WICHITA STATE UNIVERSITY

Program Review Self-Study Template

Academic unit: Biomedical Engineering _____

College: Engineering _____

Date of last review 2015 _____

Date of last accreditation report (if relevant) 2013 _____

List all degrees described in this report (add lines as necessary)

Degree: BS Biomedical Engineering _____ CIP* code: 14.0501_____

Degree: MS Biomedical Engineering_____ CIP code: 14.0501_____

Degree: _____ CIP code:_____

*To look up, go to: Classification of Instructional Programs Website, http://nces.ed.gov/ipeds/cipcode/Default.aspx?y=55

Certificate (s): _____

Faculty of the academic unit (add lines as necessary)

Name	Signature
Michael Jorgensen _____	_____
Anil Mahapatro _____	_____
Nils Hakansson _____	_____
Kim Cluff _____	_____
David Long_____	_____
Jaydip Desai_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Submitted by: Michael Jorgensen, Chair, BME Department _____ Date: 5/25/2018

In yellow highlighted areas, data will be provided

1. Departmental purpose and relationship to the University mission (refer to instructions in the WSU Program Review document for more information on completing this section).

a. University Mission:

The mission of Wichita State University is to be an essential educational, cultural, and economic driver for Kansas and the greater public good.

b. Program Mission (if more than one program, list each mission):

The mission of the Biomedical Engineering program is to provide students a comprehensive education, including integration of the life sciences and engineering principles, to prepare the students to address health needs at the local, national and global levels.

c. The role of the program (s) and relationship to the University mission: Explain in 1-2 concise paragraphs.

The role of the Biomedical Engineering (BME) program is to provide a comprehensive and interdisciplinary education to prepare students to pursue careers to address societal health needs that are becoming increasingly complex in nature, which also require interdisciplinary solutions. The Biomedical Engineering program prepares students, through its integration of science and engineering principles, to understand and contribute to scholarship, both in the classroom as well as participation in research opportunities. Additionally, the Biomedical Engineering program involves and contributes to the larger community, by its vision to integrate healthcare entities within its curricular offerings and research endeavors of its faculty and students. Consistent with the goals of WSU, the BME programs (BS and MS) provides every student an Applied Learning experience, engages MS and many BS in research activities developing new knowledge, and promotes innovation through its Capstone Design courses and annual submissions to the Shocker New Venture Competition for every Capstone Design team.

d. Has the mission of the Program (s) changed since last review? ☐ Yes ☒ No

i. If yes, describe in 1-2 concise paragraphs. If no, is there a need to change?

The mission of the BME program has not changed since the program was created in 2009. However, there may be a need to revisit the mission given the mission of Wichita State University changed. This will be a program faculty decision on whether or not to revisit the BME program mission.

e. Provide an overall description of your program (s) including a list of the measurable goals and objectives of the <u>program</u> (s) (programmatic). Have they changed since the last review?

☐ Yes ☒ No

If yes, describe the changes in a concise manner.

Biomedical Engineers are employed in private industry, hospitals, research facilities, and government regulatory agencies. To address an increasing need for expertise and a skilled and knowledgeable workforce at the intersection of health and engineering, the Biomedical Engineering program began in the Fall 2009 semester (initially called Bioengineering), and offers a BS and MS in Biomedical Engineering. During the program review period (2015-2017) the BS in BME program required 133 credit hours consisting of 53 hours of math and science (chemistry, biology, physics), 50 hours of engineering

courses, 27 hours of general education and basic skills courses, and 3 hours of open electives. The MS in BME program began in January 2017, which is a thesis-only option, consists of 24 hours of coursework and 6 hours of thesis. The BME faculty direct five laboratories that are utilized for both teaching and research purposes, consisting of the Biomaterials and Bioengineering Lab (112 Beggs Hall), the Musculoskeletal Biomechanics and Design Lab (324 Experiential Engineering Building), the Biomedical Sensors, Imaging and Modeling Engineering Lab (325 Experiential Engineering Building), the Mechanobiology and Biomedicine Lab (326 Experiential Engineering Building), and the Neuro-Robotics Lab (203 Engineering Building). Each of these labs is equipped with equipment for experiential learning activities in the BME courses as well as undergraduate and graduate students participating in research with BME faculty.

Due to the interdisciplinary structure of the BME undergraduate curriculum, graduates will have the ability to solve problems and design solutions that link engineering with physical and biological sciences, and pursue professional opportunities related to this ability. Thus, the Biomedical Engineering faculty developed three program educational objectives (PEOs) which were approved by our Advisory Board in 2013.

Biomedical Engineering alumni, within a few years of receiving their baccalaureate degree, will be successful professionals as evidenced by having:

1. Addressed problems at the interface of engineering, biology, and medicine;
2. Pursued professional development, including further study in graduate or professional schools;
3. Served in leadership roles in addressing societal needs at the local, national, and global levels.

These program education objectives were reassessed by surveying our Industrial Advisory Board in December 2016 after we had at least three years of graduates from the BME program. The results and actions resulting from this activity are shown below for each of the program educational objectives.

1. Addressed problems at the interface of engineering, biology and medicine.
    a. Summary: 100% agreed or strongly agreed that this PEO is appropriate, 100% agreed or strongly agreed that it is consistent with industry needs, and 89% agreed or strongly agreed that the BS BME program provides the education necessary to achieve this PEO.
    b. Action: no immediate departmental action is planned for this PEO.
2. Pursued professional development, including further study in graduate or professional schools.
    a. Summary: 100% agreed or strongly agreed that this PEO is appropriate, 100% agreed or strongly agreed that it is consistent with industry needs, and 78% agreed or strongly agreed that the BS BME program provides the education necessary to achieve this PEO.
    b. Action: no immediate departmental action is planned on this PEO.
3. Served in leadership roles in addressing societal needs at the local, national, and global levels.
    a. Summary: 56% strongly agreed, 33% agreed and 11% neither agree nor disagree that this PEO is appropriate, 89% agreed or strongly agreed that it is consistent with industry needs, whereas 22% neither agreed nor disagreed, and 56% felt there was insufficient data available to determine if the BS BME program provides the education necessary to achieve this PEO.
    b. Action: The BME department decided it will discuss in the future if an alternative or modified PEO is needed. If it is felt an alternative or modified PEO is needed, one will be developed and presented to the BME Advisory Board.

2. Describe the quality of the program/certificate as assessed by the strengths, productivity, and qualifications of the faculty in terms of SCH, majors, graduates, and scholarly/creative activity (refer to instructions in the WSU Program Review document for more information on completing this section).

Complete the table below and utilize data tables 1-7 provided by the Office of Planning Analysis (covering SCH by FY and fall census day, instructional faculty; instructional FTE employed; program majors; and degree production).

Scholarly Productivity	Number Journal Articles		Number Presentations		Number Conference Proceedings		Performances			Number of Exhibits		Creative Work		No. Books	No. Book Chaps.	No. Grants Awarded or Submitted	$ Grant Value
	Ref	Non-Ref	Ref	Non-Ref	Ref	Non-Ref	*	**	***	Juried	****	Juried	Non-Juried				
Year 1 2015	15	0	9	12											2	5/12	5,376.944
Year 2 2016	4	0	10	16											0	5/16	5,049,978
Year 3 2017	8	0	11	15											1	3/9	2,974,857

* Winning by competitive audition. **Professional attainment (e.g., commercial recording). ***Principal role in a performance. ****Commissioned or included in a collection.

- Provide a brief assessment of the quality of the faculty/staff using the data from the table above and tables 1-7 from the Office of Planning Analysis as well as any additional relevant data. Programs should comment on details in regard to productivity of the faculty (i.e., some departments may have a few faculty producing the majority of the scholarship), efforts to recruit/retain faculty, departmental succession plans, course evaluation data, etc.

Provide assessment here:

<u>Student credit hours, enrollment, awarded degrees</u>

The Biomedical Engineering BS program has seen a steady increase in Student Credit Hours (SCH). As shown in Figure 2.1, SCH's have increased each fiscal year from 63 in 2011 to 1274 in 2017. Since 2013, there has been a mean 38.2% annual increase in SCH from the previous year. Additionally, as shown in Figure 2.2, the 5-year rolling average SCH has also increased each successive 5-year period.

