legacy Cycle. The CBI lecture content exposes the faculty and students to CBI and provides data to the faculty on the effectiveness and efficiency of the pedagogical method. Several CBI examples were presented to faculty from former participants who served as mentors during the workdays. The workdays were scheduled in a computer lab on the UTPA campus where the faculty members were provided with training and access to a number of online tools helpful in the development of CBI content and delivery. The CBI team members from Vanderbilt University assisted in the workday by helping faculty members develop formative assessment materials that are a necessary component of CBI. During the workdays, students employed on the grant assisted faculty with the development and posting of CBI content on the CBI website. The content is housed at http://en.wikiversity.org/wiki/UTPA_STEM to allow faculty easy public access to the content and will be mirrored on a local web server. To date, content developed for twenty courses have been posted on the CBI website as listed in Table 6.

Table 6. Courses Content Posted on CBI Website

| | | |
|---|---|---|
| Animal Parasitology<br>Biology II<br>Biomedical<br>Calculus II<br>CAM (Computer Aided Manufacturing)<br>Environmental Chemistry<br>Geometry and Measurement | Graduate Seminar<br>Engineering Graphics<br>Introduction to Mechanical Engineering<br>Introduction to STEM<br>Manufacturing Processes Lab<br>Computer Networks | Measurements<br>Mechatronics<br>Numerical Methods and Statistics<br>Organic Chemistry<br>Physics I (Calculus Based)<br>Precalculus<br>Statics |

Some of the courses listed in Table 6 have content posted for several lecture topics. The Introduction to STEM course has six CBI lecture templates posted as examples on the CBI website. The CBI design and lecture outline for DNA Extraction are shown Figure 3. The developed CBI course content for this course is currently being used at STC.

