AC 2011-1812: SECOND YEAR OF THE DEVELOPMENT AND IMPLEMENTATION OF AN INTRODUCTION TO STEM COURSE FOR DUAL-ENROLLMENT PROGRAMS

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Second Year of the Development and Implementation of an Introduction to STEM Course for Dual-Enrollment Programs

Abstract

An Introduction to Science, Technology, Engineering, and Mathematics (STEM) course was improved and taught for the second time during the summer in 2010 to dual-enrollment college students at South Texas College (STC). Minority students solve challenges and perform hands-on activities as experiences to correlate their studies with real-world contexts. *Introduction to STEM* was developed as a collaboration project between STEM Faculty members at the University of Texas-Pan American (UTPA) and STC. This collaboration intended to create, support, and strengthen STEM pathways for minority students at the two year college, including students in the Dual-Enrollment Engineering Academy (DEEA) and other dual-enrollment or similar programs. The new course was offered to four groups of about 15 students each in the DEEA program, at two different STC campuses. Challenge-based instruction (CBI) was implemented; challenges, lectures, handouts, hands-on activities, and assessment tools were developed in topics such as electronics, renewable energy, mechatronics, statics, dynamics, chemistry, reverse engineering, and forward engineering. This paper describes the improvements and the modifications made to the course in order to improve student engagement and motivation during the second year Introduction to STEM was offered. Affect survey results are presented and compared to the results of the previous year of this project. Based on the positive results that were obtained in this project, it is argued that CBI is an effective and well received pedagogy for high-school student and that the CBI materials and tools developed for this course could be modified and adapted in other engineering and science courses at UTPA, STC, and other institutions to attract students to STEM fields.

1. Background

Research indicates that the lack of relevance to relate educational activities to the real world is one of the important factors that influences the decision of minority students to drop-out or transfer out of STEM undergraduate fields[1]. For minority students, the need to relate their studies to real world is exacerbated because these students lack an equitable number of successful experiences and role models within their families and friends, which in most cases imply lack of a supportive environment to encourage them to pursue STEM careers. Thus, when minority students select a STEM field of study, they experience a strong need to confirm the relevance and compatibility of their studies and the real world connections to their classroom learning experiences. Unfortunately, these connections are usually not present in the traditional classroom[1].

During the past two years, a new Introduction to STEM course was developed by STEM faculty at The University of Texas-Pan American (UTPA) and at South Texas College (STC). This course was implemented for the second time during the summer in 2010 as one of the first ever college courses that qualified junior and senior high school dual-enrollment students take at STC. This new course covers most of the material required in the *Introduction to Engineering* course at STC; besides that, challenges with hands-on activities have been added in order to engage, motivate, and encourage students to pursue STEM career. Some of the topics studied in this course are engineering professions, data presentation and graphing, ethics, engineering economics, units and conversions, and renewable energy. To limit the class time required by the new course, most of these topics were included as part of challenges and hands-on activities. For example, data presentation and graphing was a topic covered during the renewable energy challenge that included an outdoor hands-on activity and a computer lab session. In the renewable energy challenge, students collected data using voltage and current meters, and a solar panel charging a 12V battery; then, they went to the computer lab to generate tables and graphs and determine the electrical power and energy into the battery.

This project was possible due to a College Cost Reduction Access Act (CCRAA) grant to two Hispanic Serving Institutions (HSIs) by the Department of Education. It is important to mention that UTPA serves approximately 18,800 students of which about 88% are Hispanics[2] and STC is a community college with about 28,000 students, of which about 95% are Hispanics[3]. Both institutions have about 60% female students and about 60% first generation students[2-3]. The Dual-Enrollment Engineering Academy (DEEA) was started at STC in 2006 for qualified junior and senior high school students to take college courses in place of, or in addition to, their normal high school course load[4]. They can complete the DEEA program with an associate degree in Engineering by the end of their senior year of high school. The Introduction to STEM course was implemented in the DEEA program at STC during the past two years, 53 students participated during the Summer II term in 2009 and 47 students during the Summer II term in 2010, for a total of 100 students.

