Biomedical Engineering - BS
2017 - 2018 Assessment Plan

Currently status is: Report Accepted

I. ANNUAL REPORT FOR 2016 - 2017

Mission Statement

The Biomedical Engineering Program at the University of South Carolina prepares its graduates technically and professionally to meet the growing demands for positions in biomedical engineering industry and academia or continuing studies in graduate programs and medical schools. By continuously improving the undergraduate and graduate programs, the Program responds to the rapidly changing field of biomedical engineering to serve as an effective resource and partner for industry, government, and academia.

Goal 1.

Graduates will practice in a professional career or pursue an advanced or professional degree in which they are contributing to scientific, professional, and/or local communities through the improvement of human health.

Goal 1 refers to the technical grounding that graduates receive. By preparing technically competent engineers, this goal supports the mission to "*prepare…graduates technically*". The translation of knowledge into practice contributes to the mission to "*meet the growing demands for positions in biomedical engineering industry*" and "*serve as an effective resource and partner for industry, government, and academia*". The technical competence gained by graduates additionally provides a framework for "*continuing studies and graduate programs and medical schools*".

Curriculum

The curriculum for the BS in Biomedical Engineering is summarized in Table I. This curriculum was revised based upon data gathered from faculty and students and implemented beginning in Fall 2012.

BMEN 101, 202, and 303 introduce students to professional and ethical responsibility, as well as broader issues impacted by biomedical engineers.

BMEN 260, 271, 321, 345 and 361 each include a laboratory component.

BMEN 427 and 428 constitute the capstone design experience.

These and other core courses are related to Learning Outcomes as depicted in Table II.

Technical electives can be fulfilled with mathematics, biology, chemistry, or engineering courses chosen from an approved list.

Engineering electives can be fulfilled with engineering or computing courses chosen from an approved list.

Biomedical engineering electives are chosen from an approved list of courses from biomedical and other engineering disciplines.

A complete list of all approved electives can be found on the MyCEC Biomedical Engineering internal pages for current students.

Required courses in general education meet requirements defined by the University.

Learning Outcome 1.

Students will be able to apply knowledge of mathematics; biological, chemical, and physical sciences; and engineering to solve problems at the interface of engineering and medicine.

Measures and Criteria

The mathematics, biology, physiology, and basic engineering concepts acquired in the early parts of the curriculum are used in

sophomore, junior, and senior level biomedical engineering courses to solve problems typical of those encountered in biomedical engineering practice. The students are expected to demonstrate increasing mastery of the knowledge by applying this knowledge in sophomore, junior, and senior level biomedical engineering courses. Eight core courses have been selected from which to evaluate student performance with respect to application of mathematics, biology, physiology, and basic engineering topics: BMEN 260 Introduction to Biomechanics, BMEN 271 Introduction to Biomaterials, BMEN 290 Thermodynamics of Biomolecular Systems, BMEN 321 Biomonitoring and Electrophysiology, BMEN 345 Anatomy and Physiology for Biomedical Engineers, BMEN 354 Transport in Biological Systems, BMEN 361, Biomedical Measurement and Instrumentation, and BMEN 391 Kinetics in Biomolecular Systems. Student performance in each of these classes will be determined for both exams and projects. Performance on exams will be assessed both compositely for each course, and temporally across the curriculum from sophomore to junior year. For sophomore level courses, at least 70% of students must receive an average passing grade ("C" or higher) on their composite exam performance, or a continuous temporal increase throughout the duration of each applicable course must be observed, with at least 75% of students receiving a passing grade ("C" or higher) by the last exam. For junior level courses, at least 75% of students must receive an average passing grade ("C" or higher) on all exams, or a continuous temporal increase throughout the duration of each applicable course must be observed, with at least 85% of students receiving a passing grade ("C" or higher) by the last exam. Temporally, passing rates (% students receiving a grade of "C" or higher) for composite exam performance are expected to increase as students advance in the curriculum from freshman to junior year. For class projects, a single score for the project will be evaluated for each course. At least 80% of students must receive an average passing grade ("C" or higher) on projects for each freshman and sophomore level course, while at least 90% of students must receive an average passing grade ("C" or higher) for each junior level course in which a project is incorporated into the course materials. In addition, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to the application of basic science and mathematics knowledge to the solution of biomedical engineering problems. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 85% of graduating seniors must respond that they have a high level of confidence in their ability to apply basic science and mathematics knowledge to biomedical engineering problems.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on exams and class projects, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of exams and class projects, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student ability to apply knowledge of science and mathematics to solve biomedical engineering problems. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as

outlined in Chapter “Methods of Program Evaluation” will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in ”Methods” for LO 1 of goal 1:

Class exam performance for BMEN 260, BMEN 271, BMEN 290, BMEN 321, BMEN 345, BMEN 354, BMEN 361, and BMEN 391 is summarized in Table III; Table IV shows the composite student performance on class projects for the same courses.

The tabulated data for temporal student performance (Table III) indicates that the students failed to meet the criterion of 70% passing (a grade of “C” or higher) on the composite exam performance or, alternatively, continuous improvement up to a final grade of 75% in BMEN 260 and BMEN 290 in the sophomore year. The criterion of 80% passing (a grade of “C” or higher) or, alternatively, continuous improvement up to a grade of 75% passing, is met in most courses of the junior year except for BMEN 321 and BMEN 361. Both BMEN 321 and BMEN 361 show a temporal increase though with considerably more (80 and 81%, respectively) students receiving a passing grade (a grade of “C” or higher) by their final exam, barely missing the desired criterion of 85% passing. BMEN 271, BMEN 345, BMEN 354, and BMEN 391 meet both the criterion of 70% (sophomore year, BMEN 271) and 75% (junior year) passing (a grade of “C” or higher), respectively, for the composite exam performance and the criterion of 75% (sophomore year, BMEN 271) and 85% (junior year) passing for the final exam performance, respectively. Overall, composite as well as final exam performance is noticeably higher in junior level courses compared to sophomore level courses, suggesting improved attainment of this learning outcome as students move through the curriculum.

In the category of class projects (Table IV), the criterion of 80% passing (a grade of “C” or higher) for sophomore classes, and 90% passing (a grade of “C” or higher) in junior-level courses for class projects is achieved in all of the core classes in which a project was incorporated. Among graduating seniors, 87% express confidence in their ability to apply basic science and mathematics knowledge to the solution of biomedical engineering problems. Thus, the criterion of 80% student confidence was met as well.

Table III
Table IV

Use of Results

Of the courses that do not meet the criteria for this learning outcome, BMEN 260, BMEN 290, and BMEN 321 mostly showed very similar results in the last two years (data 2014, final exams: BMEN 260 90% passing, BMEN 290, 40% passing, BMEN 321, 60% passing; data 2015, final exams: BMEN 260, 50% passing, BMEN 290, 56% passing, and BMEN 321, 76% passing;). It is generally not uncommon to see a drop of student performance in the final exams as opposed to previous exams since the material covered in the final exams is a lot broader than for each individual exam. Nonetheless, it is evident that some of our students seem to struggle more in these classes which are the first core classes to focus heavily on engineering concepts (BMEN 260, BMEN 290, or BMEN 321). Within open discussions, both instructors and students noted that students often feel insufficiently prepared for these lower level engineering classes, and sometimes lack the necessary science foundation to succeed in applying engineering concepts employed in these courses. As a result of this observation, the Undergraduate Committee recommended a modified pre- and corequisite structure for presentation to the BME faculty. These modifications will add more stringency to classes that lay the science foundation for those early engineering classes BMEN 260, BMEN 290, and BMEN 321 and should help students arrive at those classes better prepared. Some of the changes, which include both new requirements as well as requirements with increased stringency e.g., implementation of C progression (a grade of “C” or better is needed to progress), are summarized in Table V.

The modified pre- and corequisite structure was confirmed via a positive BME faculty vote and submitted for approval through the College and University. Some of the changes summarized in Table V went into effect last semester; the remaining changes, marked with an asterisk, will go into effect in the Fall of 2017.

BMEN 361, a second semester junior class, only barely missed this year's criterion of 85% passing in regards to exam performance, and has consistently passed the learning outcome in previous years. It must be noted, that due to often low student numbers (~ 50) in some of the junior level core classes, more so than in the sophomore classes, student performance analysis is affected by individual performance of even a small number of students and, hence, easily skewed. The instructor has been made aware of the outcome of this year's results, and composite student performance will be re-evaluated next year to see if a similar trend is repeated. Until then, the instructor is advised to increase office hours and provide additional problem solving assignments.

Results for this learning outcome will be re-evaluated in the next two years to see if implemented prerequisite changes will lead to increased student ability to apply knowledge of mathematics, biological, chemical, and physical sciences, and engineering to solve problems at the interface of engineering and medicine.

Table V

Learning Outcome 2.

Students will be able to design and conduct laboratory experiments on living systems and their interactions with non living systems, as well as to analyze and interpret data.

Measures and Criteria

Laboratory components of BMEN 260 Introduction to Biomechanics, BMEN 271 Introduction to Biomaterials, BMEN 321 Biomonitoring and Electrophysiology, BMEN 345 Anatomy and Physiology, and BMEN 361 Biomedical Measurement and Instrumentation will involve the design and execution of biomedical engineering experiments, as well as the collection, analysis and reporting of experimental data. Student performance in the laboratory components of each of these courses will be evaluated in the form of written laboratory reports or laboratory tests. Laboratory reports/tests for each class will be assessed both compositely for each course, as well as temporally across the curriculum from sophomore to junior year. Compositely, at least 70% of students must receive an average passing grade ("C" or higher) on the graded laboratory reports/tests for each applicable sophomore level course; 80% of students must receive an average passing grade ("C" or higher) on the graded laboratory reports/tests for junior level courses. Temporally, laboratory report/test scores (% students receiving a grade of "C" or higher) are expected to increase as students advance in the curriculum from sophomore to junior year. Furthermore, student confidence in their ability to design and execute laboratory experiments will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the four sophomore and junior courses with a laboratory component. Responses, collected on a Likert scale, must reflect an average of at least 70% student confidence in all classes. Furthermore, confidence must increase temporally though the course sequence. Finally, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to the design and execution of laboratory experiments. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to design and execute laboratory experiments.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on laboratory reports and assignments, in the form of the percentage of students passing (grade of "C" or higher) each individual report/assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of laboratory reports/tests, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 260, BMEN 271, BMEN 321, and BMEN 361 to probe student confidence in the design and execution of laboratory experiments. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student ability to design and execute laboratory experiments. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter "Methods of Program Evaluation" will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in "Methods" for LO 2 of goal 1:

Student performance on laboratory reports for BMEN 260, BMEN 271, BMEN 321, BMEN 345, and BMEN 361 is summarized in Table VI.