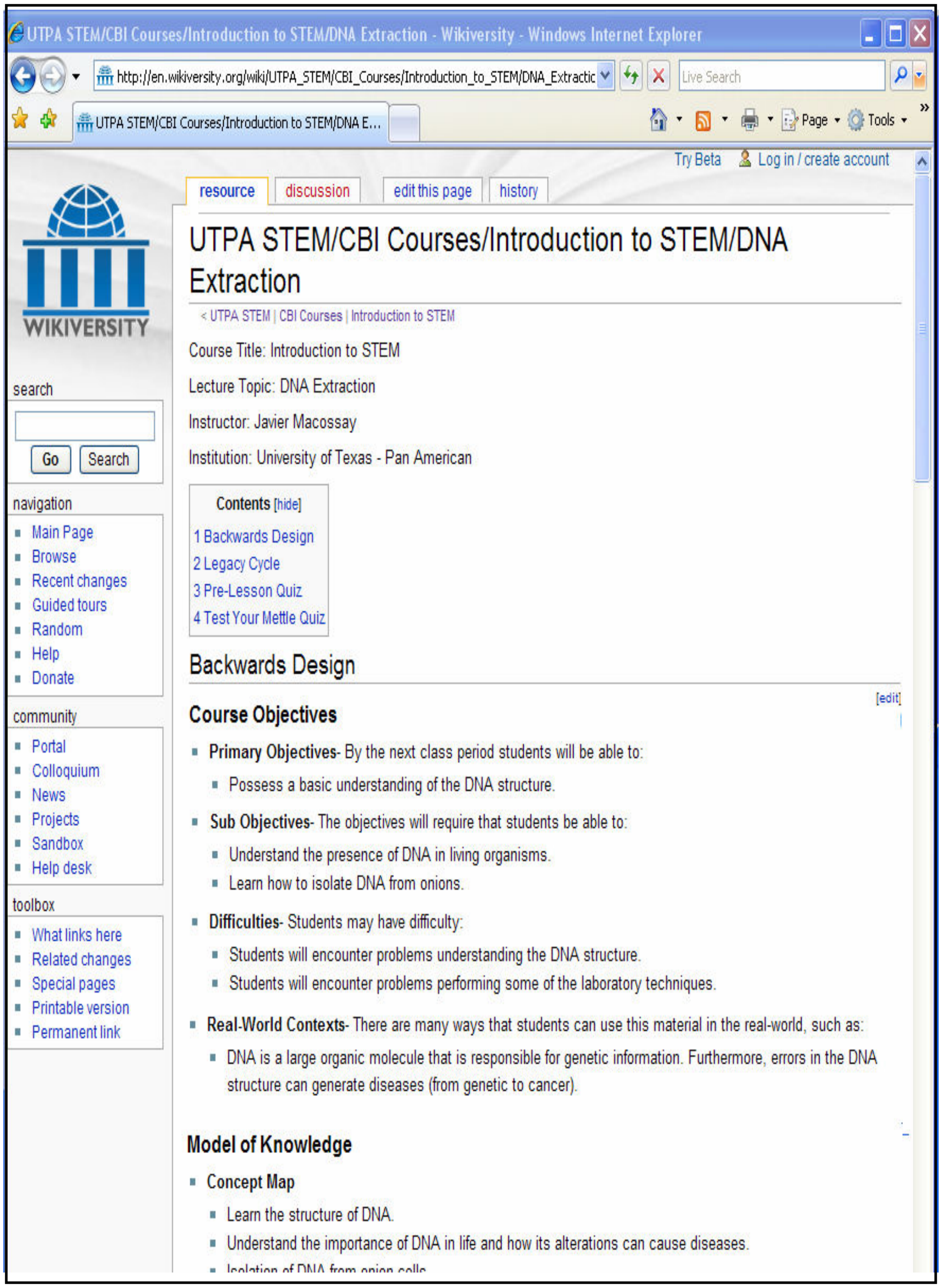


Figure 3. CBI Design and Lecture Outline for DNA Extraction

Initial reports from faculty on the student response to CBI have been positive and consistent with the results of previous studies on the student impact of CBI[3]. Given the percentage of faculty who will have participated in the faculty development activity by the end of the grant, the impact on STEM education should be significant. As the implementation of CBI into STEM courses is still in the early stages it is difficult to use broad statistics to assess the impact. However, the recent growth in STEM enrollment is encouraging and may in some ways reflect the activities of the grant. Two surveys have been developed that will be administered in various courses in the Spring 2010 semester to assess the local impact of CBI on individual courses. The surveys address the impact on both students and faculty.

At UTPA, faculty response to the announcement of faculty development workshops has been very positive and led to full enrollment for each workshop offered. The faculty stipend, possibility of additional summer support, quality of the workshops, faculty interest in improving pedagogical methods, and recommendations by former participants have all been factors in the full enrollment. The first group of participants was all part of the summer CBI curriculum development team and was therefore easier to recruit for the faculty development activity. Their positive experience in the CBI workshop was of great benefit as they recommended colleagues as future participants. The response from STC faculty has also been positive, however, proximity of the institution may have played a role in lower than expected participation. A presentation to key STC administrators may help in bringing in greater numbers of participants from STC for the final group in the Spring 2010 semester.

As the CBI STEM website nears completion it is expected that faculty who participated in the faculty development activities as well as those who simply heard about CBI will browse the CBI lecture content on the website. Many of the faculty members rotate the teaching of various STEM courses and this online resource of pedagogical improvements specific to individual courses will likely be an asset to many faculty members. The structure of the website is easy to browse by instructor, course name, and lecture topic. Additionally, the current wiki-media platform allows for the growth of the site as instructors add new content and comment or add to existing content. An example of some of the content already posted on the website is shown in the figures below. As the grant nears completion a number of examples (5) of exemplary course content will be highlighted on the website.

**Activity 4: STEM Pathways Growth and Support**

The fourth activity involves developing and supporting pathways to STEM fields at STC and UTPA with an initial focus on the STC Engineering Academy. This activity seeks to strengthen the STEM pathways to prepare transfer students to universities to obtain Bachelor degrees in STEM disciplines. To this end, an Introduction to STEM course was developed and implemented with CBI modules with hands-on activities.