It is one of the main goals of this new course to get students engaged in STEM fields through CBI, working in teams, and performing hand-on activities as early as possible in College. It is important that students integrate multidisciplinary knowledge and experience real-world situations, not only to become engaged and motivated in the learning process but also to acquire a holistic perception of the STEM education process as early as possible in their careers[5-14].

2. Education with Challenge-Based Instruction

Challenge-based instruction contextualizes the knowledge and provides an environment that is knowledge, assessment, learner, and community centered[15-20] to engage students in the learning process. CBI uses both formative and summative assessments during the learning/teaching process to continuously provide feedback to the students and instructors and to promote students to acquire adaptive expertise and to demonstrate what they know in multiple contexts[16].

For several years, UTPA faculty members have been involved in the development and implementation of CBI activities in different engineering and science courses[8,10,21]. Their results have led to several publications and most notable to assessments that indicated that CBI improved student learning at UTPA in a biomedical engineering elective course[21]. This course was taught with CBI modules; the assessment results with students at UTPA and University of Texas-Austin (UT-Austin) indicated that individual student knowledge gains were on average greater at UTPA than the control group at UT-Austin. Even though the group of students at UTPA had average pre-test results lower than the ones at UT-Austin, the average post-test results were higher at UTPA than at UT-Austin. It was estimated that under such circumstances, with a probability of 78%, a student from UTPA would learn more than a UT-Austin student[21]. Therefore, CBI was proven to be a successful educational method with UTPA students.

Figure 1 illustrates the steps in the legacy cycle which is an approach used to implement challenges[20]. The legacy cycle provides students with a procedure in which they have several opportunities to acquire and demonstrate their knowledge. Also, repeating the legacy cycle to solve several challenges becomes an iterative process that allows students to apply and reinforce knowledge in different contexts to achieve adaptive expertise. It is important to look ahead and reflect back after solving each challenge in order to leave a legacy and to accumulate knowledge and experience. The success of CBI depends greatly on how well every step of the legacy cycle is prepared and performed by the learners and instructors as a team.

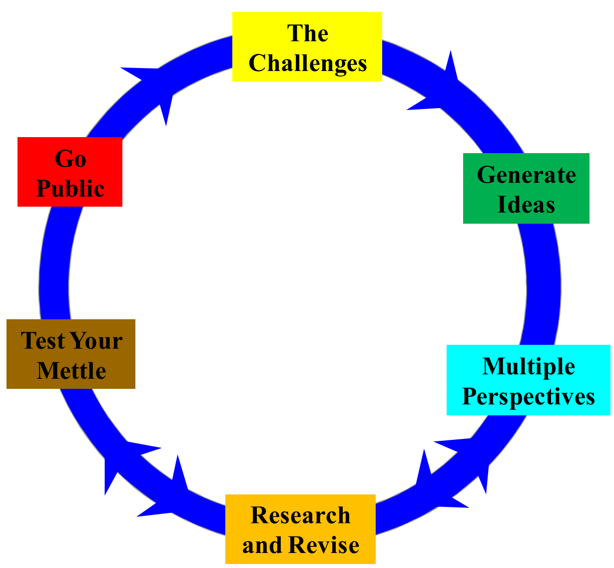

Figure 1. Legacy Cycle

The main stages of the legacy cycle used to implement CBI are[19,20]:

- **Challenge:** A challenge is created using realistic problems that contextualize knowledge.

- **Generate Ideas:** Students generate ideas about the challenge, possible solutions, and questions they might have.
- **Multiple Perspectives:** it is important to understand the challenge using several perspectives from different "experts" and resources; however, the instructor has to guide students in the desired direction.
- **Research and Revise:** students seek to solve the challenge by acquiring information from lectures, handouts, library and internet sources, and through hands-on activities, among other sources.
- **Test Your Mettle:** testing student understanding and knowledge is performed through quizzes, post-test, lab reports, exams, demonstrations, and similar ways.
- **Go Public:** a high degree of accountability and responsibility can be created by making students go public with their results and conclusions, by sharing them with others in the form of a presentation, poster, webpage, video, or other means.

