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Emphasizing Core Calculus Concepts Using Biomedical Applications to Engage, Mentor and Retain STEM Students

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Synopsis:

This project provides a series of for-credit, applied learning modules that are given in parallel to the freshman and sophomore calculus courses. The modules are developed and led by faculty members. The proposed modules emphasizes mathematics and statistics relevant to four biomedical research areas 1) orthopaedics,2) infectious diseases, 3) heat propagation in the human body, 4) mammography and radiology. Students participate in field trips to visit facilities and labs related to their module.

Emphasizing Core Calculus Concepts Using Biomedical Applications to Engage, Mentor and Retain STEM Students

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Abstract

With an increasing demand for biomedical and bioengineering professionals in the coming decades, educators are required to train a greater number of STEM students who are able to apply mathematical concepts to critical health care decisions. In this work, we have developed a series of for-credit, applied learning modules that are being given in parallel to the freshman and sophomore calculus curriculum. These modules use creative inquiry and applied learning experiences to connect mathematical concepts with bioengineering and medical applications. We hypothesize that exposure and participation in the applied learning experiences outside of standard mathematics classes, will improve the students' performance and perceived appreciation for their math curriculum.
The four module series have been offered over a 3 year period to more than 200 students, and emphasize mathematics and statistics relevant to four biomedical research areas 1) orthopaedics, 2) infectious diseases, 3) heat propagation (arc flash) in the human body, and 4) mammography and radiology. In class activities are complimented with biomedical and power plant facility field trips, greater access to professors and tutors outside of class, and audio-video tutorials. In this paper, the organization and activities of the four modules are presented. Assessment of project outcomes consists of a formative and summative evaluation. When complete, pre and post surveys, follow-up surveys, and exit interviews have been used to assess the student's satisfaction with the modules, usefulness of the field-trips, and to gage student understanding of uses of mathematics in STEM fields.

The project value to STEM goals are found in, 1) convincing students through applied learning experiences that mathematics is an important component of any research plan and indispensable to their career success, and (2) ensuring that these students do not falter in calculus and abandon their STEM goals. Furthermore, we are developing two educational apps (i) EPI-CALC app based on infectious disease module and (ii) another app based on mammography and radiology to reach broader audience including K-12 students and teachers. This paper presents our

developed methods and initial findings with the hopes of inspiring other institutions to adopt similar applied learning experiences for their STEM students.

1. Introduction

Research in science and engineering is increasingly reliant on mathematical and statistical tools. The NSF has argued that to build a competitive international workforce in STEM fields, colleges and universities must inspire a greater number of students to learn a greater amount of mathematics and statistics [1]. The growing field of biomedical science and bioengineering challenges students to make critical decisions about people's lives and diseases, and demands a deep understanding of the quantitative complexity both of the biological system and of the decision-making process. Biomedical science and bioengineering as well as other medical majors are among the most popular fields for college graduates today. For students to succeed in such fields, mathematicians must do a better job of explaining to students how mathematical concepts and quantitative analysis can be applied in biomedicine and why it is important to succeed in the undergraduate mathematics curriculum. The challenge is to catch the attention of STEM students by offering early applied learning experiences that engage them with the application of mathematics and statistics in professional practice and applied learning applications.

At a freshman or sophomore level, it can be a challenge to connect mathematical concepts with bioengineering and medical applications, and to challenge the students' view of what mathematics can offer them. Many incoming freshmen declare a STEM major, but know little about their declared field or about how Calculus can be applied to a particular STEM field. Students can be insufficiently motivated to work consistently in their Calculus courses in pursuit of undefined educational or life-long goals. Consequently, they can under achieve in these fundamental STEM courses and possibly leave their STEM field. Too often, this STEM-attrition scenario disproportionally involves women, underserved minorities, first-generation college students, and community-college transfer students [2]. The authors believe that one benefit of using medical applications in applied learning environments is their appeal to a broad range of students, as most everyone has personal experiences with health issues.