Temporal analysis of individual laboratory report scores reveals rather consistent performance among students in all of the courses with laboratory components. All courses meet the criterion of 70% passing (a grade "C" or higher; sophomore level, BMEN 260) or 80% passing (a grade "C" or higher; junior level, BMEN 271, BMEN 321, BMEN 345, and BMEN 361), respectively. Within the narrow range of 86% to 100% passing of the composite laboratory student performance, no significant temporal trend can be observed across the curriculum, though it can be noted that BMEN 260 the only sophomore course that contains a laboratory component, shows the lowest passing score, with student performance improving subsequently as students move through the curriculum. In the junior-level classes that contain a laboratory component, all individual lab reports meet the criterion of 80% passing (a grade of "C" or higher), hence exceeding the criterion of 80% passing (a grade "C" or higher) in regards to the composite report grade.

Assessment also evaluated student confidence in their ability to design and execute laboratory experiments following completion of BMEN 260, BMEN 271, BMEN 321, and BMEN 361 via supplemental questions included within course evaluations, as well as in the senior exit survey administered to seniors who graduated in May 2016 (Table VII).

Most courses do not meet the criterion of 70% of students expressing a high level of confidence, with the exception of BMEN 361, the last course in the curriculum sequence, suggesting that students, though not meeting the criterion in lower

level classes, do increase their confidence in their ability to design and conduct laboratory experiments on living systems and their interactions with non-living systems, as well as to analyze and interpret data as they move through the curriculum. During their senior year, when students are not exposed to laboratory exercises anymore, this confidence slightly drops again, with 70% of graduating seniors reporting a high level of confidence in this learning outcome.

Table VI
Table VII

Use of Results

Both indirect as well as direct assessment indicate that there is opportunity for improvement within this learning outcome. These tabulated data are in alignment with results from last year's assessment (data not shown). Within open-ended questions and discussions during their senior exit interviews, some students identified the laboratory experiences and practice of technical reports as one of the strengths of the program; other students noted some disappointment with the delivery of the laboratory experience due to increased student numbers, low number of equipment, high student throughput, and lack of teaching assistants (TAs). The increasing challenges of offering laboratory components to a rapidly growing student population, particularly at the sophomore level, led the BME Undergraduate Committee to reconsider the manner in which laboratory components were administered within the curriculum in the summer and fall of 2016. The resulting discussion culminated in the combination of laboratory components of four core courses, BMEN 260 Introduction to Biomechanics, BMEN 271 Introduction to Biomaterials, BMEN 321 Biomonitoring and Electrophysiology, and BMEN 361 Biomedical Instrumentation, into a two-semester long, four credit hour independent laboratory sequence (BMEN 381 and BMEN 382), as part of restructuring the Biomedical Engineering curriculum. Because these courses will be taken by junior-level students, this change facilitates the accommodation of the growing student population. The new structure also allows for a more structured environment in which students learn proper preparation of laboratory notebooks and reports as well as approaches for statistical data analysis, increasing students' ability to not only design experiments, but also analyze and interpret data. This new proposed change in administration of the laboratory sequence to further enhance laboratory skills important for Biomedical Engineering practice, together with other changes in the curriculum, were confirmed via a positive BME faculty vote; submitted for approval through the College and University, and will go into effect in the Fall of 2017. The program will continue to assess student attainment of this learning outcome both directly and indirectly to evaluate the impact the implemented changes in laboratory administration have on the students' ability to design and conduct laboratory experiments on living and non-living systems, as well as analysis and interpretation of data.

Learning Outcome 3.

Students will be able to design a biomedical device or process to meet desired needs within realistic constraints, including economical and ethical constraints.

Measures and Criteria

Two courses within the curriculum, BMEN 427 and 428, Biomedical Engineering Design I and II, provide the capstone design experience. In these courses, students will work in groups to design a biomedical device or process to meet specified criteria and constraints. Additionally, smaller design projects are incorporated into BMEN 290 Thermodynamics of Biomolecular Systems (sophomore level), BMEN 391 Kinetics in Biomolecular Systems and / or BMEN 354 Transport in Biological Systems (first semester junior year) and BMEN 361 Bioinstrumentation (second semester junior year). This enables students to experience progressively higher levels of design through their sophomore, junior, and senior years (BMEN 427 and BMEN 428). Performance on design projects will be evaluated separately from other course assignments in the form of a composite grade for the design project. For freshman, sophomore, and junior level courses, at least 80% of students must receive passing grades ("C" or higher) on the design project in each of these courses, while at least 90% of students must receive passing grades on the capstone design project. In addition, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to designing a biomedical engineering device or process. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to design a biomedical device or process.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on design projects, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for

the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of design projects and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student ability to design a biomedical device or process. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter "Methods of Program Evaluation" will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in "Methods" for LO 3 of goal 1:

Students completed design projects during the capstone design sequence BMEN 427 and BMEN 428. In BMEN 427, 100% of students received a passing grade (a grade "C" or higher) on the design projects, in BMEN 428, 98% of students received a grade of "C" or higher. During the 2016 calendar year sophomore (BMEN 290) and junior (BMEN 391) courses also incorporated a design project. Ninety-three (93%) of BMEN 290 students and 96% of BMEN 391 students received a passing grade on their design project. Thus, students exceed both the criterion of 80% passing grade for the sophomore and junior level courses and the criterion of 90% passing grades for the senior level design sequence. Among graduating seniors, 70% express confidence in their ability to design a medical device or process. Thus, the criterion of 80% student confidence is not achieved.

Use of Results

While the quantitative (direct) criterion of student performance is met for this learning outcome, the criterion with respect to student confidence at the senior level is not achieved. Students increasingly expand their ability to design a biomedical device or process to meet desired needs within realistic constraints, including economic and ethical constraints through continuous exposure in design projects incorporated within core courses in the BME curriculum. This experience culminates in the year-long capstone design project during the senior year. To enhance the design experience for BME students, the program has increased early student exposure to design in the last couple of years by adding design projects to the Honors section of BMEN 101, BMEN 290, and BMEN 391. Next year, BMEN 354 will also include a design project to further increase the students' experience with the engineering design process before embarking on the design capstone challenge in senior year. This continuously exposes the students to design challenges, starting earlier in the curriculum than in previous years.

In the long term, the College of Engineering and Computing (CEC) is currently discussing efforts to push toward a more integrated setting amongst the CEC's separate departments' senior design programs. Currently, each senior design sequence is

administered independently by the respective department within CEC. The CEC has launched an initiative that would bring together the various engineering disciplines for their senior design sequence. Short-term, this program will include interdisciplinary teams and a framework of common lectures over topics such as project management, product liability, innovation and creativity, codes and standards, licensing and regulations, business venture plans, and intellectual property. Although currently in its earliest stages, this concept will eventually converge to incorporate a new common space, a common guest lecture series, an industry day to showcase the projects created by students, and a yearbook to document the work done and inform potential investors. Hence, to facilitate implementation of the College-wide initiative, the Biomedical Engineering program had decided to not implement any major changes to their senior design sequence to keep the individual departments' senior design sequences aligned.

In the meanwhile, the short term changes mentioned above should increase student confidence in regard to medical device and process design. Students experiencing a higher exposure to design projects will matriculate within the next couple of years. Student confidence will be re-evaluated next year, and the following year to see whether an increased exposure to design projects within the curriculum will increase graduating seniors' confidence in their ability to design a biomedical device or process to meet desired needs within realistic constraints.

Learning Outcome 4.

Students will be able to identify, formulate, and solve problems at the interface of engineering and medicine.

Measures and Criteria

Students will have the opportunity to identify and analyze open-ended problems during class projects and to identify biomedical problems and formulate design solutions through design projects. Most importantly, students will have an in-depth experience in identifying a biomedical problem and formulating a design solution in the capstone design sequence BMEN 427 and BMEN 428. Student performance on class projects and design projects throughout the curriculum will be evaluated separately for each class. At least 80% of students must receive an average passing grade ("C" or higher) on both class projects and design projects for each course attributing to this learning outcome (see Table II). Student performance in the senior capstone design sequence will be evaluated based upon final design reports. At least 90% of students must receive a passing grade ("C" or higher) on this final design report. In addition, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to solving biomedical engineering problems. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to solve biomedical engineering problems.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on class projects and design projects, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of class projects and design projects and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student ability to identify, formulate, and solve problems at the interface of engineering and medicine. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the

Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter "Methods of Program Evaluation" will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in "Methods" for LO 4 of goal 1:

Students performed class projects that involved the identification and formulation of problems at the interface of engineering and biology, during the seminar series BMEN 101, BMEN 202, BMEN 303, as well as BMEN 211, and BMEN 271. In addition, students participated in design projects, which involved open-ended problem identification and formulation as well as solution of problems at the interface of engineering and biology, BMEN 101, BMEN 290, BMEN 391, and the capstone design sequence BMEN 427 and BMEN 428. Student performance on class projects and design projects for each of these courses is summarized in Table X.

Among courses preceding the capstone design sequence, the criterion of 80% passing (a grade of "C" or higher) is exceeded in all seven courses incorporating a class project or a design project, with greater than 90% of students passing their projects amongst all courses. Likewise, within the senior capstone design sequence, the criterion of 90% of students passing (a grade of "C" or higher) is met for both BMEN 427 and BMEN 428.

Among graduating seniors, 83% express confidence in their ability to identify, formulate, and solve problems at the interface of engineering and medicine. Thus, the criterion for this learning outcome, 80% student confidence, is met. Within open-ended questions and senior exit interview discussions, no concerns were noted in students' ability to identify, formulate, and solve problems.

Table X

Use of Results

The program is meeting its prescribed goal with respect to this learning outcome. Open-ended class projects will continue to be encouraged in courses across the curriculum so that a high level of performance with respect to this learning outcome may continue.