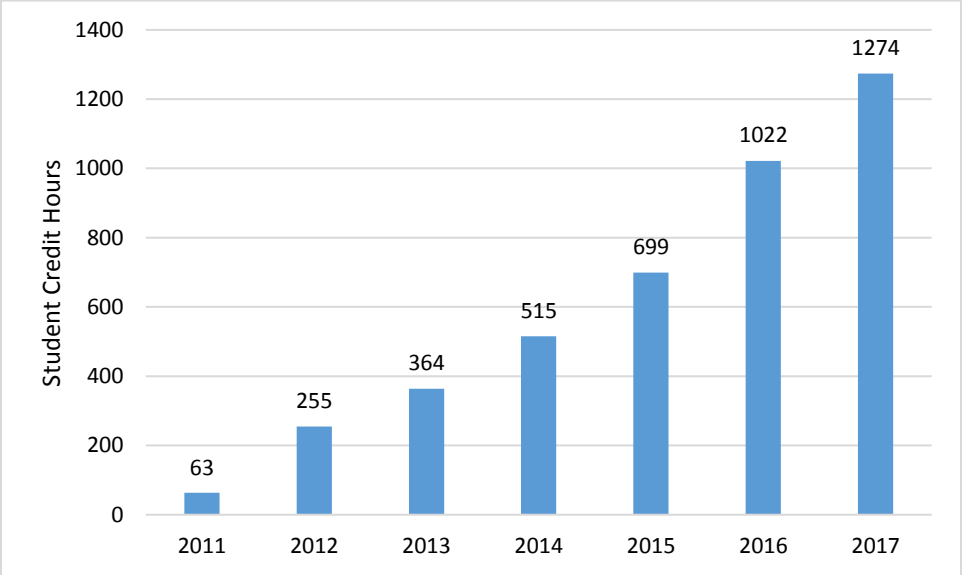

Figure 2.1 Student Credit Hours per Fiscal Year

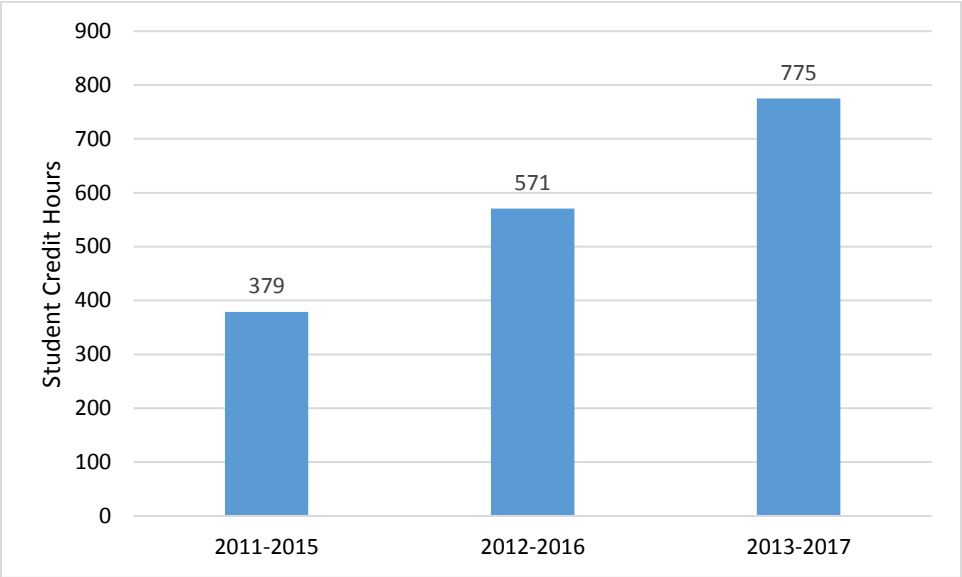

Figure 2.2 Student Credit Hours 5-Year Rolling Average

Contributing to the steady yearly increase in SCH is an increase in instructional faculty and the BS enrollment growth. The BME instructional faculty has increased from 3 in 2013, to 4 in 2014, and 5 in 2015 and 2016. The BME BS program has also seen steady enrollment growth since the inception of the program (Fall 2009). As shown in Figure 2.3, BME program majors has increased from 39 in Fall 2010 to 237 in Fall 2017. This represents a mean yearly increase in enrollment of 12.0% from 2015 to 2017. One notable statistic is that in Fall 2017, 57% of BME undergraduate students were female.

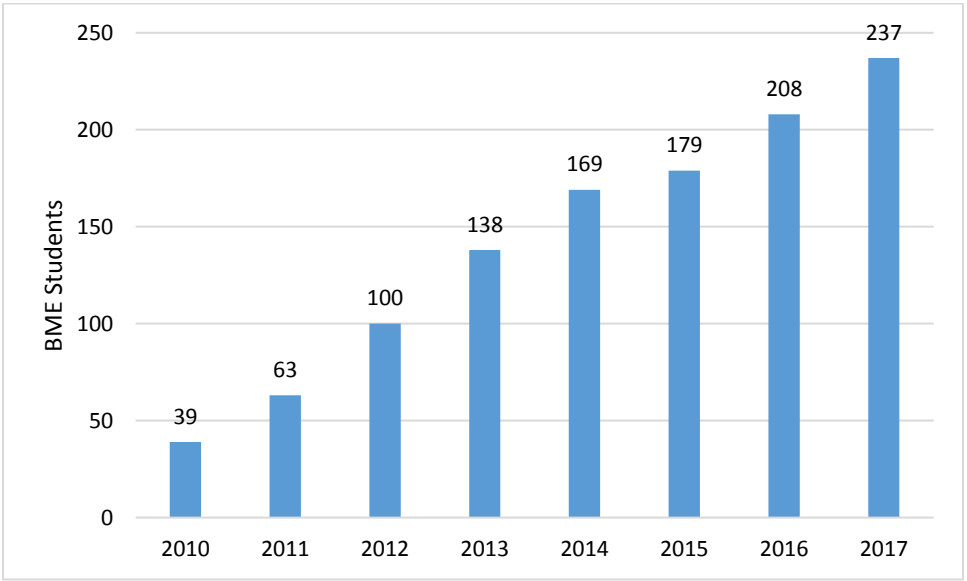

Figure 2.3 BS BME program enrollment 2010-2017 (Fall semesters)

The BME program has also seen an overall increase in BS degrees conferred since its first graduating class in Spring 2013. As shown in Figure 2.4, BS BME degrees conferred increased from 7 in 2013 to 23 in 2017, where it is estimated there will be approximately 36 degrees conferred in 2018.

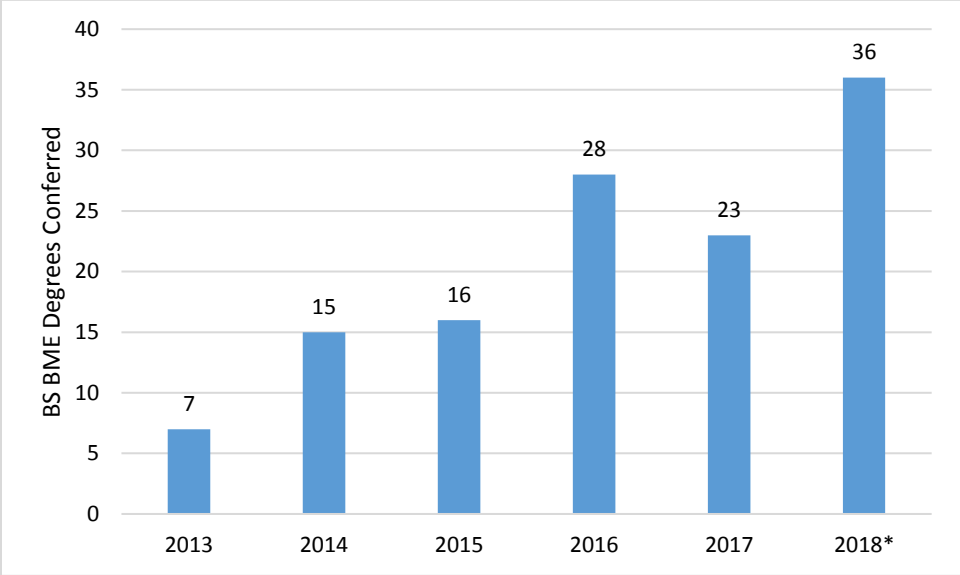

Figure 2.4 BS BME Degrees Conferred per Fiscal Year (*estimated)

The BME Department began offering a MS BME degree starting in January 2017. Since this is typically a two year degree, there have not been any graduates yet from this program.