Past research has focused on the importance of success in the first college math course and its correlation with success in engineering, and other STEM fields [3]. Calculus is particularly noted to be a stumbling block [4]. Since 2006, the efforts by the authors' home institution have been heavily invested in classroom redesign of freshman Calculus courses. All sections of Calculus I adopted a variation of the SCALE-UP active-learning instructional model which includes short lectures, student collaboration at round tables, and graded group activities [5]. These changes are consistent with research emerging from the Calculus Reform Movement showing that the longer you lecture the less students retain, as well as with recommendations to include small-group or collaborative classroom learning activities [6]. Initial results with this revised curriculum have been very promising, with 2008 results showing a nearly 50% reduction in the DFW (students receiving a D, F, or withdrawing from the course) rate compared with Fall 2005 measures. Despite these efforts however, approximately 20% of students continue to earn a DFW, and either had to repeat the course or abandon their STEM career goals. Clearly, more innovative concepts in instruction should be considered to decrease this rate of student loss.

Recent work in the authors' home department of Mathematical Sciences has included the introduction of Tablet PCs into several sections of Freshman Math courses in 2006. Student perceptions, behaviors, and performance were shown to improve [7]. With this the department created a dedicated technology classroom that included workstations with high-powered software, multiple projection capability, Smart screens, as well as Tablet PCs.

Another challenge to innovative and supplemental instruction is developing a learning opportunity that can fit it into a student's schedule and course-credit structure, and to insure that all participants (faculty and students both) receive merit-based credit for participation. At the authors' home institution, "Creative Inquiry" is a program course structure, which strives to engage students in the process of learning and discovering through faculty-mentored research and outreach activities across multi-disciplinary departments. Students that participate in these Creative Inquiry classes have been shown to learn and to think in new ways, learn non-class skills designed toward their interests, enhance their academic performance in other classes, improve their satisfaction with their learning environment, and improve their relationships with faculty. In addition, instructors that teach Creative Inquiry classes develop mentoring relationships with students, have the opportunity to develop courses toward a specific area of interest that spans several departments, and rejuvenate and improve their teaching in other courses. At the authors' home institution, the university provides monetary support for courses taught under the Creative Inquiry framework, and since its conception in 2005 the university has offered a total of 275 Creative Inquiry courses 12 of which are from the Mathematical Sciences department.

In this paper, the authors describe the 3 year NSF funded collaborative project between faculty from the Mathematical Sciences and Bioengineering departments that combines inspiration in Biomedicine with retention in Calculus, directed at freshman and sophomore students. This paper describes the activities from Module 1: Orthopaedics and Pre-Calculus, Module 2: Infectious Disease, Module 3: Health Hazards from Arc-flash, and Module 4: Mammography and Radiology.

2. Module Organization and Activities

2.1 Program Structure

Students participated in one-hour modules where they discuss biomedical applications to their current math courses, interact with faculty and student mentors, participate in field trips, and have access to a textbook repository. The goal of this program is to have all participants engaged in the interplay of mathematical and biomedical concepts in the context of interesting applications that may help them formulate career goals while deepening their understanding. This program was designed to emphasize mathematics and statistics relevant in four biomedical areas that are directly linked to the students progression through their core calculus courses:

Module 1	Orthopaedics
Module 2	Disease Epidemiology
Module 3	Mammography and Radiology
Module 4	Health Hazards from Arc-flash

Students have the opportunity to enroll in one module per semester for up to four semesters. They enter modules coordinated with their current or previous math courses (whether pre-calculus, first semester calculus (calculus of one variable), second semester calculus (calculus of one variable II), or third semester calculus (calculus of several variables)). By presenting interesting biomedical problems as early undergraduate applied learning experiences, instructors are required to decompose a difficult mathematical problem into its simpler parts that students can manipulate. These modules are broken down into 10-12 weekly lessons of one to two hours each. The modules usually begin two to three weeks into the semester, to give students an opportunity to learn the basics in their math courses before beginning these applied-learning experiences. Students are introduced to the exciting field of study and given an interesting problem to solve, with the mathematical component structured to their level of understanding. Students work through a problem, identify what they don't fully understand and seek remedies. They are then given the opportunity to interact with their peers in group activities and their instructors, and participate in on and off campus fieldtrips. This level of communication, where students work on a problem of interest, invest in learning, and even discuss future learning for their problem of interest is impossible to achieve in large content heavy math classrooms that have little time to spare.