3. Introduction to STEM Course

Introduction to STEM is one of the outcomes achieved in "Activity 4: Strength and Support of STEM Pathways" of a CCRAA grant from the Department of Education to UTPA and STC. The main objectives of *Introduction to STEM* are:

- Support and strengthen STEM pathways and increase collaboration efforts between two HSIs, a four-year University and a two-year College, which serve the same region in the southern part of Texas.
- Develop and implement CBI materials with hands-on activities to get junior and senior dual-enrollment high school students involved and engaged in practical STEM activities.
- Develop CBI materials considering the introductory level of the course in order to promote interest to pursue STEM careers. The materials developed for this course could be modified to include more or less content to be used in other courses at UTPA as well as at STC, and in other institutions, such as in the Introduction to Engineering, Statics, Introduction to Mechatronics, and Dynamics courses.
- Guide students to consider different STEM career options and to study the degree plans of different careers to understand their requirements and to correlate them with the professional opportunities that might be available after graduation. Students are advised and encouraged to continue STEM careers of their choice and to expect to progressively master knowledge throughout their careers.

In the Summer II term in 2009, *Introduction to STEM* was offered for the first time simultaneously to two groups of students at two different STC campuses, meeting every weekday from 1 to 5 pm, during a total of 92 hours (23 days) of class. Figure 2 presents the challenges that were developed, also indicating whether or not they were implemented during year 1 (2009) and/or year 2 (2010) of this project. The challenges were prepared by four STEM instructors, a Physics and Engineering Professor from STC, two Mechanical Engineering Professors from UTPA, and a Chemistry Professor from UTPA. After the first year of implementation, these instructors decided to modify the *Introduction to STEM*'s schedule for year 2, making it a shorter course, implementing only the challenges that were better prepared and that generated the best results during year 1. The challenges that were implemented in year 2 are also indicated in Figure 2, and the ones with the "*" mark were not implemented due to time limitations, however, they were prepared and could be used in the future in this or other courses.

- Basic Electronics and Mechatronics:
  - Video Game System Problem (years 1 and 2)
  - Forcing Hot Air Out of House Attics (years 1 and 2)
  - Home Alarm System (year 1)
  - Automation with PLC Programming*
  - Renewable Energy Challenge (years 1 and 2)
- Engineering Mechanics:
  - Statics: trusses and bridges (years 1 and 2)
  - Dynamics: linear motion and collisions (years 1 and 2)
- Chemistry
  - How can UV sensitive beads be used to test sunscreens? (years 1 and 2)
  - How can a battery be made from coins? (years 1)
  - Synthesis of Polymers (years 1 and 2)
  - Preparation of Soap (years 1)
  - Cold and Hot Packs (years 1)
  - Hydrogen powered cars (year 2)
- Engineering Design:
  - Reverse Engineering*
  - Forward Engineering (years 1)

Figure 2. Challenges developed for *Introduction to STEM*

Most of the lectures, challenges, and hands-on activities were revised and improved after year 1 and before their implementation during year 2. In year 2, the course was reduced to 48 hours (12 days) of class and it was offered twice at each of two STC campuses during the Summer II term in 2010. This way, a group of students taking the course had to attend it for only 12 consecutive weekdays at 1-5 p.m. This new format of the course allowed registering as many as 96 students in the course during the summer II term (4 groups of 24 students) instead of the initial estimate of 60 students during year 1. This change was also required after determining that most of the labs at STC have 8 or 12 workstations, groups of 30 students in hands-on activities would be too many; therefore, 24 students (12 teams of 2 members or 8 teams of 3 members) was the maximum allowed in each of the 4 groups during year 2. Due to DEEA recruiting procedures and after few accepted students did not start the DEEA program, the 4 groups were made with a number of students between 10 and 15 for a total of 47 students during year 2. As presented in Table 1, *Introduction to STEM* consisted of statics and dynamics challenges during 4 days, electronics, mechatronics, and renewable energy challenges during 4 days, and chemistry challenges during the remaining 4 days. During most of the 12 days in the course, other topics were studied in class in order to cover the requirements of the Introduction to Engineering course at STC and to grant students credits for such course.