Learning Outcome 5.

Students will be able to employ the techniques, skills, and modern tools necessary for biomedical engineering practice.

Measures and Criteria

Students will be required to utilize a number of mathematical software packages during BMEN 211 Mathematic Modeling and Biomedical Engineering as well as throughout the curriculum, including MathCad, MatLab, Maple, and Excel. At least 70% of students must receive an overall passing grade ("C" or higher) in BMEN 211 (assessment of mathematic modeling ability). In addition, students will have the opportunity to conduct biomedical measurements during the laboratory components of BMEN 260 Introduction to Biomechanics, BMEN 271 Introduction to Biomaterials, BMEN 321 Biomonitoring and Electrophysiology, and BMEN 361 Biomedical Measurement and Instrumentation, where they will be required to learn about the theory and operation of biomedical measurement technologies. Further opportunities for making biomedical measurements will be acquired during the capstone design experience, BMEN 427 and BMEN 428. At least 70% of students must receive an overall passing grade ("C" or higher) on their composite laboratory grades in both BMEN 260 and BMEN 271 (assessment of proficiency in experiment design and application at the interface of mechanics/materials and biology), while at least 80% of students must receive a passing grade ("C" or higher) on their composite laboratory grades in both BMEN 321 and BMEN 361 (assessment of proficiency in laboratory measurements, including data collection, handling and application of statistical analysis). Furthermore, at least 85% of students must receive a composite passing grade ("C" or higher) in both capstone design courses, BMEN 427 and BMEN 428, where students need to utilize a variety of biomedical engineering tools for their design

projects. Additionally, student confidence in the ability to employ the necessary techniques, skills, and modern tools necessary for biomedical engineering practice will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for selected courses that emphasize techniques, skills, and modern tools, and are spread out from freshman to senior level across the curriculum, including BMEN 211, BMEN 260, and BMEN 361. Responses, collected on a Likert scale, must reflect an average of at least 75% student confidence in all classes. Furthermore, confidence must either remain steady above 75% or increase temporally though the course sequence, exceeding 80% student confidence by the end of the sequence. Graduating seniors will be surveyed for an indication of their competence in biomedical engineering techniques, skills, and modern tools during exit interviews, which will be conducted annually. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must express confidence in this area.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance in exams, laboratory reports, class and design projects, in the form of the percentage of students passing (grade of "C" or higher) for each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of exams, laboratory reports, class and design projects, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 211, BMEN 260, and BMEN 361, courses that emphasize techniques, skills, and modern tools, and that are spread out from freshman to senior level across the curriculum, to probe student confidence in the ability to employ the techniques, skills, and modern tools necessary for biomedical engineering practice. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student ability to employ techniques, skills, and modern tools necessary for biomedical engineering practice. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the Undergraduate Committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter "Methods of Program Evaluation" will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment

measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in ”Methods” for LO 5 of goal 1:

Students utilize biomedical engineering tools within labs and projects throughout the curriculum, including BMEN 211 (demonstration of mathematic modeling ability), BMEN 260 and BMEN 271 (demonstration of proficiency in experiment design and application at the interface of mechanics/materials and biology), and BMEN 321 and BMEN 361 (demonstration of proficiency in laboratory measurements, including data collection, handling and application of statistical analysis). Additionally, students are required to employ a variety of biomedical tools and skill sets in the capstone design series, BMEN 427 and BMEN 428. Table XX summarizes the results for the quantitative measures described above for the calendar year of 2016 either via composite hands-on laboratory performance where applicable (BMEN 260, BMEN 271, BMEN 321, and BMEN 361) or via composite student performance (exams and projects) for BMEN 211 and BMEN 427/428. Student confidence, as assessed via supplementary questions as part of the course evaluations of BMEN 211, BMEN 260, and BMEN 361, three of the program’s core courses that emphasize techniques, skills and modern tools necessary for the practice of Biomedical Engineering and that are spread out among freshman, sophomore and junior year, respectively (second semester each), as well as student confidence among graduating seniors as assessed via an exiting senior survey is presented in Table XXI.

Students are expected to increase their proficiency in employing techniques and modern tools necessary for biomedical engineering practice as they advance through the curriculum. Sixty-three percent (63%) of students received passing grade (a grade of “C” or higher) on their composite grade in BMEN11, falling short of the criterion of 75% passing (a grade of “C” or higher) for the direct assessment measure in this class. Within the laboratory sequence from sophomore to junior level, students’ composite laboratory performance is meeting the criterion of 75% passing (a grade of “C” or higher) in both BMEN 260 and BMEN 271, and the criterion of 80% passing (a grade of “C” or higher) in both BMEN 321 and BMEN 361. One-hundred percent (100%) of students and 98% of students, respectively received passing grades in their capstone design courses, BMEN 427 and BMEN 428, meeting the criterion of 85% passing (a grade of “C” or higher). The same trend can be observed in the indirect assessment measure of perceived student confidence in this learning outcome, with lower student confidence in the freshman level class BMEN 211, and higher confidence levels in subsequent classes within the sophomore, junior and senior year. Upon graduation 83% of students report a high or very high level of confidence in their ability to employ techniques, skills, and modern tools necessary for biomedical engineering practice. Within this assessment, the criterion for 75% of students showing high confidence from their freshman to their junior year is achieved, and a temporal improvement across the curriculum is observed. The criterion of 80% of students feeling very confident in this learning outcome upon graduation is met as well.

Table XX
Table XXI

Use of Results

Quantitative data indicate that students are increasingly able to employ techniques, skills, and modern tools necessary for biomedical engineering practice as they progress throughout the curriculum. Even though the criterion is not met in freshman year (BMEN 211), due to a strong temporal upward trend, this learning outcome is achieved in sophomore and junior year; however, both quantitative and qualitative data indicate that there is still opportunity for improvement within this learning outcome. Comments from open-ended questions and senior interview discussions continue to identify the need for more exposure to additional tools, including a broader spectrum of software packages and programming languages. Instructors noted that some students struggled with the content of the lecture material and felt unprepared for the course, and these observations were speculated to result from unsatisfactory performance by students in courses encountered earlier in the curriculum. In the open comment section of the course evaluations, some students likewise noted their frustration in struggling to keep up with some of the material.

In response, the Program has recently tightened its pre-requisite system and restructured the Biomedical Engineering curriculum to better prepare students for these upper level engineering courses. These modifications were accomplished by expanding existing courses as well as creating new lower level engineering courses in which students are further familiarized with techniques, skills and tools necessary for biomedical engineering practice. As a result, lower level classes can better be

tailored to prepare students for subsequent junior and senior level core coursework. One of the changes of the revised curriculum is the expansion of BMEN 101 from one credit hour to two credit hours. Concomitantly, the course title has changed from 'Professional Development and Ethics in Biomedical Engineering I' to 'Introduction to Biomedical Engineering'. Additional course time will be used to provide students with an introduction to the most basic engineering computational tools, such as Microsoft Excel and MatLab, and to observe how these tools can be applied to biomedical problems. This expansion of material will better prepare students for BMEN 211, where they can explore more advanced applications of these tools as well as more advanced computational software, and will additionally provide freshmen students with a better understanding of the field of biomedical engineering. The revised curriculum also introduces a new BME core course 212, Fundamentals of Biomedical Systems. This course immediately follows BMEN 211 and is designed to equip students with more foundational concepts necessary for higher level BME coursework. Overall, the BMEN 211/212 sequence provides a platform to introduce several fundamental engineering concepts and implement these concepts using computational tools, thus providing a foundation for subsequent biomedical engineering coursework. This curriculum design both enhances student preparedness for subsequent coursework and allows advanced courses to cover additional material in the time that was previously required to review basic concepts. The modified curriculum structure was confirmed via a positive BME faculty vote; submitted for approval through the College and University, and will go into effect in the Fall of 2017.

Results for this learning outcome will be continued to be monitored directly (student performance) and indirectly (student confidence as assessed in course evaluations) over the next years to see if the implemented prerequisite and curriculum structure changes lead to increased student ability to employ techniques, skills, and modern tools necessary for biomedical engineering practice.

Goal 2.

Graduates will advance their careers by engaging in teamwork, effective communication, and continued learning to expand their professional development and technical understanding.

Goal 2 refers primarily to the professional skills, experiences, perspectives, and learning capabilities that will be instilled within graduates. These attributes prepare graduates to respond to an interdisciplinary, global, and continually evolving workplace in a manner that reflects social responsibility. Goal 2 asserts that graduates will continue to implement these attributes to further their development, and thus their responsible contributions to society. This versatility instilled in graduates through this goal supports the mission to "prepare…graduates… professionally".

Curriculum

The curriculum for the BS in Biomedical Engineering is summarized in Table I. This curriculum was revised based upon data gathered from faculty and students and implemented beginning in Fall 2012.

BMEN 101, 202, and 303 introduce students to professional and ethical responsibility, as well as broader issues impacted by biomedical engineers.

BMEN 260, 271, 321, and 361 each include a laboratory component.

BMEN 427 and 428 constitute the capstone design experience.

These and other core courses are related to Learning Outcomes as depicted in Table II.

Technical electives can be fulfilled with mathematics, biology, chemistry, or engineering courses chosen from an approved list.

Engineering electives can be fulfilled with engineering or computing courses chosen from an approved list.

Biomedical engineering electives are chosen from an approved list of courses from biomedical and other engineering disciplines.

A complete list of all approved electives can be found on the MyCEC Biomedical Engineering internal webpages for current students.

Required courses in general education meet requirements defined by the University.

Learning Outcome 1.

Students will be able to function on multi-disciplinary teams.