In addition to these group activities, students have the opportunity to visit local professional facilities that provide the services studied in the module. These field trips are undertaken as the students have the opportunity to explore the mathematical concepts that are relevant to the applied learning experience of interest, and are used to reinforce the practical applications and empowering nature of the mathematical skills that they are acquiring in class and applying in their learning modules.

All participants receive mentoring from their active learning experience instructor and a designated advanced undergraduate mentor that works to enhance their success in their mathematics courses. All participants are matched with faculty or undergraduate-student mentors who will communicate with them both in-person and through web-based technology at various times throughout each week.

Copies of textbooks from the core calculus courses are also available for student loan. Participation in the modules allows students the use these textbooks for the semester the module is taken. The library consists of texts from pre-calculus, single-variable calculus, multi-variable calculus, and topic specific biomedical and statistics texts that enhance their individual learning module experience.

2.2 Module 1 Curriculum

2.2.1 Orthopaedics: Fundamentals of Pre-Calculus in Orthopaedic Medicine

This beginning module was intended to reinforce pre-calculus curriculum based on the home institutions state pre-calculus standards. It was offered as a one credit course that was spread out over one semester and it was intended to engage the student in basic bioengineering problems requiring algebra and trigonometry, and introduce areas of study and applied mathematics that required the use of pre-calculus to effectively solve real-world problems. It reinforced scalar, algebraic and trigonometric concepts that were relevant to orthopaedics and total joint replacement. Students participating in this module were expected to have already taken or current be taking course content equivalent to the following university level courses: MTHSC 103 Elementary Functions, MTHSC 104 College Algebra, MTHSC 105 Precalculus.

2.3 Module 1 Course Schedule

Week 1: Orientation and Introduction to Module
(1 hour with introduction, orientation and syllabus)
Week 3: Tour of Clemson Bioengineering Department and Biomechanics Lab
(pre-survey and department tour, 1 hour)
Week 4: Activity 1: Orthopaedics, Angles and Basic Trigonometry
(15 minute lecture with 45 minute applied learning activity)
Week 5: Tour of Local Orthopaedics and Sports Medicine Practice
(2 hours)
Week 6: Activity 2: Anthropometry, Measurement, Percentiles and Averages
(15 min lecture with 45 minute applied learning activity)
Week 7: Student K-12 Outreach Project Development
(1 hour)
Week 8: Student K-12 Outreach Project Development
(1 hour)
Week 9: Activity 3: Orthopaedics, Angles and Polynomials
(15 minute lecture with 45 minute applied learning activity)
Week 10: Tour of Total Joint Replacement Testing Facility
(1 hour)
Week 11: Student K-12 Outreach Project Development
(1 hour)
Week 12: Total Joint Replacement Motion and Kinematics
(15 minute lecture with 45 minute applied learning activity)
Week 15: Student K-12 Outreach Presentations

(1 presentation and review)
Week 16: Module Review and Assessment
(1hour summary and assessment)

2.4 Module 1 Activity Example and Details

2.4.1 Week 4 (1 Hour Applied Learning Module: Orthopaedics, Angles and Basic Trigonometry)

In this module, students were given an opportunity to participate in a "life or death" project that challenged them to formulate a treatment regimen for an orthopaedic condition. This condition, known as a lower limb deformity, required the student to apply simple concepts in angle measurement and trigonometry to correct a bony anatomical deformity in a patient. This module began with in-class review of basic geometry and trigonometry and an introduction to the pathologic conditions of lower limb deformity. Students were then given a "patient's" X-rays that showed a common deformity of the lower limb. They were then asked to calculate a tibial re-alignment treatment to correct the deformity. Using these x-rays, the students used simple measures of bone length, width, and angular deformity, apply basic trigonometry to "cure" the patient. The accuracy of the surgical correction was then visualized on a surgical training bones, and a computer model of this bony system. The students were encouraged to explore a range of treatment options using these interactive models. Discussions of actual before-after surgical treatments for this condition using x-rays were presented. These concepts contained some of the challenges for pre-calc students and therefore the reiteration and application of these topics was intended to help strengthen their understanding.