Faculty productivity, recruitment/retention, course evaluations

The BME faculty have published peer-reviewed journal articles, delivered presentations at research conferences, written and been awarded research grants from internal and external funding sources, filed for patents, and have been recognized for their excellence in teaching, research and service.

As shown in the table above, BME faculty have published 15, 4 and 8 journal articles in 2015, 2016 and 2017, respectively. By the end of 2017, BME faculty also had four publications in review and one accepted for publication. The 2015-2017 journal article publication rate of 1.83 peer-reviewed journal articles per faculty is almost double (0.94/faculty) the journal article publication rate during the last program review period (2012-2014). In 2015 BME faculty was awarded one patent and filed for two others, whereas in 2016 they were awarded one patent and filed for one patent.

Productivity in terms of submitting research grant proposals to external and internal funding sources, including research expenditures, for 2015, 2016 and 2017 are shown in Figure 2.5. Specific categories of grant activity are as follows:

- Funded: 2015 (N=5): $229,207; 2016 (N=7): $1,236,429; 2017 (N=3): $117,500
- Not funded: 2015 (N=6): $1,160,347; 2016 (N=9): $2,998,382; 2017 (N=7): $2,261,753

As a result of the research grant submission activity, research expenditures from BME faculty have increased from $73,522 in 2015 to $345,311 in 2017.

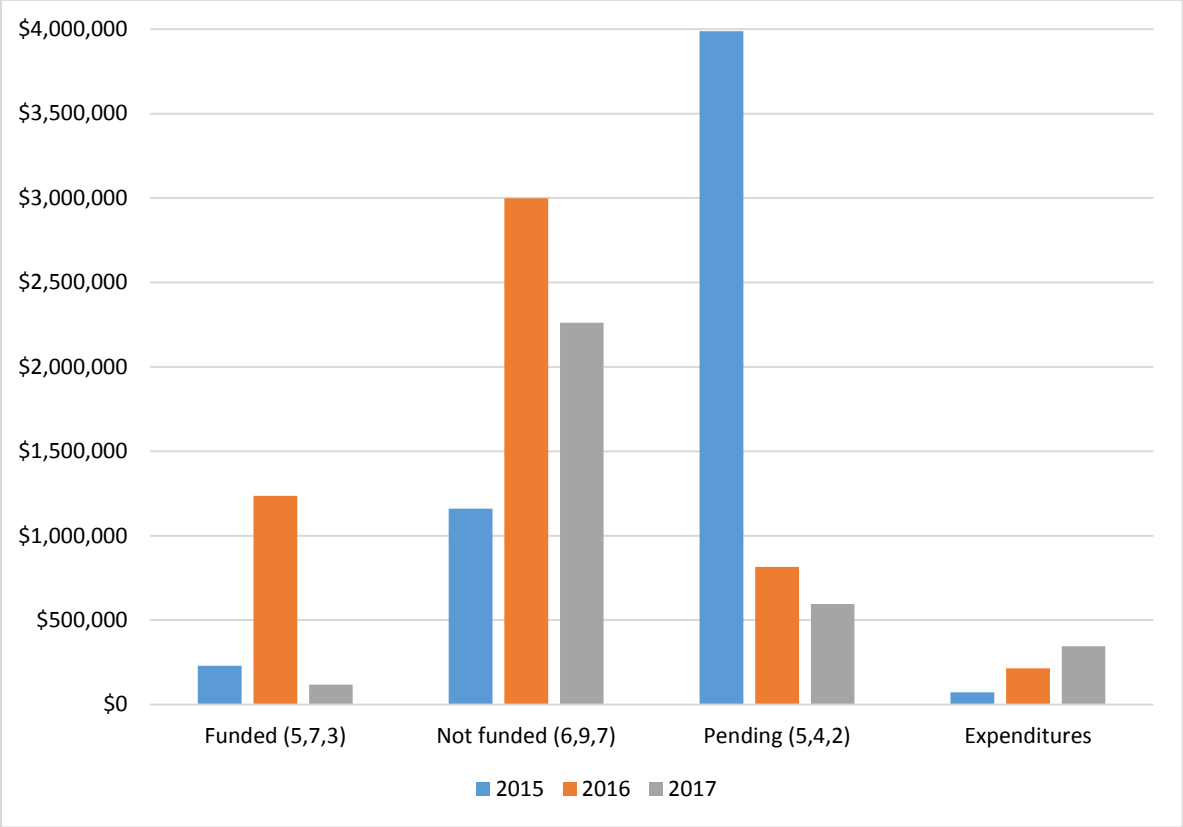

Figure 2.5 BME Faculty Research Grant Proposal Activity: Funded, Not awarded, Pending (at the end of each calendar year), and Research Expenditures.

In addition to research grant submission activity and funding students from the awarded research grants, the BME faculty have a commitment to mentoring and directing undergraduate students in pursuing research funding (e.g., McNair Scholars, K-INBRE research grants, WSU Undergraduate Research grants, College of Engineering summer research stipends, etc.). As such, BME faculty have assisted and mentored BME students in obtaining funding solely for undergraduate research as follows: 2015: $49,505; 2016: $23,700; 2017: $29,020.

The BME faculty have also excelled in the classroom in terms of perceived value of course instruction as measured by the Student Perception of Teaching Effectiveness (SPTE) surveys. As shown in Figure 2.6, the mean Perceived Course Value from 2013 to 2017 for BME courses have been above the 50th percentile as compared to all Engineering courses, and all within the Very Good category. Additionally, the mean 2012-2014 3-year mean SPTE was 47.7%, which increased to 63.5% for the 2015-2017 3-year SPTE.

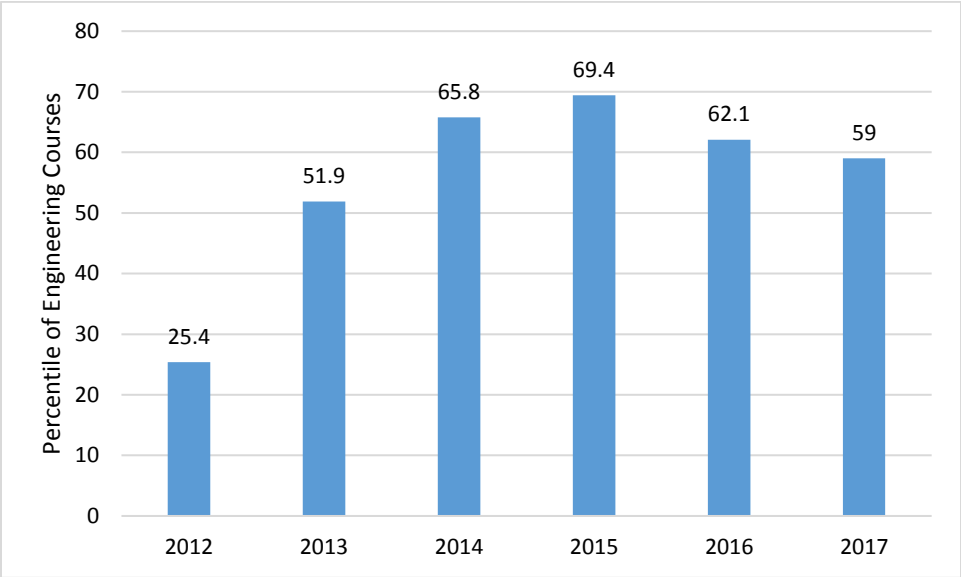

Figure 2.6 Mean SPTE Perceived Course Value (compared to all Engineering courses) Percentiles from 2012 to 2017.

The BME faculty have been recognized for their excellence in teaching, research and service during the 2015-2017 program review period.

- 2015
  - Dr. Anil Mahapatro, College of Engineering Dwane and Velma Wallace Excellence in Teaching Award
- 2016
  - Dr. Kim Cluff: College of Engineering Dwane and Velma Wallace Excellence in Teaching Award
- 2017
  - Dr. Kim Cluff: College of Engineering Dwane and Velma Wallace Excellence in Research Award
  - Dr. Kim Cluff: WSU Excellence in Teaching Award
  - Dr. Gary Brooking: College of Engineering Dwane and Velma Wallace Faculty Service Award
- 2018 (reflective of their activity during the program review reporting period, 2015-2018)
  - Dr. Kim Cluff: WSU Board of Trustees Young Faculty Scholar Award
  - Dr. Nils Hakansson: WSU Excellence for Community Research Award

During this program review reporting period, the BME Department saw two faculty leave: Dr. Marlon Thomas left in Summer 2015 to pursue private industry employment, Dr. Gary Brooking transferred to the WSU Engineering Technology program to assume the Director position in Fall 2017. The BME Department has also seen growth in faculty as two Assistant Professors started in 2017 (Dr. David Long in January, and Dr. Jaydip Desai in August), and have successfully hired a tenure track Assistant Professor to start in August 2018.