UTPA and STC faculty members developed and taught a new Introduction to STEM course for the Dual-Enrollment Engineering Academy (DEEA) at STC. This course was offered during Summer II, 2009, at both Pecan (McAllen) and Mid-Valley (Weslaco) campuses. This new course covers the topics in the Introduction to Engineering Syllabus currently used at STC and, besides that, it includes challenges with hands-on activities. Around 50 students in the DEEA program at STC were enrolled and participated in the new Introduction to STEM course developed in Activity 4 of this project. These students took Introduction to STEM as their first College course ever. It was expected that in this course, students increase their interest and motivation to discover new knowledge in STEM fields, and be encouraged to pursue careers in STEM fields.

Fourteen challenges and hands-on activities were developed during year 1 in the Activity 4 of this project. Several of these challenges were initially tested during the Spring 2009 semester in the Introduction to Mechanical Engineering course at UTPA. A list of the developed challenges for the Introduction to STEM course are presented below; the ones with the "*" mark were not implemented during the 2009 summer due to time limitations, but, since they have been prepared, they could be implemented in the future.

- Basic Electronics: Video Game System Problem
- Electronics: Forcing Hot Air Out of House Attics
- Home Alarm System
- Automation with PLC Programming*
- Renewable Energy Challenge
- Statics
- Dynamics
- How can UV sensitive beads be used to test sunscreens?
- How can a battery be made from coins?
- Synthesis of Polymers
- Preparation of Soap
- Cold and Hot Packs
- Reverse Engineering*
- Forward Engineering

More information about these challenges is available is going to be presented in an additional publications specifically describing the developing and implementation of a new Introduction to STEM course with CBI and hands-on activities for dual-enrollment programs.

An affect survey was administered to determine students' opinion about the new Introduction to STEM course, the challenges that were implemented, and the hands-on activities. The affect survey used for the challenges that were implemented in the basic electronics, mechatronics, and renewable energy topics is presented in Figure 4

**Affect Survey**

Please carefully read the questions and provide us with **<u>an assessment of the Electronics and Mechatronics Challenges and Activities</u>** in this course: basic Electronics, Electronics, Mechatronics, and Renewable Energy.
Use the following scale and circle a number for each corresponding question:

1. Strongly disagree
2. Disagree
3. Neither agree or disagree
4. Agree
5. Strongly Agree

I was able to recall previous knowledge and apply it to my challenge
1 2 3 4 5

I enjoyed the Challenge Based Instruction and the overall experience of the legacy cycle
1 2 3 4 5

Working together with classmates helped my overall learning experience
1 2 3 4 5

These challenges did nothing to enhance my learning experience
1 2 3 4 5

These challenges helped me apply my critical thinking skills in order to solve the problems.
1 2 3 4 5

Figure 4. Affect survey for the Introduction to STEM course in Activity 4.

Figure 5 presents the results obtained with this affect survey applied to the two DEEA groups, one group in each of two STC campuses. The group in the Weslaco campus had 29 students and the group in the Pecan campus had 24 students, for a total of 53 students, but 49 students participated in the survey. The results show that about 90% of the students “agree” or “strongly agree” that CBI with hands-on activities was an enjoyable learning experience in the Introduction to STEM course.

Notice that the answer to question 4 might contradict answers to other questions in the affect survey; therefore, a survey with contradictory answers can be eliminated because it indicates the responder did not read the questions. Except for question #1 of the affect survey, the majority of the 49 students indicated to “agree” or “strongly agree” in a positive way towards the experience they had in the challenges implemented in the area of electronics, mechatronics, and renewable energy in the Introduction to STEM course. Similar statistics will be determined and published in the future for the challenges in the chemistry and engineering mechanics areas in the Introduction to STEM course. Disagree or neutral as an answer for question #1 is a reasonable response because it is expected that some students do not recall previous information related to the challenges.