2.4.2 Week 4 Outcomes
Hands-on use of rulers and protractors. Applied knowledge of scalar quantities, radians and degrees, relative and absolute angles, applied use of sines, cosines, tangent functions. Participation in Team Activity. Discussions of experimental variables. Mathematics applied: basic trigonometric functions.

2.3. Module 2 Curriculum

2.3.1 Epidemiology: Math Applications in the Spread of Diseases

This module was intended to reinforce the calculus I curriculum. It was offered as a one credit course that was spread out over one semester and it was intended to engage the student in basic epidemiology problems requiring differentiation, probability, and modeling a disease. The course highlighted algebraic, probability, and differentiation as these concepts applied to the modeling of disease spread. Students participating in this module were expected to have already taken or current be taking course content equivalent to the following university level courses: MTHSC 106 Calculus of One Variable I**.**

2.3.2 Module 2 Course Schedule

Week 1: Organizational Meeting; Introduction; surveys; Basics of Epidemiology; Definitions; Brief History of Disease

Week 3: Activity 1: How Disease Spreads; Reproduction Ratio;
(1 hour - activity on basic spread of disease, introduce concepts of modeling and variables)
Week 4: Activity 2: Introductions to SRI model as applied to the Hong Kong Flu
(1 hour - interactive explanation and worksheets for students)
Week 5: Activity 3: SRI model: Continuous Variable Model (Derivatives)
(1 hour - Changing from time step equations to differential equations – interactive explanation and worksheets for students)
Week 6: Activity 4: SRI model: Continuous Variable Model Continued; Quarantine Model; Incubation Model
(1 hour - Understanding more complicated models)
Week 7: Field Trip to CDC & Emory Radiology
(5 hours)
Week 8: Introduction to Projects; Demo of Current Ipad App; Forming Groups
(1 hour)
Week 9: Work on Group Projects
(1 hour)
Week 10: Work on Group Projects
(1 hour)
Week 11: Present Group Projects
(1 hour)
Week 12: Present Group Projects; Post Surveys
(1 hour)

2.3.3 Module 2 App: Epi-Calc Using Calculus in Epidemiology

Weekly meetings between the Module 2 mathematics faculty (Reba and Breazel) and the Computer Science App Programming Team (Pargas and his students) led to the development of an interactive mobile app on Epidemiology and Calculus. This app allows students to manipulate the equations that model various diseases and to observe how the graphical representations change. Below is the outline of the app structure:

General Model
- Model Explanation (SIRT)
- Example Disease: Chickenpox
  - Symptoms, Geography, Mortality, Treatment, What's Next
- Example Disease: Hong Kong Flu
  - Symptoms, Geography, Mortality, Treatment, What's Next
- General Model: Graphs

Quarantine Model
- Model Explanation
- Example Disease: Small Pox
  - Symptoms, Geography, Mortality, Treatment, What's Next
- Quarantine Model Graphs

Incubation Model
- Model Explanation
- Example Disease: Bacterial Meningitis
- Incubation Model Graphs

2.4 Module 3 Curriculum

2.4.1 Mammography and Radiology Module

This module was intended to reinforce the calculus II curriculum. It was offered as a one credit course that was spread out over one semester and it was intended to engage the student in basic medical imaging with some knowledge of integration, solving a system of algebraic equations, and multivariable calculus. The course highlighted integration and spherical coordinates to model CT scans. Students participating in this module were expected to have already taken or current be taking course content equivalent to the following university level courses: MTHSC 108 Calculus of One Variable II.