3. **Academic Program/Certificate: Analyze the quality of the program as assessed by its curriculum and impact on students for each program (if more than one). Attach updated program assessment plan (s) as an appendix (refer to instructions in the WSU Program Review document for more information).**

a. For undergraduate programs, compare ACT scores of the majors with the University as a whole. (Evaluate table 8 [ACT data] from the Office of Planning and Analysis).

As shown in Figure 3.1, the mean ACT composite score for BME Junior/Senior students has been consistently higher than the University students as a whole from 2010 to 2016.

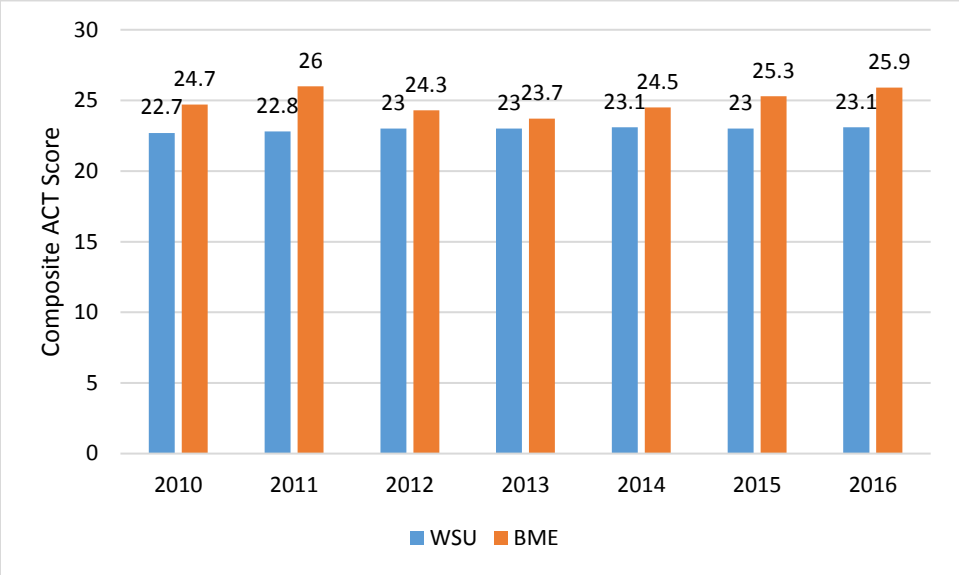

Figure 3.1 Mean ACT Score of Enrolled Junior and Seniors: BME and University Students

The latest 5-year average (2012-2016) composite ACT scores were 23.1 and 24.9 for WSU and BME program students, respectively. The BME student mean composite ACT scores were an average of 2.5 points higher than the University students as a whole for 2015 and 2016, whereas the 5-year average (2012-2016) mean composite ACT scores were 1.8 points higher than the University students as a whole.

b. For graduate programs, compare graduate GPAs of the majors with University graduate GPAs. (Evaluate table 9 [GPA data] from the Office of Planning and Analysis). The MS in BME program started in January 2017, thus, there were no data reported for this category by the Office of Planning and Analysis.

c. Identify the principal learning outcomes (i.e., what skills does your Program expect students to graduate with). Provide aggregate data on how students are meeting those outcomes in the table below. Data should relate to the goals and objectives of the program as listed in 1e. Provide an analysis and evaluation of the data by learner outcome with proposed actions based on the results.

In the following table provide program level information. You may add an appendix to provide more explanation/details. Definitions:
Learning Outcomes: Learning outcomes are statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program (e.g., graduates will demonstrate advanced writing ability).
Assessment Tool: One or more tools to identify, collect, and prepare data to evaluate the achievement of learning outcomes (e.g., a writing project evaluated by a rubric).

Criterion/Target: Percentage of program students expected to achieve the desired outcome for demonstrating program effectiveness (e.g., 90% of the students will demonstrate satisfactory performance on a writing project).
Result: Actual achievement on each learning outcome measurement (e.g., 95%).
Analysis: Determines the extent to which learning outcomes are being achieved and leads to decisions and actions to improve the program. The analysis and evaluation should align with specific learning outcome and consider whether the measurement and/or criteria/target remain a valid indicator of the learning outcome as well as whether the learning outcomes need to be revised.

Table 3.1 Learning Outcomes, Assessment, Target/Criteria, Results and Analysis (BME 335: Biomedical Computer Applications; BME 452: Biomechanics; BME 462: Intro to Biofluids; BME 477: Intro to Biomaterials; BME 480: Bioinstrumentation; BME 482: Design of Biodevices; BME 585: Capstone Design I; BME 595: Capstone Design II).

Learning Outcomes (most programs will have multiple outcomes)	Assessment Tool (e.g., portfolios, rubrics, exams)	Target/Criteria (desired program level achievement)	Results	Analysis
1. Ability to apply knowledge of mathematics, science, and engineering	Courses: BME 452, 462, 480 Assessment Tool: Questions on exams/quizzes	Mean of 80% across all students in courses assessed	2015: 88.5% 2016: 87.8% 2017: 90.0%	Learning outcome is being achieved, improved over time
2. Ability to design and conduct experiments, as well as to analyze and interpret data	Courses: BME 452, 477, 480, 595 Assessment Tool: Questions on exams/quizzes, criteria for term paper, lab report and poster	Mean of 80% across all students in courses assessed	2015: 92.0% 2016: 89.2% 2017: 91.3%	Learning outcome is being achieved
3. Ability to design a system, component or process to meet desired needs with realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Courses: BME 335, 482, 595 Assessment Tool: Questions on exams/quizzes, criteria for case study review	Mean of 80% across all students in courses assessed	2015: 93.9% 2016: 89.0% 2017: 90.6%	Learning outcome is being achieved
4. Ability to function on multidisciplinary teams	Courses: BME 585, 595 Assessment Tool: Peer evaluation metrics from CATME survey	Mean of 80% across all students in courses assessed	2015: 93.9% 2016: 89.4% 2017: 92.0%	Learning outcome is being achieved
5. Ability to identify, formulate and solve engineering problems	Courses: BME 335, 462, 595 Assessment Tool: Questions on exams, design criteria rubric	Mean of 80% across all students in courses assessed	2015: 90.8% 2016: 90.2% 2017: 89.6%	Learning outcome is being achieved
6. Understanding of professional and ethical responsibility	Courses: : BME 477, 585, 595 Assessment Tool: Questions on exams, report rubric	Mean of 80% across all students in courses assessed	2015: 91.5% 2016: 91.9% 2017: 90.6%	Learning outcome is being achieved
7. Ability to communicate effectively	Courses: BME 482, 585, 595 Assessment Tool: Rubric for oral presentations, written reports	Mean of 80% across all students in courses assessed	2015: 90.8% 2016: 91.3% 2017: 91.2%	Learning outcome is being achieved
8. Broad education necessary to understand the impact of engineering solutions	Courses: BME 585, 595 Assessment Tool: Rubric for oral presentations, written reports	Mean of 80% across all students in courses assessed	2015: 89.0% 2016: 91.4% 2017: 89.6%	Learning outcome is being achieved

in a global, economic, environmental, and societal context				
9. Recognition of the need for, and an ability to engage in life-long learning	Courses: BME 480, 482, 585, 595 Assessment Tool: Questions on exams/quizzes, rubric for poster/presentation	Mean of 80% across all students in courses assessed	2015: 89.3% 2016: 88.3% 2017: 90.2%	Learning outcome is being achieved
10. Knowledge of contemporary issues	Courses: BME 585, 595 Assessment Tool: rubric for poster/presentation	Mean of 80% across all students in courses assessed	2015: 89.8% 2016: 90.5% 2017: 90.0%	Learning outcome is being achieved
11. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Courses: BME 335, 482, 585, 595 Assessment Tool: Questions on exams, rubric for paper/presentation	Mean of 80% across all students in courses assessed	2015: 92.0% 2016: 89.6% 2017: 90.4%	Learning outcome is being achieved
12. An understanding of biology and physiology	Courses: BME 462, 477, 480 Assessment Tool: Questions on exams	Mean of 80% across all students in courses assessed	2015: 93.5% 2016: 91.6% 2017: 95.6%	Learning outcome is being achieved
13. The capability to apply advanced mathematics to solve problems at the interface of engineering and biology	Courses: BME 452, 462, 480 Assessment Tool: Questions on exams	Mean of 80% across all students in courses assessed	2015: 86.8% 2016: 85.2% 2017: 89.8%	Learning outcome is being achieved, has improved over time
14. The ability to make measurements on and interpret data from living systems	Courses: BME 452, 480 Assessment Tool: Questions on exams, rubric for term project, lab report	Mean of 80% across all students in courses assessed	2015: 94.1% 2016: 83.3% 2017: 88.2%	Learning outcome is being achieved
15. Address problems associated with the interaction between living and non-living materials and systems	Courses: BME 477, 480, 482, 595 Assessment Tool: Questions on exams, rubric for project report	Mean of 80% across all students in courses assessed	2015: 91.2% 2016: 88.3% 2017: 90.7%	Learning outcome is being achieved, has improved over time