Even though students enjoyed and participated in all activities required in the 23-day 4-hour a day course in year 1, it was determined that such format of the course was too long; therefore, it was reduced to 12 days; this change was also convenient expecting to achieve future sustainability ad adaptability of the course being taught either as *Introduction to STEM* or *Introduction to Engineering* at STC and/or UTPA, or elsewhere, in the summer or in the regular semesters.

Table 1. Topics and Challenges Covered in *Introduction to STEM*.

Class Day	Topics and Challenges
1	What is STEM? Statics Challenge.
2	Teamwork Skills. Statics Challenge.
3	Funding your Education. Dynamics Challenge.
4	Problem Solving: Methods, Formats, and Conventions. Dynamics Challenge.
5	Dimensions; Units and Conversions; Problem Solving. Basic Electronics Challenge.
6	Using Common Engineering Concepts. Electronics/Mechatronics Challenge.
7	Data Presentation and Graphing. Engineering Economics. Electricity Cost and Residential Energy Audit.
8	Engineering Design. Renewable Energy Challenge.
9	STEM Job Functions and Major Fields; Profile of the STEM Education and Profession. Work Experience, PE Registration. Introduction to Ethics. Chemistry safety rules.
10	Chemistry Challenge: Testing Sunscreens.
11	Chemistry Challenge: Synthesis of Polymers.
12	Chemistry Challenge: Hydrogen powered cars.

Every challenge was estimated to be completed in a period from 3 to 6 hours, which consisted of almost an entire 4-hour class session to, at the most, one and a half 4-hour class sessions. During the challenges, students worked in groups of two and in some cases in groups of three members.

It was determined that in an ideal situation in *Introduction to STEM*, topics such as engineering economics, using common engineering concepts, and unit conversions, among others, could be blended into the challenges and hands-on activities. For example, the electronics/mechatronics challenge during day 6 in Table 1 consisted of "Forcing hot air out of house attics", and common engineering concepts such as voltage, power, volume, temperature, and pressure are of interest in the context of this challenge at different stages. Consequently, the integration of the design of a challenge in contexts that involved and require learning the targeted concepts and the implementation procedure is an essential factor for CBI to be a successful instruction method.

A detailed explanation of how a particular day of class was organized in *Introduction to STEM* is presented next related to day 6, in which the topic "common engineering concepts" was studied and the electronics/mechatronics challenge was implemented with the corresponding hands-on activity. The 4-hour class session in day 6, shown in Figure 2, was organized as follows:

- Class started with a 10-minute pre-test to determine students' knowledge and questions about the concepts targeted by the challenge.
- It continued with a 10-minute generating ideas session in which students brainstormed and wrote down ideas and questions about the challenge, and they turned them in to the instructor.
- After that, during approximately 40 minutes, the instructor presented a lecture and examples to explain common engineering concepts, the challenge targeted concepts, and guidelines before performing the hands-on activity.
- During approximately 2.5 hours, the hands-on activity was performed to connect a K-type thermocouple, a thermocouple amplifier, an instrumentation amplifier, and a comparator to create an on/off controller for a 12V fan. Students performed measurements, asked questions, troubleshoot their circuit, and reached conclusions.
- Finally, a wrapping up session for report completion, conclusions, and post-test took about 30 minutes.

Sometimes students get exceptionally engaged in the hands-on activity in such a way that they do extra work or want to continue doing additional work. For instance, in the challenge in day 6, described above, some students were also measuring the temperature of cold and warm water using the thermocouple; others asked the instructor or the assistant about the cost of a breadboard and all the components as if they want to purchase the equipment to continue the hands-on activity on their own. This type of results demonstrates engagement and desire of the students to continue learning. It is a rewarding result for the instructor to get students engaged and motivated in the teaching/learning process.