2.4.2 Module 3 Course Schedule

Week 1: Introduction and Overview of Biomedical Imaging
- (1 hour introduction to generic medical imaging applications)

Week 2: Solving the Milk Delivery Problem and Image Accuracy
- (1 hour in class activity involving a game)

Week 3: Solving Linear Systems of Equations and Image Resolution
- (1 hour in class activity involving solving a linear system for imaging)

Week 4: Calculus of Computer Tomography: Applications to Mammography
- (1 hour introduction to CT scans and Radon transform)

Week 5: Geometry of Computer Tomography: X-Ray Image Reconstruction
- (1 hour introduction to spherical coordinates and ray transform)

Week 6: MATLAB Computer Tomography GUI
- (1 hour in class activity performing Radon transform in MATLAB)

Week 7: Risks and Benefits of Imaging Modalities. False Positive and False Negative
- (1 hour in class activity on Bayes formula)

Week 8: Review of Other Imaging Modalities: PET Scan/MRI (Math Equations)
- (1 hour in class activity on math connection between CT and PET)

Week 9: Tour of Department of Radiology, Emory, Atlanta, GA
- (5 hour trip to CDC and Center for Systems Imaging, Emory University, Atlanta)

Week 10: End of semester presentation on projects based on Emory Trip

2.4.3 Student Project: "Patient Bread"

Before visiting the Emory Center for Systems Imaging, Atlanta, our students discuss a couple of imaging projects for example, imaging a crayon immersed in water in a bottle using MRI, imaging a bread with food dye with radioactivity injected to mimic a tumor etc. Students learn how to collect data at Emory and bring back the data for the imaging scans for analysis at

Clemson. For the bread experiment, students prepared bread with food coloring dye with radioactivity that was injected inside the bread to mimic tumors at a couple of locations. At Emory, students see how to do the PET scan of the bread with the help of the technician. Students bring back the data for analysis at Clemson. The students then reconstruct the images and predict the coordinates (X,Y,Z) where the tumors might be in "patient bread." Then in order to verify the calculations, patient bread is dissected and students can check firsthand how imaging works in practice.

2.4.4 App Development

Several meetings with the Computer Science App Programming Team (Pargas and his students) led to the idea of developing an interactive mobile app on mammography and radiology. The module overview is given as a short introductory video. Then using x-ray Radon transform games, it is explained on how to model CT ray scans making connections to calculus using Riemann sum. Then using an image for example of fingers, it is demonstrated how to compute the data which is called the "sinogram." The user can determine the number of angles and number of distances from the center mainly the rays used to scan the object. The user also learns about how the size, location, and shape of the object changes the sinogram data and also how to invert the sinogram using filtered back projection with a couple of simple examples.

2.5 Module 4 Curriculum

2.5.1 Health Hazards from Arc-Flash

Module 4 is a team taught class on the mathematical modeling of certain physical phenomena relating to an overall goal of heat propagation along a human arm due to an electric arc. The class demonstrates and introduces students to higher level applied calculus and differential equations. The students are required to research different topics relating to heat propagation, and then present their understanding to the class. The topics include: Physics of Electrical Arcs, Heat Transfer, Self-Heating, Viscoelastic Modeling, and Modeling of Mechanical Vibrations. These five topics cover the general concepts that students need to be familiar with in order to further look into the overall goal of the class. Students are required to have taken or currently taking MTHSC 208 Differential Equations.

2.5.2 Module 4 Course Schedule

Week 1: Orientation and Introduction to the class
(1 hour introduction to the course)
Week 2: Tour of the Clemson Bioengineering Laboratory
(1 hour tour of the lab discussing heat propagation in human tissue)
Week 3: Heat Transfer Presentation
(1 hour presentation on heat transfer)
Week 4: Physics of Electric Arc Presentation
(1 hour presentation on arc flash)
Week 5: Self-Heating Presentation
(1 hour presentation on self-heating)