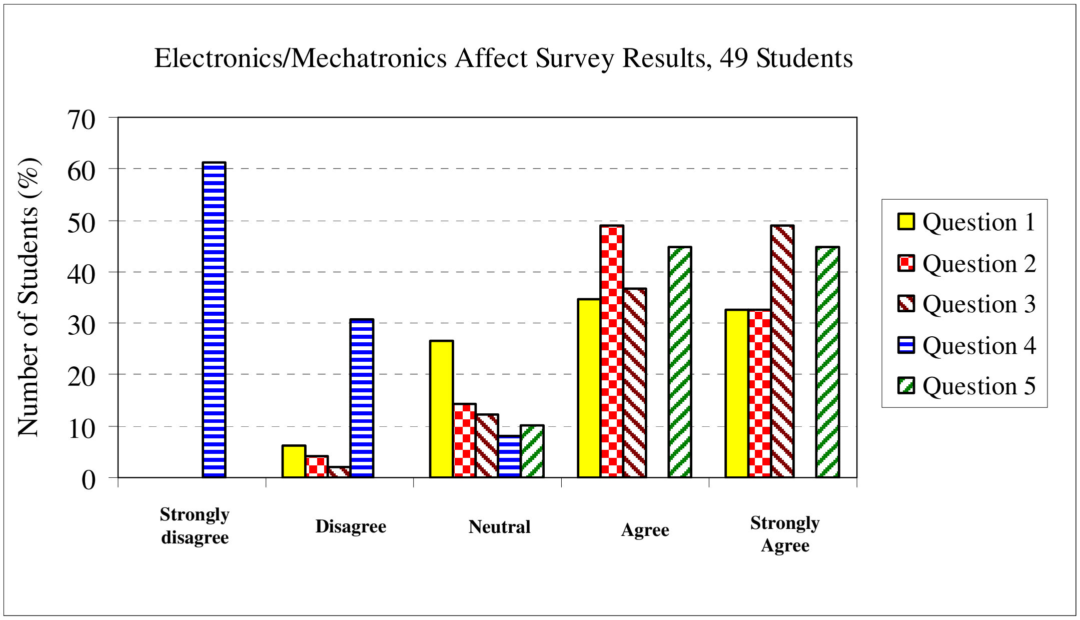


Figure 5. Affect survey results for the new Introduction to STEM course at DEEA

## Conclusions

This paper describes the year one activities and the results of the integrated STEM pathways support initiative for the Rio South Texas Region:

- Activity 1: Enhanced Student Services – STEM Orientation and Mentoring Program and STEM Calculus I Student Assistant Support Program;
- Activity 2: Curriculum Reform– Curriculum development based on Challenge-Based Instruction (CBI);
- Activity 3: Faculty Development – Faculty development seminars and workshops on CBI; and
- Activity 4: STEM Pathways Growth and Support – Dual enrollment programs at STC.

Overall, it is clear that the CCRAA key personnel and faculty are doing an outstanding job of executing the essential, yet numerous features of the project. In effect all parts of the project display impressive effort and ingenuity. Clearly, each intervention has elicited enthusiasm from faculty and students, and overall, the CCRAA project can be deemed a success given that the first year of grant activities indicate strong progress toward achieving the goals of the project.

Formative evaluation measures currently indicate that in Activity 1, the SA interventions 0 for Calculus I have been very positive, both fostering success in Calculus I as well as enthusiasm for the project. Additional data are being collected and assessed to determine the impact of these interventions on the enrollment and retention of STEM majors. In Activity 2, full implementation of the CBI modules occurred in 5 CBI course sections at UTPA and/or STC and partial implementation occurred in 3 course sections. Conclusive data on the effectiveness of the integrated and systematic implementation of CBI throughout the curriculum will be presented in future publications. In Activity 3, about sixty STEM faculty members have completed the CBI workshops to date. Reports from faculty on the student response to CBI have been very positive and favorably consistent with the results of previous studies on CBI student impact. In Activity 4, the results included the successful development and implementation of a new "Introduction to STEM" course for the Dual-Enrollment Engineering Academy (DEEA) at STC. Student effect surveys used to measure students' perceptions about this course clearly indicate that students find the challenges implemented in this course have elicited positive growth and attitudes toward science and engineering. Feedback regarding evaluation reports for the different activities has been facilitated by the biweekly team meeting where progress (or setbacks) is discussed and procedures planned and implemented.

This project is building a model that will have a significant impact on the number of STEM graduates and that will be simple to replicate in other geographical areas. This project intends to increase the number of students successfully engaged in STEM fields which is a national priority.

## Acknowledgements

The authors would like to thank the anonymous reviewers for their valuable suggestions, which helped improve the exposition of the paper. In addition, the authors would like to acknowledge funding from the Department of Education for the activities in this paper.

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