Similar procedures were followed during most of the 12 days in *Introduction to STEM*. In a few occasions, the hands-on activities were performed outdoor such as when sunlight was required to complete them. Since weather conditions have to be considered when performing the renewable energy and the hydrogen powered car challenges, alternative activities have to be prepared in case they need to be cancelled. Two mechatronics challenges in which students program and connect microcontrollers have been prepared and could be implemented in such situations. Because, of the geographic location and being performed in the summer, conditions were good most of time during the implementation of these outdoor activities in both year 1 and year 2 of this project, except during a cloudy day when not much solar energy could be collected during the renewable energy challenge.

In summary, several challenges with hands-on activities were developed and integrated with topics usually taught in *Introduction to Engineering* to create a new Introduction to STEM course. Hands-on activities allow Engineers and Scientists to acquire and strengthen knowledge and skills in multidisciplinary areas which are needed to develop abilities to apply concepts and principles to a wide range of problems and situations[12]. The modern STEM job market has a high and increasing demand for skillful graduates with multidisciplinary experience[12,13].

4. Developing Challenges with Hands-on Activities

Challenges must be educationally effective and students are expected to develop adaptive expertise to apply their knowledge in multiple contexts. The backwards design approach was used to develop the challenges for *Introduction to STEM*. This approach consists of determining and prioritizing the concepts to be targeted by the challenge, identifying engaging real-world problems that conveniently could teach those concepts, and also considering the difficulties students might have learning and understanding those concepts. Besides that, the objectives and sub-objectives of the challenge have to be established.

Next is the procedure that was followed and that is recommended to develop CBI:

- Identify the concepts that students are expected to learn, get familiar with, and understand by the end of the challenge. Also include the skills and practical experience that students are expected to obtain during the hands-on activity.
- Categorize and prioritize the challenge targeted concepts using Table 2.

Table 2. Concept Map and Content Priorities in the Challenge (Check the corresponding cell)

Concept Map	**Content Priorities**		
	Enduring Understanding	Important to Do and Know	Worth Being Familiar with
Concept 1			
Skill 1			
Concept 2			
Concept 3			
Skill 2 …			

- Identify and describe the objectives and sub-objectives of the challenge:
  - Primary Objectives**.** By the end of this challenge, students are going to be able to:
    - Understand and explain concepts about ...
    - Understand ....
    - Use measurement equipment to ....
  - Sub-Objectives. The objectives require that students be able to:
    - Implement ...
    - Determine …
- Identify and describe the difficulties and real-world contexts associated with the challenge.
  - Difficulties. Students have difficulty with:
    - Using the correct …
    - Calculating …
    - Identifying …
    - Measuring …
  - Real-World Contexts
    - Importance and applications of the challenge targeted concepts are …
    - Residential, commercial, or industrial applications …

        - Technology trends …
- Prepare formative and summative assessment tools to collect information to allow grading the students and to provide feedback about student learning and understanding of the targeted concepts.
    - Pretest
    - Classroom activities
        - Generating ideas
        - Team or individual class work, examples, quizzes
    - Lab activities
        - Measurements
        - Observations
        - Computations
    - Homework
    - Measurements and computation requirements during the hands-on activity
    - Post-test
    - Challenge report with results, conclusions, and solution to the challenge
    - Presentation or discussion
    - Affect survey

In order to implement and solve the challenges, students followed the steps in the legacy cycle[20] which is a framework with an appropriate structure for implementation of CBI. CBI is a teaching and learning methodology based on student, knowledge, assessment, and community centered instruction[8,15].

Pre-test, post-test, and other assessment tools need to be implemented to determine student knowledge and understanding of the challenge concepts before and after the challenge. Affect surveys are convenient tools to determine student attitudes and opinions about the challenges, hands-on activities, and CBI.