Week 6: Mechanical Vibrations Presentation
(1 hour presentation on vibrations)
Week 7: Viscoelastic Materials Presentation
(1 hour presentation on viscoelastic materials and human tissue)
Week 8: Activity/CDC in Atlanta, GA Tour
(5 hours trip to CDC and Emory Center for Systems Imaging)
Week 9: Francis Marion University Conference
(2 days trip to undergraduate conference)
Week 10: Duke Energy World of Energy Tour
(3 hours trip to Oconee Nuclear Power Plant)
Week 11: Lecture and Discussion
(1 hour wrap up presentation)
Week 12: End of Class Summary and Review

2.5.3 Heat Transfer Presentation Example

There are three main types of heat transfer: Convection, Radiation, and Conduction. The main mode of heat transfer for modeling heat propagation through a human arm is conduction. The governing equations for heat conduction are discussed in class for example Fourier's law, Maxwell's law, and Maxwell-Cattano equation. The heat equation is then classified as the parabolic equation with physical parameters such the effective length, a proportionality constant known as thermal diffusivity, and the solution is the temperature of the rod at length x and time t. The students learn that the heat gradient is proportional to the surface insulation. If the surface is not insulated, heat will exit through the ends. If the surface is insulated, the temperature at the ends will be fixed to a value of zero. Consider a circular rod, and the rod is required to have an insulated surface along its length, which may or may not include its ends. Assuming the ends of the rod are not insulated, the rod will experience heat transfer through its ends. The heat transfer along the rod is modeled by the one dimensional heat equation is discussed along with relevant boundary and initial conditions that are practical.

2.5.4 Student Projects and Activities

The main projects for the students are the researching of the heat propagation topics. The students work in teams to learn and prepare presentations about the specific topic that they have been assigned. The students are required to meet with each other both in and out of class as well as with the instructors. They then present their topic to the rest of the class and share their understanding of the material. Following each presentation, the instructor will give a more in depth explanation as to how the topic relates to the overall goal of the class, which is modeling the heat propagation through a human arm due to an electric arc. Students are also encouraged to ask questions and discuss the material presented. Among the student research projects, students also have the ability to attend, and even participate at various mathematics conferences resulting in research publications [8]. Some of the conferences attended over the past three years are the Francis Marion Undergraduate Mathematics Conference held at Francis Marion University, and the UNC Greensboro Regional Mathematics and Statistics Conference held at University of North Carolina Greensboro. The students also attend a tour at the World of Energy in Seneca, South Carolina. The World of Energy is a part of the Duke Energy Oconee Nuclear Station, and offers an informative self-guided tour where students can learn more in depth about energy production and electricity in general. Another tour that the World of Energy can offer when they are able is a nuclear plant control room simulator session, where experts demonstrate and teach about how nuclear fission is used to produce electricity as well as how it is operated in the control room. During one of these simulator sessions, students participate in an exercise where they are allowed to operate the simulator themselves.

3. Assessment

Assessment focused on how this approach, combined with introducing the students to mathematical skills they will need to learn (in some cases next semester), enabled the student to more confidently approach an entire mathematical concept in the context of applied learning. Formative evaluations began with the first teaching of Modules, and will continue with every implementation of each module. External evaluations are to take place midway through the 3 year program and again at the end of the program. Both evaluations are designed to gather information in order to answer the following questions:

- Goal 1: Does participation in these activity based learning modules improve student knowledge in current math courses?
- Goal 2: Do these modules improve student performance in current math courses?
- Goal 3: Does participation in these activity based learning modules improve student performance in future math courses?
- Goal 4: Does the implementation of activity based learning using medical applications affect the retention in STEM majors?
- Goal 5: Do applied learning modules, such as the ones proposed, have disseminative potential to high-school, community college and other 4 year institutions with an interest in adopting this approach to enhance early undergraduate applied learning?

3.1 Internal Evaluation

The formative evaluation consists of pre and post exams aimed at testing the basic math skills utilized in the module. Student performance and major changes are monitored in semesters following module participation until graduation. Pre and post surveys are conducted focusing on the improvements needed in implementation.