Measures and Criteria

Students will be required to work in teams during the laboratory components of BMEN 260 Introduction to Biomechanics, BMEN 271 Introduction to Biomaterials, BMEN 321 Biomonitoring and Electrophysiology, and BMEN 361 Biomedical Measurement and Instrumentation. Group work will also be incorporated within class projects and design projects in these courses as well as other courses that do not have laboratory components. In addition, student group work will be an intricate part of the capstone design sequence, BMEN 427 and BMEN 428. Student satisfaction with group function will be evaluated by providing instructors with a supplemental question to include within their student evaluations that will facilitate collection of data with respect to student satisfaction with group work interactions. These questions will be included within evaluations for each of the three courses within the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303, which are spaced throughout the freshman, sophomore, and junior years and within which teamwork is central to the class. Responses, collected on a Likert scale, must reflect an average of at least 80% student confidence in all classes. Furthermore, confidence must increase temporally though the course sequence. Similarly, instructors will also be probed for their satisfaction of student ability to work in teams. For freshman, sophomore, and junior level courses, instructors must report at least 70%, 75%, and 80% of students, respectively, capable of effectively contributing to group function, while instructors must report at least 90% of students capable of effectively contributing to group within the capstone design sequence (senior year). In addition, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to functioning in multi-disciplinary groups. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 85% of graduating seniors must respond that they have a high level of confidence in their ability to function as part of a group.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student ability to work in multi-disciplinary teams, in the form of survey results that probe instructor assessment of students' ability to effectively contribute to group function, recorded in the form of the percentage of student groups working effectively and efficiently for each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of group function and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 101, BMEN 202, and BMEN 303 to probe student confidence in the ability to function as part of a team. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student ability to work in multi-disciplinary teams. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the Undergraduate Committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student

strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter "Methods of Program Evaluation" will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in "Methods" for LO 1 of goal 2:

Students work in teams for laboratory experiments in BMEN 260, BMEN 271, BMEN 321, and BMEN 361 as well as for group projects in BMEN 101, BMEN 211, BMEN 271, BMEN 290, BMEN 303, and BMEN 361. In addition, the capstone design sequence, BMEN 427 and BMEN 428 requires a strong component of group work. For each of these courses, instructors reported the percentage of groups that functioned efficiently and effectively. These results are summarized in Table VIII.

In freshman, sophomore, and junior courses, the criterion of 70% (freshman), 75% (sophomore), and 80% (junior) of students, respectively, being capable of effectively contributing to group function was exceeded for all courses that incorporate group work (Table VIII). The satisfaction rate for all these courses stayed consistently above 90%, with the exception of BMEN 303 where 85% of groups were reported to have worked efficiently and effectively, still meeting the criterion of 80%. In the senior capstone design sequence, the criterion of 90% satisfaction with group function is met for both BMEN 427 and BMEN 428.

Assessment also evaluated student confidence in teamwork skills following individual courses via supplemental questions included within course evaluations. This assessment was specifically conducted following each of the three courses within the seminar series, BMEN 101, BMEN 202, and BMEN 303, where teamwork is central to the class (Table IX). Furthermore, these three seminar courses are spaced strategically throughout the curriculum and therefore allow for temporal assessment of student improvement in this learning outcome. Ninety-four percent (94%) of students enrolled in BMEN 101, 94% of students enrolled in BMEN 202, and 93% of students enrolled in BMEN 303 express confidence in their teamwork skills. These results show a consistently high student confidence in teamwork skills from the freshman to the junior level, exceeding the criterion of 80% student confidence. Due to the consistently high level, a temporal trend is not noticeable. Among graduating seniors, 81% reported feeling confident in their ability to function in multi-disciplinary teams, meeting the criterion for 80% student confidence in this learning outcome.

Table VIII
Table IX

Use of Results

The criteria for this learning outcome are exceeded in all aspects. In senior exit open-ended questions and interview discussions, many graduating seniors identified their acquired team work skills to be a strength of the program. This is also confirmed in the assessment of project scores as well as high student satisfaction in this learning outcome as assessed by course evaluations. Student group functionality and efficiency, as rated by the respective instructors, was consistently above 90% passing in nearly all courses implementing group work, and student confidence was consistently above the desired criterion throughout the course of the curriculum. Group work will continue to be emphasized and monitored throughout the Biomedical Engineering curriculum, so that performance will continue to meet the specified criteria with respect to this learning outcome.

Learning Outcome 2.

Students will demonstrate professional and ethical responsibility.

Measures and Criteria

Students will be increasingly exposed to professional and ethical responsibility during the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303. Semester-long projects within these classes emphasize professionalism and include an ethics component. Student performance on these class projects will be evaluated for each class. At least 75% of students must receive an average passing grade ("C" or higher) on class projects within BMEN 101, while at least 85% of students must receive an average passing grade ("C" or higher) on class projects within BMEN 202 and BMEN 303. In addition, students are expected to apply these responsibilities when performing independent research, conducting experiments, or implementing engineering design within other core courses in the curriculum. Student confidence in their ability to demonstrate professional and ethical responsibility will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the three seminar series courses, where professionalism and ethics are emphasized. Responses, collected on a Likert scale, must reflect an average of at least 75% student confidence in all classes. Furthermore, confidence must increase temporally though the course sequence. In addition, an exiting survey of graduating seniors will be administered annually to determine the students' perceived ability to exercise professional and ethical responsibility. This will be accomplished with closed ended questions to be answered using a Likert scale. At least 85% of graduating seniors must respond that they are confident in their ability to exercise professional and ethical responsibility.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on course-long projects incorporating professional and ethical responsibilty within the Biomedical Engineering Seminar Series in the form of the percentage of students passing (grade of "C" or higher). The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of relevant course-long projects within the Biomedical Engineering Seminar Series and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 101, BMEN 202, and BMEN 303 to probe student confidence in their ability to demonstrate professional and ethical responsibility. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student ability to exercise professional and ethical responsibility Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the Undergraduate Committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter "Methods of Program Evaluation" will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in "Methods" for LO 2 of goal 2:

> Professionalism and ethics are increasingly emphasized within the Biomedical Engineering seminar series, BMEN 101, BMEN 202, and BMEN 303, in which students enroll during their freshman, sophomore, and junior years, respectively. Each of the seminar classes utilizes class projects which include a professional development as well as an ethics component. Student performance on these class projects for each of the three courses is summarized in Table XI.
>
> The criterion of 75% passing (a grade of "C" or higher on class projects) within BMEN 101 (freshman year), as well as the criterion of 80% passing (a grade of "C" or higher on class projects) in BMEN 202 and BMEN 303 (sophomore and junior year, respectively) is achieved in all three seminar courses. In BMEN 303 (junior year), when emphasis on this learning outcome is highest, 100% of students received a grade of "C" or higher on their projects.
>
> Additionally, student confidence in demonstrating professional and ethical responsibility following these courses is assessed via supplemental questions included within course evaluations of BMEN 101, BMEN 202, and BMEN 303 (see Table XII). Ninety seven percent (97%) of students in BMEN 101, 100% of students in BMEN 202, and 98% of students following BMEN 303 expressed confidence in their ability to demonstrate professional and ethical responsibility. Student confidence in this student outcomes stayed consistently very high; no temporal trend in student confidence in regards to this learning outcome can be observed. Among graduating seniors, 92% express confidence in their professional and ethical responsibility. Thus, the criterion for this learning outcome, 80% student confidence, is exceeded. Students did not address any concerns regarding this learning outcome during the open-ended senior exit questions session and the online senior exit interview.

Table XI
Table XII

Use of Results

> Based upon the available data, the program is meeting its prescribed goal with respect to this learning outcome. Student performance on class projects focused on professional development and ethics is consistently above 90% passing grade (criterion freshman year: 75%, sophomore and junior year: 80%), and students feel confident in their ability to demonstrate professional and ethical responsibility throughout the curriculum, including the graduating seniors. These results are in line with data collected in previous years in regards to this learning outcome. The program will continue its efforts in regards to teaching professional and ethical responsibility during its Professional Development seminar series (BMEN 101, BMEN 202, and BMEN 303) so that the high standards of this learning outcome can be maintained.

Learning Outcome 3.

Students will be able to present technical material through professional written reports and oral presentations.

Measures and Criteria

Final written reports and oral presentations will be required for the capstone design sequence, BMEN 427 and 428. In addition, written reports and oral presentations will be required for an array of other courses, which may include BMEN 101, BMEN 202, and BMEN 303 within the Biomedical Engineering Seminar series as well as BMEN 211 Modeling and Simulations of Biomedical Systems, BMEN 260 Introduction to Biomechanics, BMEN 271 Introduction to Biomaterials, BMEN 290 Thermodynamics of Biomolecular Systems, BMEN 321 Biomonitoring and Electrophysiology, BMEN 354 Transport in Biological Systems, BMEN 361 Biomedical Measurement and Instrumentation, and BMEN 391 Kinetics in Biomolecular Systems. Written reports and oral presentations in each of these courses will be graded separately. Within freshman and sophomore level courses, at least 75% of students must receive passing grades ("C" or higher), while at least 80% of students

within junior level courses must receive passing grades (“C” or higher) on both written reports and oral presentations. In senior year, at least 85% of students must receive passing grades (C or higher) on written and oral components of the capstone design sequence. In addition, student confidence in their ability to present technical material will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the four courses that contain laboratory components, BMEN 260, BMEN 271, BMEN 321, and BMEN 361, where presentation of technical material is emphasized. Responses, collected on a Likert scale, must reflect an average of at least 75% student confidence in all classes. As such, confidence must either remain steady above 75% or increase temporally though the course sequence, exceeding 80% student confidence by the end of the sequence. Finally, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to presenting technical material in both a written and oral format. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 85% of graduating seniors must respond that they have a high level of confidence in their ability to present technical material in both written and oral format.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor’s assessment of student performance (in the form of grades), the student’s assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on written reports and oral presentations, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of written reports and oral presentations and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 260, BMEN 271, BMEN 321, and BMEN 361, each of the four courses that contain laboratory components, and where presentation of technical material is emphasized, to probe student confidence in the ability to present technical material. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student ability to present technical material in written reports and oral presentations. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the Undergraduate Committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter “Methods of Program Evaluation” will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this

report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in ”Methods” for LO 3 of goal 2:

Students performed class projects and design projects, which included a written report, an oral presentation, or both in the following courses: BMEN 101, BMEN 202, BMEN 211, BMEN 271, BMEN 290, BMEN 303, BMEN 361, BMEN 427, and BMEN 428. The written and oral portions of these projects were evaluated separately, and student performance on these components is summarized in Table XIII.