Results: The BME program annually assesses learning outcomes from all of its required courses in its curriculum. The BME program utilizes learning outcomes that are defined by ABET, the accrediting body for engineering programs. The faculty of the BME program have mapped specific learning outcomes from specific required BME courses to the ABET defined program outcomes, as shown in the Table 3.1 above. Not all learning outcomes are assessed in each required course, however, most of the learning outcomes are assessed in at least two of the courses. The BME faculty have also determined an acceptable threshold for each learning outcome is a mean attainment of 80% across all students for the metric being measured, across all courses assessed for each learning outcome. Metrics consist of specific exam/quiz questions, specific criteria from rubrics for oral presentations, lab reports or term projects, as well as specific criteria from the peer-evaluation for assessment of teamwork from CATME surveys. The overall collective results

are shown in Table 3.1, whereas the specific results for each learning outcome mapped to the specific courses they are assessed from 2015 to 2017 are shown in Appendix 2. As shown in the table above, the attainment threshold level of 80% is being met for all learning outcomes across 2015 to 2017.

Analysis: Collectively, all learning outcomes are being met across the required courses in the Biomedical Engineering curriculum. Given these are ABET defined learning outcomes, the learning outcomes in the table above will continue to be assessed on an annual basis.

d. Provide aggregate data on student majors' satisfaction (e.g., exit surveys), capstone results, licensing or certification examination results (if applicable), employer surveys or other such data that indicate student satisfaction with the program and whether students are learning the curriculum (for learner outcomes, data should relate to the outcomes of the program as listed in 3c).

The Biomedical Engineering program surveys the senior students in the BME 595 Capstone Design II course at the end of each academic year. Perceived 'Confidence in Knowledge' of various discipline areas, the perceived 'Ability to Perform Satisfactorily', as well as perceived value of the required BME courses are part of the survey. The BME faculty have determined a minimum threshold of 3.5 out of 5 as an acceptable level of attainment (scale: 1 = no confidence to 5 = extremely confident).

The specific categories of the student's perceived confidence in knowledge or understanding on the survey are shown below, with the results shown in Figure 3.2. The results indicated that the students perceived confidence in probability and statistics was below the acceptable threshold in 2015 and 2016. The BME program moved the required probability and statistics course from the Junior year to the Sophomore year in the curriculum, has made it a prerequisite to the Junior year Bioinstrumentation course (BME 480), and now requires students to utilize statistical procedures in some required BME courses.

Survey: Confidence in knowledge or understanding (1 = no confidence to 5 = extremely confident):

- Basic sciences (e.g., physics, chemistry, biology)
- Mathematics (e.g., calculus, differential equations)
- Probability and Statistics
- Engineering sciences
- Engineering design principles
- Engineering professionalism and ethical standards
- Teamwork
- Socio-economic context in which engineering is practiced

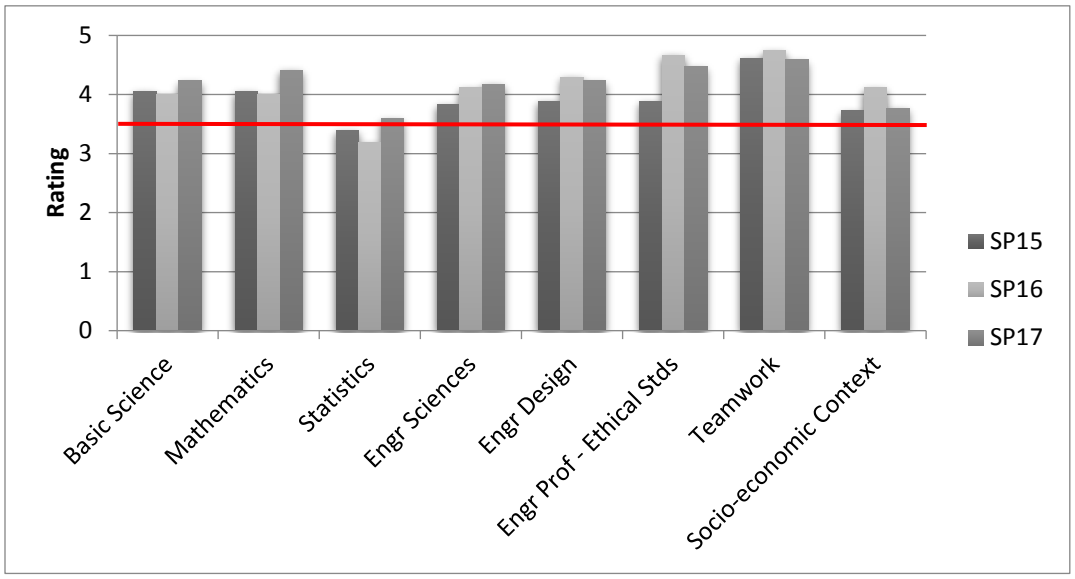

Figure 3.2 Senior Exit Survey Results for 'Confidence in Knowledge Area' (1 = no confidence to 5 = extremely confident).

The specific categories of the student's perceived confidence in ability to perform satisfactorily on the survey are shown below, with the results shown in Figure 3.3. The 2015 results indicated that the students perceived confidence in communicating with drawings and graphics was just above the acceptable threshold. The BME program teaches Solidworks (three-dimensional computer aided design software) for design in its Biomedical Computer Applications class (sophomore year), and has now required it use in at least two subsequent courses. The 2016 and 2017 results showed the perceived confidence level for this category increased. Other notable trends include consistently high confidence in written and verbal communication, an increase in the ability to self-learn, as well as confidence in problem solving and facilitating team processes.

Survey: Confidence in ability to perform satisfactorily (1 = no confidence to 5 = extremely confident):

- Integrate knowledge and information for engineering problem solving
- Communicate ideas and results verbally
- Communicate ideas and results in writing
- Communicate engineering ideas and results in drawings and graphic expressions
- Build teams and facilitate team processes/outcomes
- Locate needed knowledge and self-learn
- Work effectively in an international/global environment