5. Challenges in *Introduction to STEM*

This section explains the improvements and compare the results obtained in year 2 to the ones obtained in year 1. As it was presented in Figure 2, 15 challenges were developed for *Introduction to STEM*, 12 challenges were implemented in year 1 (2009) and 8 of the challenges were implemented in year 2 (2010). During year 2 of this project, the 8 challenges that were implemented consisted of two challenges in engineering mechanics, three in electronics, mechatronics, and renewable energy, and three in chemistry. Being *Introduction to STEM* the first course the DEEA students ever took in College, it was focused to provide them with fundamental knowledge in the topics mentioned above with the intention of increasing their motivation to pursue STEM careers.

The engineering mechanics challenges consisted of a challenge about statics and another about dynamics. Both challenges included hands-on activities in which students studied the performance of corresponding systems using sensors and data acquisition systems. The hands-on activity that was developed for the statics challenge consisted of constructing prototype bridges with different configurations and applying loads to determine the forces acting on the different links. Students determined which links were in tensions and the ones that were in compression. They used load cells and data acquisition systems to collect data and visualize the performance of the bridge under different loading conditions.

The statement of the dynamics challenge is presented in Figure 3. It consists of solving a problem with a real-world context in which students learn about collisions and the parameters that are important in the dynamics of a collision. A hands-on activity is also part of the dynamics challenge and it consists of using “frictionless” tracks and prototype cars to experiment with collisions in the lab. The same data acquisition system used in the statics challenge was used with other sensors to determine the velocity, position, time, and forces involved before, during, and after the prototype car collisions.

Dynamics Challenge

You will be shown a video of a frontal impact of a 2010 model car. Using data collected from the video and other sources, report the likely biological impact such a collision would have on the human body.

Figure 3. Statement for the dynamics challenge.

One challenge about basic electronics, one about electronics/mechatronics, and one about renewable energy were also implemented in *Introduction to STEM*, all of them with corresponding hands-on activities. The basic electronics challenge was developed to teach about electronics lab equipment and components such as breadboards, power supplies, light emitting diodes (LEDs), and resistors. The electronics/mechatronics challenge required students to create an on/off analog controller to activate a fan depending on the temperature detected with a thermocouple. The renewable energy challenge consisted of two parts: a residential energy audit to estimate the electricity consumption and cost for a residence similar to the student’s house, and a solar energy system design to harvest and store energy using a solar panel and a battery for later powering direct current (DC) loads. In this renewable energy challenge, 10 Watt solar panels and 12V, 7.5A·h, lead acid batteries were used to collect and store the energy.

The statement of the renewable energy challenge is presented in Figure 4.

Renewable Energy Challenge

Your city has hired you in a new position as an engineer responsible for sustainability and development of renewable energy systems.
You must:

- Raise awareness of energy consumption issues and renewable energy opportunities.
- Determine the average energy consumption of a household.
- Determine if solar energy is appropriate and cost effective to generate electricity for household consumption.
- Consider cost, environmental impact, and energy generation and consumption.

Figure 4. Statement of the energy challenge.

The challenges were designed to engage students by assigning them responsibilities and tasks related to real-world situations that include some expectations and consequences of their achievements while solving the challenge.

Besides that, three challenges in chemistry were developed and implemented in year 2 to introduce students to additional science topics, such as general chemistry, fuel cell reactions, and polymers. Students learned basic science and their correlation with real-world applications, i.e. the interaction of light with matter and how this knowledge can be applied to designing and/or selecting sunblock lotions. Another example consisted of studying the synthesis of polymers and their applications such as making rubbers or fibers. The other chemistry challenge consisted of using solar energy to power a fuel cell working as an electrolizer to generate hydrogen and oxygen to, later, reverse the role of the fuel cell to produce electricity and power a motor to get a small car in motion.

Affect Survey Results

An affect survey was prepared to determine the opinion and attitude of the students towards the challenges with hands-on activities in *Introduction to STEM.* This survey was applied by the three instructors after completing the engineering mechanics, electronics, mechatronics, and renewable energy, and chemistry sections of the course. The affect survey is presented in Figure 5. Note that the fourth question has an expected response that is inverted in comparison with the other questions for the purpose of identifying surveys that were carelessly completed.