Among freshman and sophomore level courses (BMEN 101, BMEN 202, BMEN 211, and BMEN 290), the criterion of 75% passing (a grade of “C” or higher) for both the written and oral components of class projects was achieved in all four courses. Moreover, with the exception of BMEN 211, student performance for written reports and oral presentations is consistently above 90% passing (a grade of “C” or higher), thus exceeding this criterion. Additionally, the criterion of 85% passing (a grade of “C” or higher) for both the written and oral components of class or design projects is met in all three junior level classes (BMEN 271, BMEN 303, BMEN 361) that incorporate class projects, with student performance consistently at 100% passing (a grade of “C” or higher). Within the senior capstone design sequence (BMEN 427 and BMEN 428), the criterion of 85% of students passing (a grade of “C” or higher) is met for BMEN 427 in regards to written reports, but falls 1% short of the criterion for oral presentations in this course. BMEN 428 meets the criterion for both written reports and oral presentations. Though BMEN 427 falls short of the criterion of 85% passing by 1% in regards to the oral component of this learning outcome, it has to be noted that the data presented is the average out of two oral presentations given by students during this semester; sixty-eight percent (68%) of students received a passing grade (a grade of “C” or higher) for their first presentation, while 100% of students received a passing grade (a grade of “C” or higher) for their second presentation, demonstrating considerable improvement in this learning outcome; this trend is continued within BMEN 428. Generally, percentages passing (a grade of “C” or higher) have improved considerably for both courses of the capstone design sequence compared to last year (data not shown), with the exception of the oral component for BMEN 427, which is probably due to the low performance in the first presentation of this course. This overall trend is most likely due to an increase in exposure to both oral presentations as well as written reports and proposals that has been implemented in the last year within the capstone design sequence.

Assessment also evaluated student confidence in written and oral presentation skills following individual courses via supplemental questions included within course evaluations. This assessment was specifically conducted following each of the four courses that include laboratory components, within which presentation of technical material and data is emphasized. Additionally, graduating seniors are asked for their confidence in regards to this learning outcome as part of the exiting senior survey. Results of these two indirect assessment measures are shown in Table XIV.

After an initial high level of confidence in their ability to present technical material in their sophomore year (BMEN 260, 85%), students confidence drops considerably in the subsequent semesters. This trend could be due to an increase in exposure to written assignments and oral presentations, and higher expectations in regards to this learning outcome. However, as students mature through the curriculum, a clear increase in student confidence in this learning outcome is observed with 78% of students reporting high confidence in their ability to present technical material in written and oral form by the end of their junior year. This upward trend is further continued within the capstone design sequence where emphasis on this learning outcome is highest. Upon graduation, 98% of seniors feel very confident in their ability to present technical material, exceeding the criterion of 85%. In open-ended discussion questions, graduating seniors often noted that the frequent oral presentation and written report assignments, both individually and in groups, within a variety of BME core courses has greatly increased both their oral and written communication confidence and skills, and this aspect was viewed as a very valuable asset for their post-graduation career pursuits.

Table XIII
Table XIV

Use of Results

This learning outcome is exceeded in most classes; however, the prescribed levels of student confidence in regards to technical presentation are not met until the junior year. The Biomedical Engineering program has recently closed its second cycle of continuous improvement and is restructuring its curriculum to include a two-semester long, four credit hour independent laboratory sequence (BMEN 381 and BMEN 382) which will be a combination of the lab components of the previous four BMEN core courses, BMEN 260, BMEN 271, BMEN 321, and BMEN 361. Students starting in Fall 2017 will undergo this two-semester laboratory sequence in their junior year. Restructuring the laboratory sequence into two separate courses will allow for more time to teach students oral and written technical and experimental data presentation while keeping student group sizes small. It also overcomes the previous challenge of the laboratory manager to coordinate lecture material with the main course instructors of core classes with laboratory components, as well as handling temporal and material conflicts with other assessments in each respective class, such as exams and assignments, whilst maintaining student focus and compliance for the laboratory component.

Implementation of the new laboratory sequence should hence further strengthen students' ability to present technical material through professional written reports and oral presentations. Furthermore, the program will continue to have a high focus on written reports and oral presentations in the form of team and individual assignments or projects within all of its core classes and the senior design sequence (Table XIII) to remain the high standards of oral and written technical presentation skills in regards to this learning outcome.

Learning Outcome 4.

Students will be able to recognize economic, social, and global issues and to evaluate the impact that biomedical engineering solutions may have upon society.

Measures and Criteria

Students will be introduced to economic, social, and global issues that are impacted by biomedical engineering during the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303. Semester long projects within these classes incorporate elements of economic, social, and global issues. Student performance on these class projects will be evaluated for each class. At least 75% of students must receive an average passing grade ("C" or higher) on class projects within BMEN 101, and at least 80% of students must receive an average passing grade ("C" or higher) on class projects within BMEN 202 and BMEN 303. In addition, students apply these skills during the capstone design experience. At least 85% of students must receive passing grades ("C" or higher) on the capstone design project. Students are also expected to consider these issues throughout the curriculum. Student confidence in their ability to recognize economic, social, and global issues will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the three courses within the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303. Responses, collected on a Likert scale, must reflect an average of at least 75% student confidence in all classes. Furthermore, confidence must either remain steady above 75% or increase temporally though the course sequence. An exiting survey of graduating seniors will be administered annually to determine how intently students considered these issues. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have considered the impact of biomedical engineering upon one or more of these issues.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on class projects emphasizing economic, social and global issues within the Biomedical Engineering Seminar Series and capstone design projects, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of class projects within the Biomedical Engineering Seminar Series and capstone design projects and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 101, BMEN 202, and BMEN 303 to probe student confidence in the ability to recognize economic, social, and global issues. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student recognition of economic, social, and global issues. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the Undergraduate Committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter "Methods of Program Evaluation" will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in "Methods" for LO 4 of goal 2:

Students are introduced to economic, social, and global issues within the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303, in which students enroll during their freshman, sophomore, and junior years, respectively, and they continue to consider these issues throughout the curriculum, most explicitly in their senior year capstone design experience (BMEN 427 and BMEN 428). Student performance (percentage of students with a grade "C" or higher) in class projects that incorporate economic, social, and global issues in the Biomedical Engineering Seminar Series, as well as senior capstone design performance is reported in Table XV.

Student performance in this learning outcome is exceeding the prescribed goal in all five courses incorporating economic, social, and global issues. The criterion of 75% of students receiving a grade "C" or higher in BMEN 101 (freshman level, moderate exposure), and the criterion of 80% of students receiving a passing grade of "C" or higher in BMEN 202 (sophomore level, moderate exposure) and BMEN 303 (junior level, high exposure) is met, with percentages passing (a grade of "C" or higher) consistently higher than 97%. Within the capstone design series, BMEN 427 and BMEN 428, the criterion of 90% passing is achieved as well.

Assessment also evaluated student confidence in considering economic, social, and global issues following seminar courses via supplemental questions included within course evaluations. BMEN 101, BMEN 202, and BMEN 303 all incorporate projects and assignments that integrate economic, social and global issues, and are spread out across the curriculum from freshman to junior year. Table XVI reports student confidence for this learning outcome as recorded in the student evaluations for BMEN 101, BMEN 202, and BMEN 303.

Table XV
Table XVI

Use of Results

Ninety-six percent (96%) of students following BMEN 101, 100% of students following BMEN 202 and 92% of students following BMEN 303 expressed confidence in their ability to consider economic, social, and global issues. These results exceed the criterion of 75% student confidence in all three classes. However, among graduating seniors, only 75% express confidence in their ability to consider economic, social, and global issues when solving biomedical engineering problems, falling short of meeting the criterion of 80% for the senior year. These data show a significant increase in student confidence in this learning outcome compared to last year, especially in the junior year (student confidence BMEN 303 2014: 63%, 2015: 84%), which may be attributed to increased exposure to economic, social and global issues with measures such as an increase of student opportunities for industry field trips, research seminars, and various guest lectures, some of which are now mandatory for students enrolled in BMEN 303. Students who have been exposed to increased focus on this learning outcome, mainly in their sophomore and junior year, will not graduate before May 2017, possibly explaining the current drop in student confidence in regard to this learning outcome from junior to senior year. Both direct (student performance in projects encompassing economic, global, and social issues) and indirect (student confidence) assessment measures will be re-evaluated next year to see if the upward trend of students' ability to recognize economic, social, and global issues of biomedical engineering solutions in lower level courses due to increased exposure to projects and assignments in this area will extend into the senior year. Data collected over the next two years should indicate whether the measures taken over the last year, such as exposing students to industrial and interdisciplinary issues through guest lectures, field trips, and seminars has increased their confidence in respect to this learning outcome.

Learning Outcome 5.

Students will recognize the need for lifelong learning and demonstrate the ability to learn independently.

Measures and Criteria

Students will be introduced to literature searching techniques during the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303. Throughout the curriculum, students will be required within projects to individually research various topics in biomedical engineering. In particular, independent research projects will be required during the Biomedical Engineering Seminar Series, BMEN 101, BMEN 202, and BMEN 303, as well as other Biomedical Engineering core courses. For example, students may be asked to investigate a new medical technology or to defend a position on a current social/technical issue relevant to biomedical engineering. Furthermore, the capstone design sequence, BMEN 427 and BMEN 428, will require a considerable amount of independent learning. Projects in each of these courses will be graded separately. Within freshman level courses, at least 75% of students must receive passing grades ("C" or higher), while within sophomore, and junior level courses, at least 80% of students must receive passing grades ("C" or higher) on projects. In senior year at least 90% of students must receive passing grades ("C" or higher) on their capstone design project. In addition, student confidence in their ability to learn independently will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the three courses within the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303. Responses, collected on a Likert scale, must reflect an average of at least 80% student confidence in all classes. Furthermore, confidence must either remain steady above 80% or increase temporally through the course sequence. Finally, an exiting survey of graduating seniors will be administered annually to determine how students perceive the need for continued independent learning and how prepared they feel for future, job-related independent learning. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 85% of graduating seniors must respond that they recognize the value of continued independent learning and feel confident in their ability to learn independently.