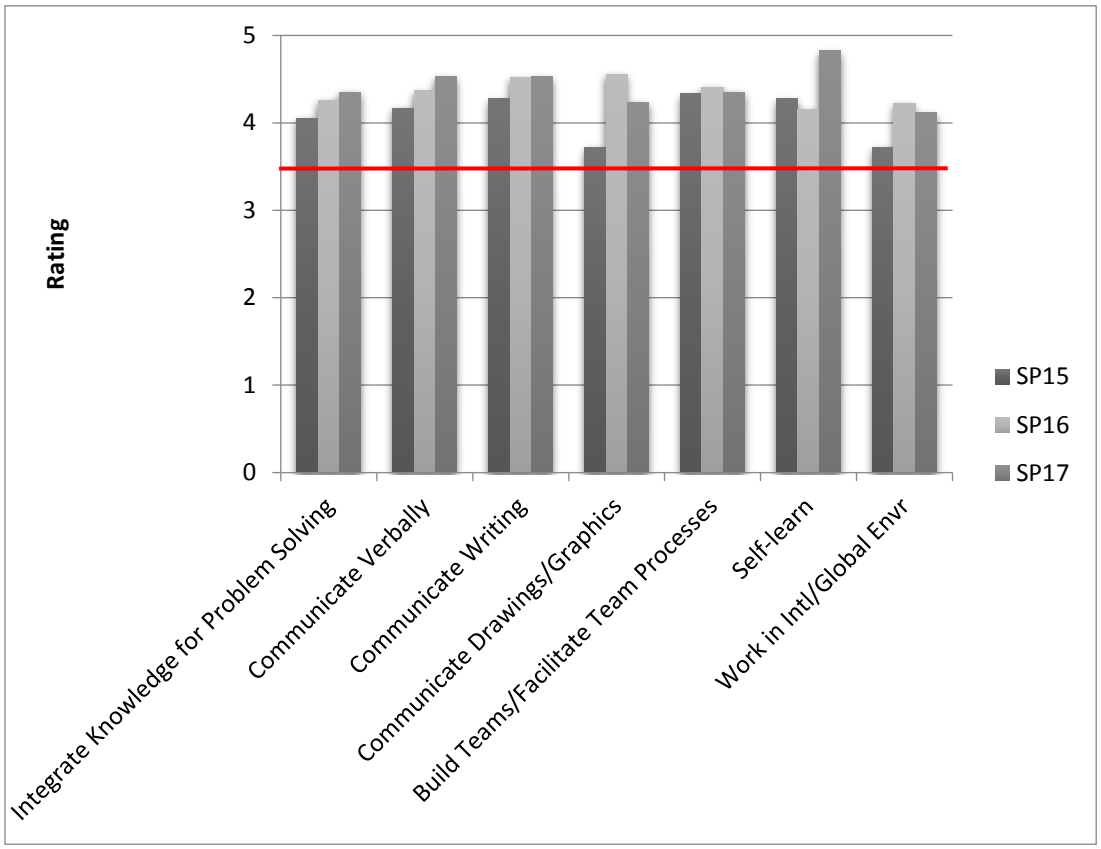

Figure 3.3 Senior Exit Survey Results for 'Confidence to Perform Tasks (1 = no confidence to 5 = extremely confident).

The perceived value of required courses are also surveyed from the senior BME students, with the results shown in Figure 3.4. BME 335 (Biomedical Computer Applications) is a fairly new course, which received high perceived value, likely due to the software taught in this course and utilization of these software skills in subsequent courses. BME 452 (Biomechanics) was below the acceptable threshold in the 2015. In 2016 and 2017 the perceived value increased, which may be due in part to the implementation of a Problem Based Learning approach in this course and additional lab activities. The Capstone Design courses (BME 585 and 595) remain at the highest perceived value of all required BME courses, likely due to the substantial clinical immersion time and real-world design experience that is required for these courses. Although the acceptable thresholds of perceived value were attained for BME 477 (intro to Biomaterials), BME 480 (Bioinstrumentation) and BME 482 (Design of Biodevices), a downward trend was noted. These trends will be reassessed and addressed as needed after the Spring 2018 BME Senior Exit Survey data are collected and reviewed.

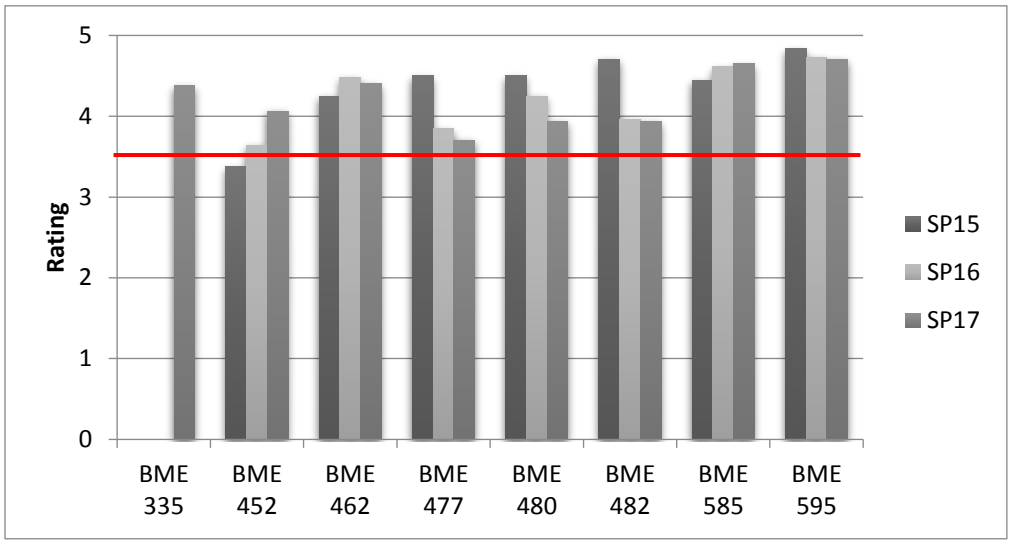

Figure 3.4 Senior Exit Survey Results for 'Perceived Value of Required Courses' (1 = no value to 5 = very high value; BME 335: Biomedical Computer Applications; BME 452: Biomechanics; BME 462: Intro to Biofluids; BME 477: Intro to Biomaterials; BME 480: Bioinstrumentation; BME 482: Design of Biodevices; BME 585: Capstone Design I; BME 595: Capstone Design II).

Figure 3.5 shows the results of 'Satisfaction with Program' from WSU Senior exit surveys. From 2013 to 2017, the BME program student's level of satisfaction (satisfied or very satisfied) was consistently higher than the satisfaction level of the College of Engineering undergraduate students, whereas it was very similar to WSU undergraduate student satisfaction levels.

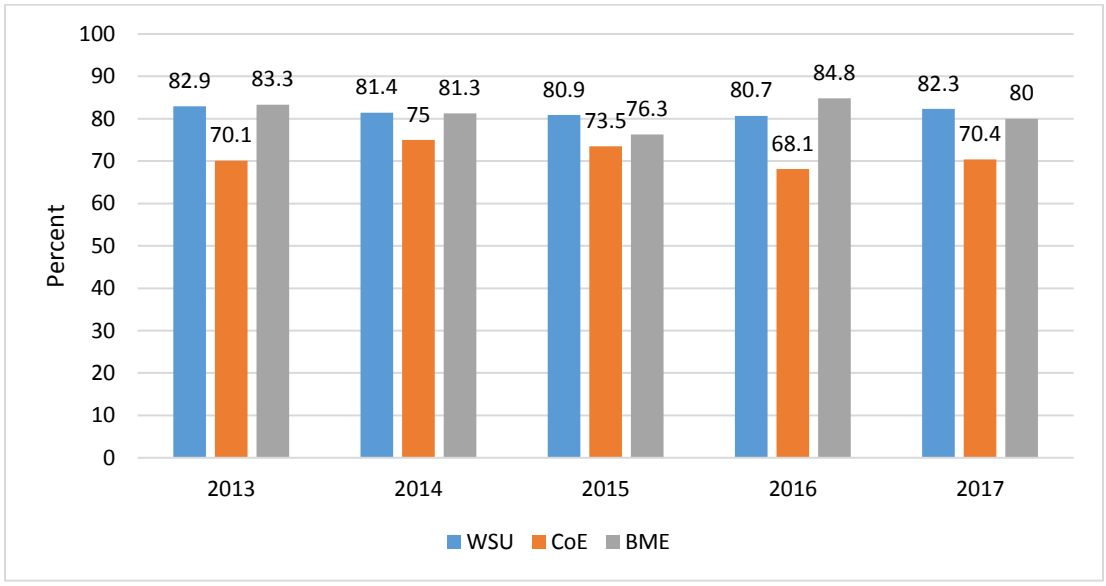

Figure 3.4 WSU Senior Exit Survey 'Satisfaction with Program' Results (percent satisfied or very satisfied with program)

e. Provide aggregate data on how the goals of the *WSU General Education Program* and *KBOR 2020 Foundation Skills* are assessed in undergraduate programs (optional for graduate programs).