Affect Survey

Please carefully read the questions and provide us with **an assessment of the Electronics and Mechatronics Challenges and Activities** 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 5. Affect survey for basic electronics and Mechatronics challenges.

During year 1 (2009), 49 students completed the survey, specifically about the electronics, mechatronics, and renewable energy challenges, and the results are presented in Figure 6. In a similar way, during year 2 (2010), 47 students completed the same survey, and the results are presented in Figure 7. Note that any survey could be eliminated or invalidated in case that the response to question 4 contradicts other responses, which could happen when a student responds the survey without reading the questions. But, this only happened once during year 1 and another time during year 2.

In question 1 of the affect survey, “disagree” or “neutral” as an answer is a reasonable response because it is expected that some students do not recall any previous information related to the challenges. In year 1, about 33% of the students, and in year 2, about 20% of the students indicated to “disagree” or being “neutral” about recalling previous information and applying it to solve the challenge.

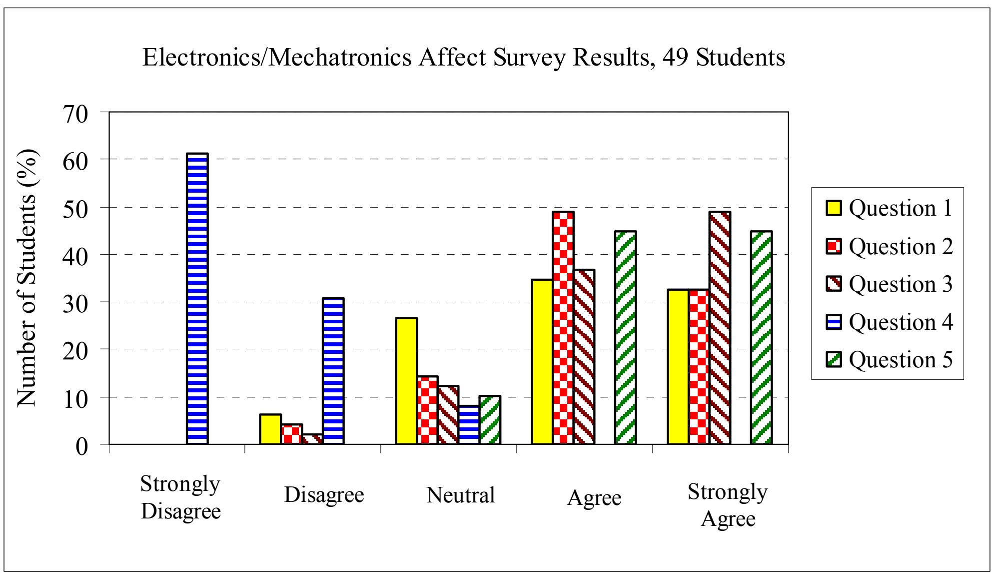

Figure 6. Affect survey results for the electronics, mechatronics, and renewable energy challenges in year 1.