Methods

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on class and design projects requiring independent learning, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of class and design projects requiring independent learning, and the associated action items will be discussed during the course review. Course review materials prepared by

the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 101, BMEN 202, and BMEN 303 to probe students' confidence in their ability to learn independently. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address student recognition of the need for and ability to carry out lifelong learning. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the Undergraduate Committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Results

In concurrence with our last assessment report, direct and indirect assessment of the student learning outcomes (LOs) as outlined in Chapter "Methods of Program Evaluation" will be reported for the calendar year of 2016: the spring semester of 2016 and the fall semester of 2016. Course evaluation data for spring 2017 will not be available until after the deadline of this report. This data, together with direct assessment of student performance, is used as a supplementary indirect assessment measure. Hence, all assessment, direct and indirect, for spring 2017 will be provided in the next report (fall and spring of year 2017) to aid with report consistency and comprehensibility.

During the 2016 calendar year, the biomedical engineering core curriculum included BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 345, BMEN 354, BMEN 361, BMEN 391, BMEN 427, and BMEN 428. The complete curriculum for the BS in Biomedical Engineering is summarized in Table I. Table II summarizes the relation of all the core courses to the Student Learning Outcomes (LOs), indicating the emphasis of each course for the respective LO.

In May 2016, the program graduated its seventh class of students, which included a total of 53 graduates.

Below are the evaluation data for both 2016 semesters as outlined in "Methods" for LO 5 of goal 2:

Throughout the curriculum, students are required to independently research various topics in biomedical engineering. In particular, students must increasingly demonstrate proficiency in this learning outcome in the Biomedical Engineering Seminar series BMEN 101, BMEN 202, and BMEN 303, which puts high emphasis on independent literature research through a variety of homework assignments as well as more extensive individual and group research projects. In particular, research projects about biomedical engineering technologies, processes, and products are an intricate part of these courses. For example, students may be asked to investigate a new medical technology or to defend a position on a current technical issue relevant to biomedical engineering. Additionally, a very high level of independent research and learning is expected of the students as part of their senior design course series, BMEN 427 and BMEN 428.

The percentage of students showing satisfactory performance in this learning outcome (overall grade "C" or higher) for the three seminar courses is summarized in Table XVII; individual (in the form of journal grading and individual interviews) and group research (design proposal and report) performance as part of the senior capstone design experience is presented in Table XVIII.

The criterion of 75% of students receiving a grade "C" or higher in the freshman course BMEN 101, and the criterion of 80%

of students receiving a passing grade of "C" or higher in BMEN 202 and BMEN 303, sophomore and junior level courses, respectively, is exceeded, with all three courses showing passing percentages (a grade of "C" or higher) of greater than 90%. Within the capstone design series, BMEN 427 and BMEN 428, the criterion of 90% passing is achieved in both courses for both individual as well as group performance.

Assessment also evaluated student confidence in respect to independent learning following individual courses via supplemental questions included within course evaluations. This assessment was specifically conducted following each of the three courses within the seminar series, which are spaced strategically throughout the curriculum and within which independent learning techniques are introduced and subsequently emphasized (Table XIX). Ninety-seven percent (97%) of students following BMEN 101, 98% of students following BMEN 202, and 96% of students in BMEN 303 expressed confidence in their ability to learn independently. Amongst graduating seniors, 91% rated their ability to learn independently as high or very high. Hence, the criterion of 80% of students expressing confidence in this learning outcome within freshman to junior year, as well as the 85% criterion for graduating seniors for the same learning outcome is achieved.

Table XVII
Table XVIII
Table XIX

Use of Results

Both quantitative (direct) and qualitative (indirect) data indicate that this learning outcome is achieved across the curriculum. Within open-ended questions on senior exit surveys and during senior exit interview discussions, students identify no shortcomings in their ability to recognize the need for lifelong learning and their ability to demonstrate the ability to learn independently. The program will continue to implement literature search skills and independent projects within multiple courses from freshman to senior year, and development of student performance and perceived confidence will be further monitored to assess possible trends.

II. FUTURE ASSESSMENT PLAN FOR 2017 - 2018

Mission Statement

"The Biomedical Engineering Program at the University of South Carolina prepares its graduates technically and professionally to meet the growing demands for positions in biomedical engineering industry and academia or continuing studies in graduate programs and medical schools. By continuously improving the undergraduate and graduate programs, the Program responds to the rapidly changing field of biomedical engineering to serve as an effective resource and partner for industry, government, and academia."

The B.S. degree in biomedical engineering fits into the program's mission of developing technically and professionally competent biomedical engineers.

Goal 1.

"Graduates will practice in a professional career or pursue an advanced or professional degree in which they are contributing to scientific, professional, and/or local communities through the improvement of human health."

Goal 1 refers to the technical grounding that graduates receive. By preparing technically competent engineers, this goal supports the Program's mission to "*prepare…graduates technically*".

Table I
Table II

Curriculum

The curriculum for the BS in Biomedical Engineering is summarized in Table I. This curriculum was revised based upon data gathered from faculty and students and implemented beginning in fall 2012.

BMEN 101, 202, and 303 introduce students to professional and ethical responsibility, as well as broader issues impacted by biomedical engineers.

BMEN 260, 271, 321, 345 and 361 each include a laboratory component.

BMEN 427 and 428 constitute the capstone design experience.

These and other core courses are related to the Learning Outcomes as depicted in Table II.

Technical electives can be fulfilled with mathematics, biology, chemistry, or engineering courses chosen from an approved list.

Engineering electives can be fulfilled with engineering or computing courses chosen from an approved list.

Biomedical engineering electives are chosen from an approved list of courses from biomedical and other engineering disciplines. A complete list of all approved electives can be found on the MyCEC Biomedical Engineering internal pages for current students.

Required courses in general education meet requirements defined by the University.

Learning Outcome 1.

Ability to apply knowledge of mathematics; biological, chemical, and physical sciences; and engineering to solve problems at the interface of engineering and medicine.

Measures and Criteria

The mathematics, biology, physiology, and basic engineering concepts acquired in the early parts of the curriculum are used in sophomore, junior, and senior level biomedical engineering courses to solve problems typical of those encountered in biomedical engineering practice. The students are expected to demonstrate increasing mastery of the knowledge by applying this knowledge in sophomore, junior, and senior level biomedical engineering courses. Eight core courses have been selected from which to evaluate student performance with respect to application of mathematics, biology, physiology, and basic engineering topics: BMEN 260 Introduction to Biomechanics, BMEN 271 Introduction to Biomaterials, BMEN 290 Thermodynamics of Biomolecular Systems, BMEN 321 Biomonitoring and Electrophysiology, BMEN 345 Anatomy and Physiology for Biomedical Engineers, BMEN 354 Transport in Biological Systems, BMEN 361, Biomedical Measurement and Instrumentation, and BMEN 391 Kinetics in Biomolecular Systems. Student performance in each of these classes will be determined for both exams and projects. Performance on exams will be assessed both compositely for each course, and temporally across the curriculum from sophomore to junior year. For sophomore level courses, at least 70% of students must receive an average passing grade (“C” or higher) on their composite exam performance; for junior level courses, at least 80% of students must receive an average passing grade (“C” or higher) on their composite exam performance. Temporally, passing rates (% students receiving a grade of “C” or higher) for composite exam performance are expected to increase as students advance in the curriculum from freshman to junior year. For class projects, a single score for the project will be evaluated for each course. At least 70% of students must receive an average passing grade (“C” or higher) on projects for each freshman and sophomore level course, while at least 80% of students must receive an average passing grade (“C” or higher) for each junior level course in which a project is incorporated into the course materials. In addition, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to the application of basic science and mathematics knowledge to the solution of biomedical engineering problems. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to apply basic science and mathematics knowledge to biomedical engineering problems.

Methods

Two primary assessment tools will be employed to assess that students are meeting the criteria for LO 1: direct assessment of student performance on exams and class projects, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor’s assessment of student performance (in the form of grades), the student’s assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on exams, and class projects for BMEN 260, BMEN 271, BMEN 290, BMEN 321, BMEN 345, BMEN 354, BMEN 361, and BMEN 391, in the form of the percentage of students passing (grade of “C” or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of exams and class projects, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students' ability to apply knowledge of mathematics; biological, chemical, and physical sciences; and engineering to solve problems at the interface of engineering and medicine. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Learning Outcome 2.

Ability to design and conduct laboratory experiments on living systems and their interactions with non-living systems, as well as to analyze and interpret data.

Measures and Criteria

Laboratory components of BMEN 260 Introduction to Biomechanics,BMEN 271 Introduction to Biomaterials, BMEN 321 Biomonitoring and Electrophysiology, BMEN 345 Anatomy and Physiology, and BMEN 361 Biomedical Measurement and Instrumentation will involve the design and execution of biomedical engineering experiments, as well as the collection, analysis and reporting of experimental data. Student performance in the laboratory components of each of these courses will be evaluated in the form of written laboratory reports or laboratory tests. Laboratory reports/tests for each class will be assessed both compositely for each course, as well as temporally across the curriculum from sophomore to junior year. Compositely, at least 70% of students must receive an average passing grade (“C” or higher) on the graded laboratory reports/tests for each applicable sophomore level course; 80% of students must receive an average passing grade (“C” or higher) on the graded laboratory reports/tests for junior level courses. Temporally, laboratory report/test scores (% students receiving a grade of “C” or higher) are expected to increase as students advance in the curriculum from sophomore to junior year. Furthermore, student confidence in their ability to design and execute laboratory experiments will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations of four sophomore and junior courses with a laboratory component, one per semester: BMEN 260, BMEN 271, BMEN 321, and BMEN 361. Responses, collected on a Likert scale, must reflect an average of at least 70% student confidence in all sophomore level classes, and 80% in all junior level classes. Furthermore, confidence must increase temporally though the course sequence. Finally, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to the design and execution of laboratory experiments. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to design and execute laboratory experiments.

Methods

Three primary assessment tools will be employed to assess that students are meeting the criteria for LO 2. These include direct assessment of student performance on laboratory assignments, student self-assessment of confidence in their ability to design and conduct laboratory experiments and to analyze data, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor’s assessment of student performance (in the form of grades), the student’s assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on laboratory reports and assignments for BMEN 260, BMEN 271, BMEN 321, BMEN 345, and BMEN 361, in the form of the percentage of students passing (grade of “C” or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of laboratory assignments, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 260, BMEN 271, BMEN 321, and BMEN 361 to probe student confidence in the design and execution of laboratory experiments. These questions are evaluated

on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students' ability to design and execute laboratory experiments on living systems and their interactions with non-living systems, as well as to analyze and interpret data. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Learning Outcome 3.