Outcomes:	Results	
○ Have acquired knowledge in the arts, humanities, and natural and social sciences ○ Think critically and independently ○ Write and speak effectively ○ Employ analytical reasoning and problem solving techniques	Majors	Non-Majors

Note: Not all programs evaluate every goal/skill. Programs may choose to use assessment rubrics for this purpose. Sample forms available at: http://www.aacu.org/value/rubrics/

f. For programs/departments with concurrent enrollment courses (per KBOR policy), provide the assessment of such courses over the last three years (disaggregated by each year) that assures grading standards (e.g., papers, portfolios, quizzes, labs, etc.) course management, instructional delivery, and content meet or exceed those in regular on-campus sections.
Provide information here: N/A

g. Indicate whether the program is accredited by a specialty accrediting body including the next review date and concerns from the last review.
Provide information here:

The BME undergraduate program received full accreditation by ABET after its 2013 accreditation visit. The next ABET accreditation visit is 2020.

h. Provide the process the department uses to assure assignment of credit hours (per WSU policy 2.18) to all courses has been reviewed over the last three years.
Provide information here:

All faculty utilize a standardized Wichita State University syllabus, and all syllabi contain the required language defining the definition of a credit hour appropriate the type of the course.

i. Provide a brief assessment of the overall quality of the academic program using the data from 3a – 3e and other information you may collect, including outstanding student work (e.g., outstanding scholarship, inductions into honor organizations, publications, special awards, academic scholarships, student recruitment and retention).
Provide assessment here:

Many students choose to major in Biomedical Engineering because they enjoy math, science, how this engineering discipline intersects with medicine and the improvement of health, and that this is a discipline where students can have a real and tangible impact on people's lives. Additionally, 20% of BME students also indicate they are interested in a career in medicine when they enter BME. Thus, students who choose to major in BME tend to have skills in various academic areas (e.g., math, science, communication), which is consistent with the BME students mean composite ACT scores averaging 2.5 points higher the past two years than WSU students overall. The BME curriculum is assessed each academic year by the BME faculty for student learning outcomes defined by ABET, across the various

required BME courses. As our annual academic year assessments have shown, each student learning outcome is being achieved, many at very high levels of attainment. BME students also perceive themselves collectively to have confidence in knowledge of various areas including basic science, use of mathematics, engineering sciences and design, an increasing confidence in use of statistics, and an overall high level of confidence in teamwork. Additionally, BME students also have a high level of confidence to self-learn, communicate verbally, in writing as well as with drawings and graphics, and have confidence in working in teams. BME graduates are satisfied with the program overall as evidenced by similar percent satisfied or very satisfied with the program as results from WSU undergraduate students overall.

Additional accomplishments of students (supported and directed by the BME faculty) as listed below which collectively demonstrate the high quality of the students and the BME program overall:

- Scholarships, Innovation and Awards. BME students during the program review period have included a number of students awarded significant scholarships and recognition awards.
    - From 2015-2017, there were 12 active Wallace Scholars who majored in BME (Wallace Scholarships are awarded to 10 to 11 incoming outstanding engineering freshmen each year in the College of Engineering), three BME students were selected as University Innovation Fellows, and four BME students were Distinguished Scholarship Invitational finalists.
    - Special WSU awards include WSU Student of the Year in 2016 and 2017 (and a finalist in 2015) and two students selected for WSU Senior Honors in Spring 2018.
- Shocker New Venture Competition. BME Capstone Design teams are required to enter their project into the WSU Shocker New Venture Competition (SNVC) each year, which typically has more than 60 entries each year. Each of the past three years, BME Capstone Design teams have made the SNVC Trade Show (final 16 teams): 2015 – three Capstone Design teams; 2016 – three Capstone Design teams; 2017 – five Capstone Design teams. As a side note, in 2018, there were nine BME Capstone Design teams in the SNVC Trade Show, with BME teams placing 1st and 3rd place overall.
- Coulter College. In 2015, a WSU BME team of six students, a faculty mentor and clinical mentor were one of 20 teams selected from universities across the U.S.to participate in an event called Coulter College, which was a three-day innovation event to solve a medical need through the development of a medical device or process. Other teams selected to participate were from notable universities such as Johns Hopkins University and Georgia Tech.
- Undergraduate Research. Many BME students have an interest in engaging in research, and the BME faculty also have a commitment to mentoring undergraduate students in research and dissemination of the student's research.
    - In the past two summers, BME undergraduate students were selected to participate in research at the following institutions: KU School of Medicine, University of Virginia, University of Georgia, Johns Hopkins University, Vanderbilt University, University of Georgia, Wake Forest University, University of Illinois, and East Carolina University.
    - BME undergraduate students have been authors on four published journal articles, one that has been accepted, and two that are currently in review.
    - BME students have presented their research at various research conferences and forums in Wichita (i.e., Undergraduate Research and Creative Activity Forum) and conferences around the U.S. As shown in Figure 3.5, research presentations by BME

undergraduate students has increased each year, from two in 2012 to 30 in 2017. Many of the students who presented at various conferences and forums were awarded first or second place presentation awards.

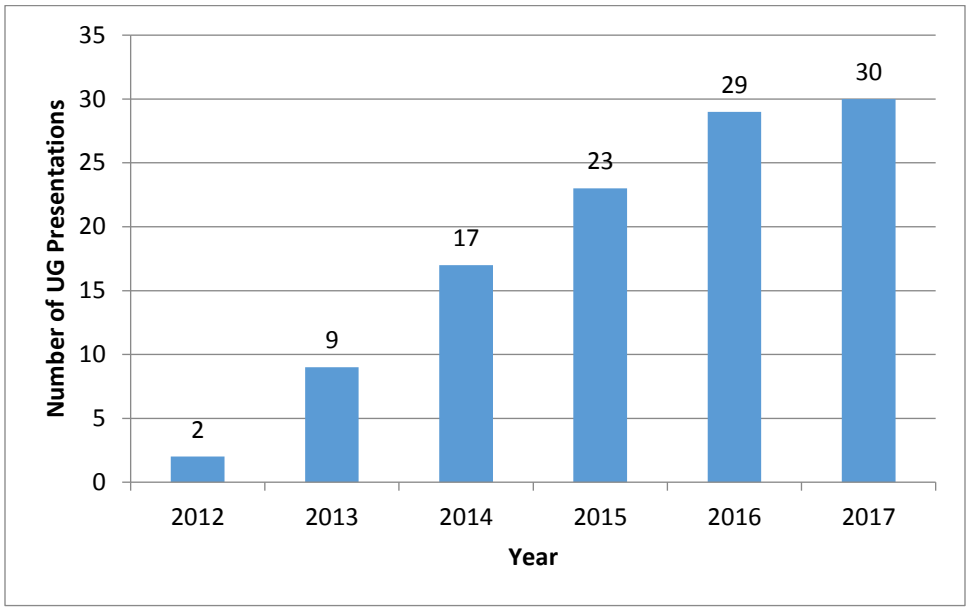

Figure 3.5 Number of yearly BME Undergraduate Research Presentations at Various Research Conferences and Forums.

Finally from 2015 to 2017, 66 BS BME degrees were conferred. Of the 66 BS BME graduates:

- 68.2% completed minors (12 different minors: Chemistry, Women Studies, Biology, Exercise Science, Physics, Math, History, Music, Spanish, Philosophy, French, Computer Science)
- Graduates matriculated to positions in private industry and labs, graduate schools (MS and PhD programs), and professional schools (e.g., medical school, pharmacy school, law school, physician assistant program, prosthetics and orthotics – see Figure 3.6). Placements of BS BME graduates can be found at this webpage: http://webs.wichita.edu/?u=bme&p=/alumni/.

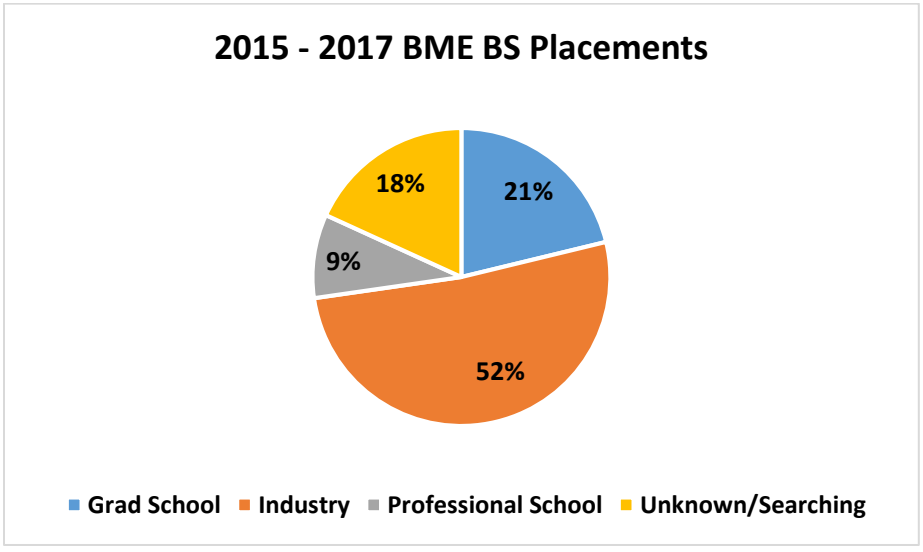

Figure 3.6 Placements of BS BME graduates from 2015 to 2017.