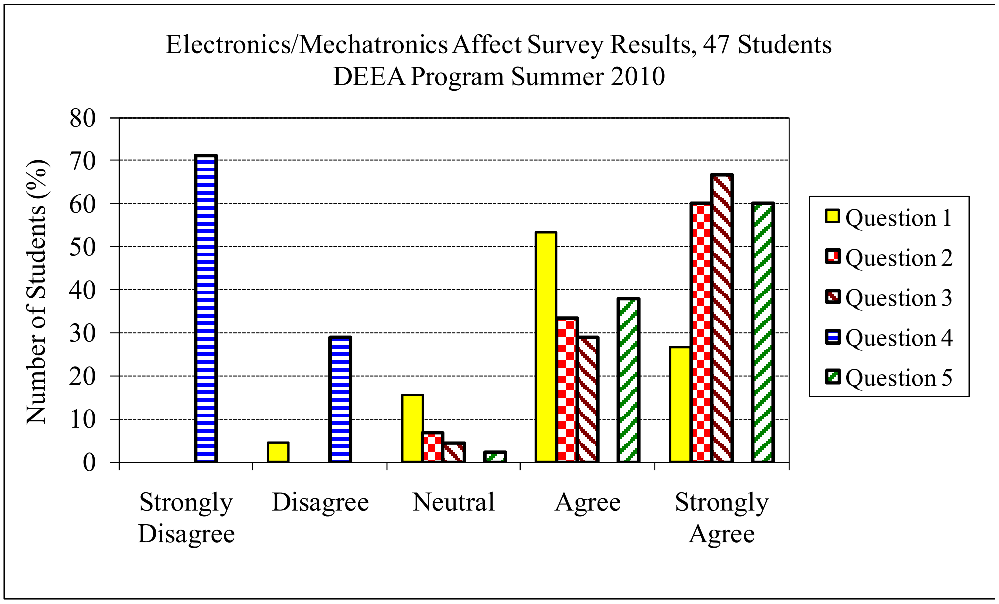

Figure 7. Affect survey results for the electronics, mechatronics, and renewable energy challenges in year 2.

In question 2, 82% of the students during year 1, and 93% during year 2 indicated that they “strongly agree” or “agree” to enjoy CBI and the experience with the legacy cycle; that is an improvement of 11%. In question 3, 86% of the students during year 1, and 96% during year 2 indicated that they “strongly agree” or “agree” that working in teams helped their overall learning experience, which is an improvement of 10%. In question 3, 86% of the students during year 1, and 96% during year 2 indicated that they “strongly agree” or “agree” that working in teams helped their overall learning experience, which is an improvement of 10%. In question 4, 92% of the students during year 1, and 100% during year 2 indicated that they “strongly disagree” or “disagree” about the challenges not enhancing their learning experience, which is an improvement of 8%. Finally, in question 5, 90% of the students during year 1, and 98% during year 2 indicated that they “strongly agree” or “agree” that the challenges helped them apply critical thinking skills to solve the problems, which is an improvement of 8%.

In general, the results of the affect survey were more positive in year 2 than in year 1 of this project. It is believed that the reasons for the improvements are due to the changes made in the course, mainly the revisions and enhancements made to the challenges, the reduction of the number of days required for the course, and the reduction in the number of students per group. Another reason for such improvement was the fact that the instructors have more experience developing and implementing challenges with hands-on activities, therefore, they might provided more and better formative assessment activities and more attention to each student since the groups were small from 10 to 15 students.

6. Conclusion

A new Introduction to STEM course was developed during the past two years and it was implemented using CBI with hands-on activities during summer terms in 2009 and 2010 at STC. Even though fifteen challenges were developed, twelve of them were implemented in year 1 and eight were implemented in year 2. The other challenges have been implemented in other courses at UTPA. *Introduction to STEM* was taught for the second time in the summer II term in 2010 twice at each of two STC campuses; it took twelve 4-hour sessions to complete the course, which is equivalent to a 3-hour per week lab course in a regular semester. A description and explanation of CBI and the legacy cycle were presented in this paper. The contents and organization of *Introduction to STEM* were also presented and the procedure that was followed to develop and implement challenges was explained. Examples of challenges were described and the results obtained from an affect survey in both year 1 and year 2 of this project were presented and analyzed. Analysis of the affect survey results indicated a high level of student achievement and satisfaction in *Introduction to STEM.* The results indicated that students enjoyed the challenges and the team work in hands-on activities. Students that took *Introduction to STEM* acquired basic understanding and skills in multidisciplinary STEM areas; therefore, comprehension of related new material in the future might become more meaningful, interesting, and practical because of the experience acquired in this early career course. The novelty of the initiative presented in this paper has been developing and implementing CBI with hands-on activities for the second time in a new Introduction to STEM course which is expected to be sustainable and adaptable. This research addresses the need of curriculum development that helps minority students to see the relevance of their studies to the real world since this is one of the important factors that influences minority students' decision to drop-out or transfer out of STEM undergraduate careers.

7. Acknowledgments

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