Ability to design a biomedical device or process to meet desired needs within realistic constraints, including economical and ethical constraints.

Measures and Criteria

Two courses within the curriculum, BMEN 427 and 428, Biomedical Engineering Design I and II, provide the capstone design experience. In these courses, students will work in groups to design a biomedical device or process to meet specified criteria and constraints. Additionally, smaller design projects are incorporated into BMEN 211 Modeling and Simulation of Biomolecular Systems (freshman level), BMEN 290 Thermodynamics of Biomolecular Systems (sophomore level), and BMEN 391 Kinetics in Biomolecular Systems (junior level). This enables students to experience progressively higher levels of design through their sophomore, junior, and senior years (BMEN 427 and BMEN 428). Performance on design projects will be evaluated separately from other course assignments in the form of a composite grade for the design project. For freshman, sophomore, and junior level courses, at least 80% of students must receive passing grades (“C” or higher) on the design project in each of these courses, while at least 90% of students must receive passing grades on the capstone design project. In addition, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to designing a biomedical engineering device or process. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to design a biomedical device or process.

Methods

Two primary assessment tools will be employed to assess that students are meeting the criteria for individual learning outcomes: direct assessment of student performance on course design projects and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor’s assessment of student performance (in the form of grades), the student’s assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on design projects for BMEN 211, BMEN 290, BMEN 391, BMEN 427, and BMEN 428, in the form of the percentage of students passing (grade of “C” or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of engineering design projects, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students' ability to design a biomedical device or process to meet desired needs within realistic constraints, including economical and ethical constraints. Student responses to both closed ended questions to be answered using a Likert scale and

open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Learning Outcome 4.

Ability to identify, formulate, and solve problems at the interface of engineering and medicine.

Measures and Criteria

Students will have the opportunity to identify and analyze open-ended problems during class projects and to identify biomedical problems and formulate design solutions through design projects. Most importantly, students will have an in-depth experience in identifying a biomedical problem and formulating a design solution in the capstone design sequence BMEN 427 and BMEN 428. Student performance on class projects and design projects throughout the curriculum will be evaluated separately for each class. At least 80% of students must receive an average passing grade ("C" or higher) on both class projects and design projects for each course attributing to this learning outcome (see Table II). Student performance in the senior capstone design sequence will be evaluated based upon final design reports. At least 90% of students must receive a passing grade ("C" or higher) on this final design report. In addition, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to solving biomedical engineering problems. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to solve biomedical engineering problems.

Methods

Two primary assessment tools will be employed to assess that students are meeting the criteria for individual learning outcomes: direct assessment of student performance on class and design projects, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on class projects and design projects for BMEN 101, BMEN 202, BMEN 211, BMEN 271, BMEN 290, BMEN 303, BMEN 361, BMEN 391, BMEN 427, and BMEN 428, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of class and design projects, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students' ability to identify, formulate, and solve problems at the interface of engineering and medicine. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Learning Outcome 5.

Ability to employ the necessary techniques, skills, and modern tools necessary for biomedical engineering practice.

Measures and Criteria

Students will be required to utilize a number of mathematical software packages during BMEN 211 Mathematic Modeling and

Biomedical Engineering as well as throughout the curriculum, including MathCad, MatLab, Maple, and Excel. At least 70% of students must receive an overall passing grade ("C" or higher) in BMEN 211 (assessment of mathematic modeling ability). In addition, students will have the opportunity to conduct biomedical measurements during the laboratory components of BMEN 260 Introduction to Biomechanics,BMEN 271 Introduction to Biomaterials, BMEN 321 Biomonitoring and Electrophysiology, and BMEN 361 Biomedical Measurement and Instrumentation, where they will be required to learn about the theory and operation of biomedical measurement technologies. Further opportunities for making biomedical measurements will be acquired during the capstone design experience, BMEN 427 and BMEN 428. At least 70% of students must receive an overall passing grade ("C" or higher) on their composite laboratory grades in both BMEN 260 and BMEN 271 (assessment of proficiency in experiment design and application at the interface of mechanics/materials and biology), while at least 80% of students must receive a passing grade ("C" or higher) on their composite laboratory grades in both BMEN 321 and BMEN 361 (assessment of proficiency in laboratory measurements, including data collection, handling and application of statistical analysis). Furthermore, at least 90% of students must receive a composite passing grade ("C" or higher) in both capstone design courses, BMEN 427 and BMEN 428, where students need to utilize a variety of biomedical engineering tools for their design projects. Additionally, student confidence in the ability to employ the necessary techniques, skills, and modern tools necessary for biomedical engineering practice will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for selected courses that emphasize techniques, skills, and modern tools, and are spread out from freshman to junior level across the curriculum, including BMEN 211, BMEN 260, and BMEN 361. Responses, collected on a Likert scale, must reflect an average of at least 70% student confidence in BMEN 211 (freshman level), 75% student confidence in BMEN 260 (sophomore level), and 80% student confidence in BMEN 361 (junior level). Confidence is expected to increase temporally though the course sequence, exceeding 80% student confidence by the end of the sequence. Graduating seniors will be surveyed for an indication of their competence in biomedical engineering techniques, skills, and modern tools during exit interviews, which will be conducted annually. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must express confidence in this area.

Methods

Three primary assessment tools will be employed to assess that students are meeting the criteria for individual learning outcomes. These include direct assessment of student performance on course assignments (exams, laboratory reports, class projects, and design projects), student self-assessment of confidence in their ability to employ the necessary techniques, skills, and modern tools necessary for biomedical engineering practice, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on all exams, laboratory reports, class and design projects for BMEN 211, BMEN 260, BMEN 271, BMEN 321, BMEN 361, BMEN 427, and BMEN 428, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of exams, laboratory reports, and project assignmetns, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 211, BMEN 260, BMEN 361 to probe student confidence in the ability to employ the techniques, skills, and modern tools necessary for biomedical engineering practice. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Goal 2.

"*Graduates will advance their careers by engaging in teamwork, effective communication, and continued learning to expand their professional development and technical understanding*."

Goal 2 refers primarily to the professional skills, experiences, perspectives, and learning capabilities that will be instilled within graduates. These attributes prepare graduates to respond to an interdisciplinary, global, and continually evolving workplace in a manner that reflects social responsibility.

Table I
Table II

Curriculum

The curriculum for the BS in Biomedical Engineering is summarized in Table I. This curriculum was revised based upon data gathered from faculty and students and implemented beginning in fall 2012.

BMEN 101, 202, and 303 introduce students to professional and ethical responsibility, as well as broader issues impacted by biomedical engineers.

BMEN 260, 271, 321, 345 and 361 each include a laboratory component.

BMEN 427 and 428 constitute the capstone design experience.

These and other core courses are related to the Learning Outcomes as depicted in Table II.

Technical electives can be fulfilled with mathematics, biology, chemistry, or engineering courses chosen from an approved list.

Engineering electives can be fulfilled with engineering or computing courses chosen from an approved list.

Biomedical engineering electives are chosen from an approved list of courses from biomedical and other engineering disciplines. A complete list of all approved electives can be found on the MyCEC Biomedical Engineering internal pages for current students.

Required courses in general education meet requirements defined by the University.

Learning Outcome 1.

Ability to function on multi-disciplinary teams.

Measures and Criteria

Students will be required to work in teams during the laboratory components of BMEN 260 Introduction to Biomechanics,BMEN 271 Introduction to Biomaterials, BMEN 321 Biomonitoring and Electrophysiology, and BMEN 361 Biomedical Measurement and Instrumentation. Group work will also be incorporated within class projects and design projects in these courses as well as other courses that do not have laboratory components. In addition, student group work will be an intricate part of the capstone design sequence, BMEN 427 and BMEN 428. Student satisfaction with group function will be evaluated by providing instructors with a supplemental question to include within their student evaluations that will facilitate collection of data with respect to student satisfaction with group work interactions. These questions will be included within evaluations for each of the three courses within the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303, which are spaced throughout the freshman, sophomore, and junior years and within which teamwork is central to the class. Responses, collected on a Likert scale, must reflect an average of at least 70% student confidence BMEN 101 (freshman level), and 80% student confidence in BMEN 202 and BMEN 303 (sophomore and junior level, respectively). Furthermore, confidence must increase temporally though the course sequence. Similarly, instructors will also be probed for their satisfaction of student ability to work in teams. For freshman, sophomore, and junior level courses, instructors must report at least 70%, 75%, and 80% of students, respectively, capable of effectively contributing to group function, while instructors must report at least 90% of students capable of effectively contributing to group within the capstone design sequence (senior year). In addition, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to functioning in multi-disciplinary groups. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to function as part of a group.

Methods

Three primary assessment tools will be employed to assess that students are meeting the criteria for LO 1. These include instructor assessment of student group performance on laboratory and class group projects, student self-assessment of confidence in their to ability function on multi-disciplinary teams, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment

performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to assess students' ability to effectively contribute to group function for group assignments in BMEN 101, BMEN 202, BMEN 211, BMEN 260, BMEN 271, BMEN 290, BMEN 303, BMEN 321, BMEN 361, BMEN 391, BMEN 427, and BMEN 428 in the form of the percentage of groups working efficiently and effectively on each individual assignment or laboratory report. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of group function and effectiveness, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 101, BMEN 202, and BMEN 303 to probe student confidence in the ability to function as part of a team. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students' ability to work in multi-disciplinary teams. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Learning Outcome 2.

Demonstration of professional and ethical responsibility.