3.2 Pre-survey

Pre-surveys were administered in the first week of each module semester (during the introductory meeting) by the module instructor. These surveys gathered information about the demographics of the students registered for the module. In addition, the preliminary surveys gather information on the student’s math background and initial perception of uses of mathematics in STEM fields. Instructors are then able to gage the module according to the information obtained.

3.3 Post-survey

Post-surveys were administered at the last meeting of the module during the semester by the module instructor. These surveys gathered information on the students' satisfaction of the instructors and the material taught. In addition, these surveys gaged the students' perception of how much their participation in the modules helped their performance in their math and biology courses. The information obtained from these surveys was used to make improvements to the modules for future implementation.

3.4 Follow-up Surveys

After a student has completed at least a semester of study after the participation in a module, participants will complete an on-line follow up survey to gage the retention, and usefulness of the knowledge obtained from the modules in the subsequent semesters. Students are asked to participate in these follow-up surveys every semester until graduation.

3.5 Student Performance and Retention in CES majors

In the institutions core calculus courses, semester and final exams are recorded for each student. Of this program comparisons will be made for participants in these modules versus comparable students that did not participate for the semester the student takes the module as well as subsequent semesters. In addition, the participating students will be monitored for change in majors to a major outside of STEM until graduation. Comparisons will be made on proportion of participating students that switch majors (to outside STEM) to a comparable group of students that did not participate in the modules. Comparable students will be obtained via quantitative measures such as math SAT score, previous exam scores, math placement scores etc. These student control groups will be chosen with assistance from an in house statistician, and the identity of these participants will be kept blind from the participating instructors and departments until the conclusion of each semester and module.

4. Discussion

A key component of this work is the use of multi-departmental (or multi-disciplinary) collaborations to arrive at a greater academic impact. In the case of the authors host institution, collaborative educational activities between the department of Mathematical Sciences and Bioengineering were originally sparked by a creative inquiry project to that focused on bringing undergraduate students and faculty from both departments together to explore research areas and ideas that bridge the disciplines and require the expertise of both fields to address biomedical and applied mathematical concepts. Over 3 years' time, over 72 cross-disciplinary faculty lectures were presented, over 240 undergraduates took the course for credit, and 12 student groups conducted multi-disciplinary research under this initiative. The work presented here is a further extension of this collaboration, and offers a further bridge between the two departments. Dissemination of this work is a key component of this project. As is the case with the current work, the results of each module will be assembled for conference dissemination. A project website has been developed that can be used by participating students, and this site will be opened to other institutions to assist in implementing similar programs at their high school, college or university. For each module the website will house video of lectures, worksheets, podcasts, pictures from field trips, and more. In addition to the module information the website will have the results of all pre and post surveys, follow-up surveys, reports of assessment from each evaluation period, and a final report from the entire 2 year project.

Long-term plans for this work include expansion of the modules to include Data Mining, Genetic Sequencing, Nano-Medicine, BioFluid Dynamics, and Network simulation for the “Smart Grid Technologies.” Dissemination would hope to expand the program into other institutions. An external evaluation model will be used to assess the implementation of the program, and the final report will be shared and published through the project website and by the project members at various conferences.

The goal of engaging, mentoring and retaining STEM students can be empty rhetoric without a lot of creative thinking. The project presented here stands on the shoulders of creative projects in the Mathematics and Bioengineering departments that involve new instructional methodology, new uses of technology, and experience in creative inquiry connecting undergraduates with experts in various fields in the university and industry. The project also stands on the shoulders of the host institution’s efforts at developing undergraduate scholarship in the Creative Inquiry program. The program strategy and plan involves faculty members who have participated in projects like the ones described above and who have experience in the development of applied-learning experiences in Biomedicine that involve quantitative issues at the level of the students’ current math courses. The evaluation of the project makes use of the extensive database on individual student performance maintained by the Mathematics Department. The project management team consisted of faculty members from Mathematical Sciences and Bioengineering who were enthusiastic about working together to recruit students for this project, implement the research experiences, accompany students on trips to labs in medicine and industry, mentor the students in their mathematics courses, and evaluate the project.

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