Measures and Criteria

Students will be increasingly exposed to professional and ethical responsibility during the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303, Professional Development and Ethics in Biomedical Engineering I, II, and III, respectively. Semester-long projects within these classes emphasize professionalism and include an ethics component. Student performance on these class projects will be evaluated for each class. At least 70% of students must receive an average passing grade ("C" or higher) on class projects within BMEN 101, while at least 80% of students must receive an average passing grade ("C" or higher) on class projects within BMEN 202 and BMEN 303. In addition, students are expected to apply these responsibilities when performing independent research, conducting experiments, or implementing engineering design within other core courses in the curriculum. Student confidence in their ability to demonstrate professional and ethical responsibility will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the three seminar series courses, where professionalism and ethics are emphasized. Responses, collected on a Likert scale, must reflect an average of at least 70% student confidence BMEN 101 (freshman level), and 80% student confidence in BMEN 202 and BMEN 303 (sophomore and junior level, respectively). Confidence must increase temporally though the course sequence. In addition, an exiting survey of graduating seniors will be administered annually to determine the students' perceived ability to exercise professional and ethical responsibility. This will be accomplished with closed ended questions to be answered using a Likert scale. At least 80% of graduating seniors must respond that they are confident in their ability to exercise professional and ethical responsibility.

Methods

Three primary assessment tools will be employed to assess that students are meeting the criteria for LO 2. These include direct assessment of student performance on class projects in BMEN 101, BMEn 202, and BMEN 303, student self-assessment of

confidence in their ability to demonstrate professional and ethical responsibility, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on class assignments for BMEN 101, BMEN 202, BMEN 303, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of class assignments with focus on professional and ethical responsiblity, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 101, BMEN 202, and BMEN 303 to probe students' confidence in their ability to demonstrate professional and ethical responsibility. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students' ability to exercise professional and ethical responsibility. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Learning Outcome 3.

Ability to present technical material through professional written reports and oral presentations.

Measures and Criteria

Final written reports and oral presentations will be required for the capstone design sequence, BMEN 427 and 428. In addition, written reports and oral presentations will be required for an array of other courses, which may include BMEN 101, BMEN 202, and BMEN 303 within the Biomedical Engineering Seminar series as well as BMEN 211 Modeling and Simulations of Biomedical Systems, BMEN 271 Introduction to Biomaterials, BMEN 290 Thermodynamics of Biomolecular Systems, BMEN 361 Biomedical Measurement and Instrumentation, and BMEN 391 Kinetics in Biomolecular Systems. Written reports and oral presentations in each of these courses will be graded separately. Within freshman and sophomore level courses, at least 70% of students must receive passing grades ("C" or higher), while at least 80% of students within junior level courses must receive passing grades ("C" or higher) on both written reports and oral presentations. In senior year, at least 90% of students must receive passing grades (C or higher) on written and oral components of the capstone design sequence. In addition, student confidence in their ability to present technical material will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the four courses that contain laboratory components, BMEN 260, BMEN 271, BMEN 321, and BMEN 361, where presentation of technical material is emphasized. Responses, collected on a Likert scale, must reflect an average of at least 70% student confidence in BMEN 260 and BMEN 271, classes with minor to moderate emphasis on presentation of technical data, and at least 80% student confidence in BMEN 321 and BMEN 361, where emphasis on this learning outcome is increased.Confidence is expected to

increase temporally though the course sequence. Finally, an exiting survey of graduating seniors, administered annually, will determine the level of confidence that students have with respect to presenting technical material in both a written and oral format. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have a high level of confidence in their ability to present technical material in both written and oral format.

Methods

Three primary assessment tools will be employed to assess that students are meeting the criteria for individual learning outcomes. These include direct assessment of student performance on written reports and oral presentations, student self-assessment of confidence in their ability to present technical material through professional written reports and oral presentations, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on written reports and oral presentations for BMEN 101, BMEN 202, BMEN 211, BMEN 271, BMEN 290, BMEN 303, BMEN 361, BMEN 391, BMEN 427, and BMEN 428, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of written reports and oral presentations, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 260, BMEN 271, BMEN 321, and BMEN 361 to probe student confidence in students' ability to present technical material. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students' ability to present technical material in professional written reports oral presentations. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Learning Outcome 4.

Ability to recognize economic, social, and global issues and to evaluate the impact that biomedical engineering solutions may have upon society.

Measures and Criteria

Students will be introduced to economic, social, and global issues that are impacted by biomedical engineering during the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303. Semester long projects within these classes incorporate elements of economic, social, and global issues. Student performance on these class projects will be evaluated for

each class. At least 70% of students must receive an average passing grade (“C” or higher) on class projects within BMEN 101, and at least 80% of students must receive an average passing grade (“C” or higher) on class projects within BMEN 202 and BMEN 303. In addition, students apply these skills during the capstone design experience. At least 90% of students must receive passing grades (“C” or higher) on the capstone design project. Students are also expected to consider these issues throughout the curriculum. Student confidence in their ability to recognize economic, social, and global issues will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the three courses within the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303. Responses, collected on a Likert scale, must reflect an average of at least 70% student confidence BMEN 101 (freshman level), and 80% student confidence in BMEN 202 and BMEN 303 (sophomore and junior level, respectively). Furthermore, confidence is expected to increase temporally though the course sequence. An exiting survey of graduating seniors will be administered annually to determine how intently students considered these issues. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they have considered the impact of biomedical engineering upon one or more of these issues.

Methods

Three primary assessment tools will be employed to assess that students are meeting the criteria for individual learning outcomes. These include direct assessment of student performance on class projects in courses with focus on economic, social, and global issues, student self-assessment of confidence in their ability to recognize economic, social, and global issues within Biomedical Engineering practice, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor’s assessment of student performance (in the form of grades), the student’s assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on class projects for BMEN 101, BMEN 202, BMEN 303, BMEN 427, and BMEN 428, in the form of the percentage of students passing (grade of “C” or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of class projects discussing economic, social and global issues, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 101, BMEN 202, and BMEN 303 to probe student confidence in the ability to recognize economic, social, and global issues in regards to Biomedical Engineering. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students’ recognition of economic, social, and global issues, and students' ability to evaluate the impact that biomedical engineering solutions may have upon society. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

Learning Outcome 5.

Recognition of the need for lifelong learning and demonstration of the ability to learn independently.

Measures and Criteria

Students will be introduced to literature searching techniques during the Biomedical Engineering Seminar series, BMEN 101,

BMEN 202, and BMEN 303. Throughout the curriculum, students will be required within projects to individually research various topics in biomedical engineering. In particular, independent research projects will be required during the Biomedical Engineering Seminar Series, BMEN 101, BMEN 202, and BMEN 303, as well as other Biomedical Engineering core courses. For example, students may be asked to investigate a new medical technology or to defend a position on a current social/technical issue relevant to biomedical engineering. Furthermore, the capstone design sequence, BMEN 427 and BMEN 428, will require a considerable amount of independent learning. Projects in each of these courses will be graded separately. Within freshman level courses, at least 70% of students must receive passing grades ("C" or higher), while within sophomore, and junior level courses, at least 80% of students must receive passing grades ("C" or higher) on projects. In senior year at least 90% of students must receive passing grades ("C" or higher) on their capstone design project. In addition, student confidence in their ability to learn independently will be evaluated by providing instructors with a supplemental question to include within their student evaluations. These questions will be included within evaluations for each of the three courses within the Biomedical Engineering Seminar series, BMEN 101, BMEN 202, and BMEN 303. Responses, collected on a Likert scale, must reflect an average of at least 70% student confidence BMEN 101 (freshman level), and 80% student confidence in BMEN 202 and BMEN 303 (sophomore and junior level, respectively). Confidence is expected to increase temporally through the course sequence. Finally, an exiting survey of graduating seniors will be administered annually to determine how students perceive the need for continued independent learning and how prepared they feel for future, job-related independent learning. This will be accomplished with closed ended questions to be answered using a Likert scale, as well as open-ended questions. At least 80% of graduating seniors must respond that they recognize the value of continued independent learning and feel confident in their ability to learn independently.

Methods

Three primary assessment tools will be employed to assess that students are meeting the criteria for individual learning outcomes. These include direct assessment of student performance on research and design projects, student self-assessment of confidence in their ability to recognize the need for lifelong learning and demonstration of the ability to learn independently, and senior exit interviews.

Individual instructors will keep records of student performance on course assignments, and relevant individual assignment performance will be presented during course reviews. Course reviews will be conducted after each offering of a course, during the ensuing semester. During these reviews, the instructor provides written information which includes the course syllabus, objectives, and topics; the instructor's assessment of student performance (in the form of grades), the student's assessment of their own performance (in the form of standard and supplemental questions asked during student course evaluations); and suggestions for changes and improvements for the course. In addition, the course instructor will be asked to specifically compile and analyze data associated with student performance on class projects and design projects for BMEN 101, BMEN 202, BMEN 303, BMEN 427, and BMEN 428, in the form of the percentage of students passing (grade of "C" or higher) each individual assignment. The instructor will provide a summary of this assessment in conjunction with action items for the next offering of the course aimed at improving learning outcomes. In addition to the general course content, course assessment, and overall student performance, this more specific assessment of class and design projects, and the associated action items will be discussed during the course review. Course review materials prepared by the instructor and notes taken by the Chair of the Undergraduate Committee during the course review discussions will be compiled into binders for each course. This documentation will be stored in the Biomedical Engineering Office.

At the end of each semester, students complete course evaluations for each course. These evaluations include a standard set of questions that probe instructor performance. In addition, course-specific questions can be included within these evaluations. Thus, these evaluations will be leveraged to assess student self-assessment of their confidence level with respect to acquired skills. Specifically, questions will be incorporated into the course evaluations for BMEN 101, BMEN 202, and BMEN 303 to probe student confidence in their ability to learn independently. These questions are evaluated on a Likert scale, with responses entered in bubble sheet format and automatically tabulated for average values. Results of course evaluations will be distributed to individual course instructors to utilize during course reviews. In addition, results will be collected Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.

At the end of each spring semester, student exit interviews will be conducted for students that graduate in May or during the upcoming summer or fall semesters. The Chair of the Undergraduate Committee will conduct these interviews. Students will be asked to assess the outcomes of their education. Specifically, questions will be incorporated into these exit interviews to address students' recognition of the need for and ability to carry out lifelong learning. Student responses to both closed ended questions to be answered using a Likert scale and open-ended questions will be collected in each of these areas and compiled by the Chair of the Undergraduate Committee. The compiled data will be distributed to the undergraduate committee and

discussed at a designated meeting of the Undergraduate Committee for the purpose of listing student strengths and weaknesses and formulating action items for improvement of learning outcomes and program goals. Discussion comments and action items will be documented by the Chair of the Undergraduate Committee and filed in the Biomedical Engineering Office.