4. Analyze the student need and employer demand for the program/certificate. Complete for each program if appropriate (refer to instructions in the WSU Program Review document for more information on completing this section).

a. Evaluate tables 11-15 from the Office of Planning Analysis for number of applicants, admits, and enrollments and percent URM students by student level and degrees conferred.

b. Utilize the table below to provide data that demonstrates student need and demand for the program.

Employment of Majors*							
	Average Salary	Employ-ment % In state	Employment % in the field	Employment: % related to the field	Employment: % outside the field	No. pursuing graduate or profes-sional educa-tion	Projected growth from BLS** Current year only.
Year 1							
Year 2							
Year 3							7.2% growth from 2016-2026

* May not be collected every year

** Go to the U.S. Bureau of Labor Statistics Website: http://www.bls.gov/oco/ and view job outlook data and salary information (if the Program has information available from professional associations or alumni surveys, enter that data)

- Provide a brief assessment of student need and demand using the data from tables 11-15 from the Office of Planning and Analysis and from the table above. Include the most common types of positions, in terms of employment graduates can expect to find.

Provide assessment here: As shown in Figure 4.1, the applicants to the BME program have grown each year since 2012, with a substantial increase from 2016 to 2017. The percent of the applicants that matriculated to the BME program was 49% in 2015 and 46% in 2016 and 2017.

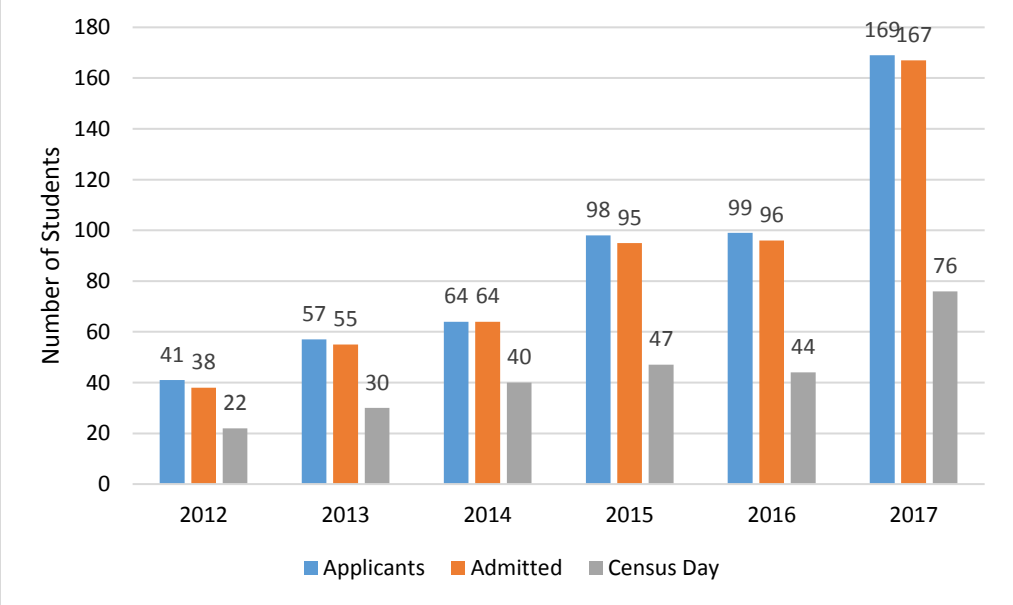

Figure 4.1 Applicants, Admits and Enrollment on Census Day

As shown in Figure 4.2, between Fall 2012 and Fall 2016, under-represented minorities represented and average of 16% of the BME majors. Additionally, the percent of conferred BS BME degrees that were under-represented minorities ranged from 6.3% to 26.7% from 2013 to 2017 (Figure 4.3), with an average of 13.8% over that timeframe. This level is similar to that of WSU (13.9%) and higher than the College of Engineering (9.8%) over that timeframe.

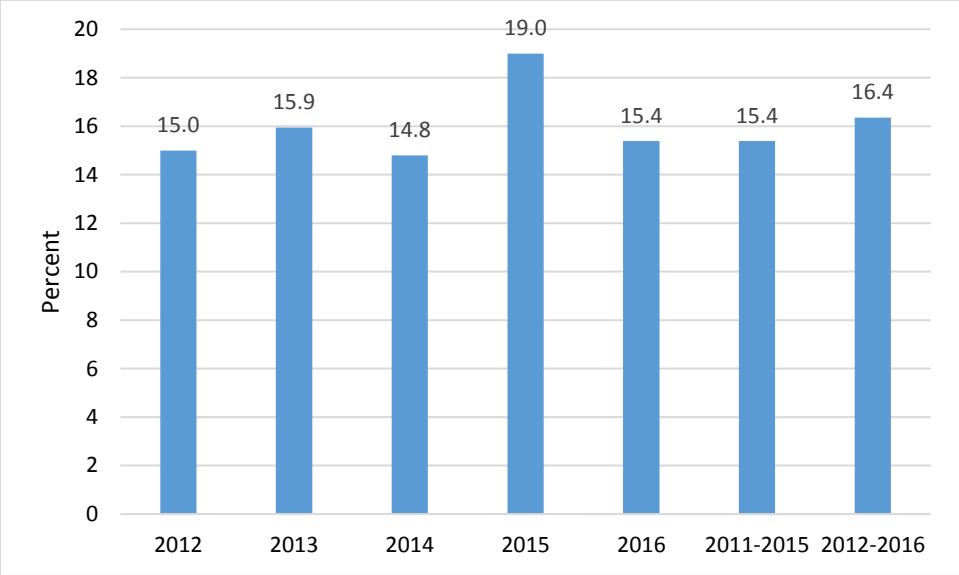

Figure 4.2 Percent BME Program Major Under-Represented (URM) Minorities on Fall Census Day

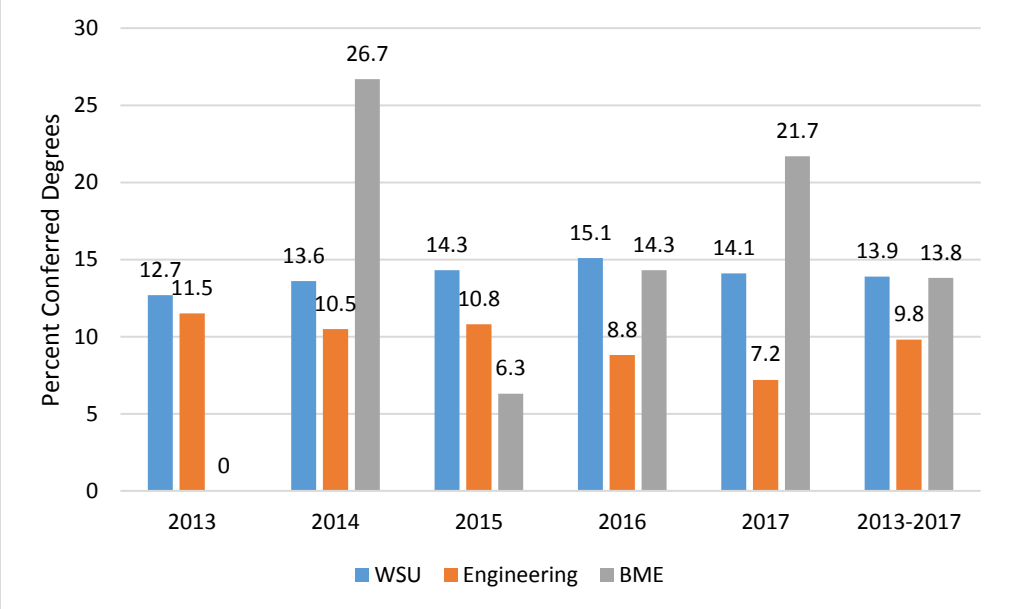

Figure 4.3 Percent of Conferred BS BME Degrees to Under-Represented Minorities (URM)

Projections from the U.S. Bureau of Labor Statistics estimate employment growth of 7.2% for Biomedical Engineers from 2016 to 2026. From 2015 to 2017, 66 BS BME degrees at WSU were conferred. Of these graduates, 52% matriculated to positions in private industry and labs, 21% to graduate schools (MS and PhD programs in engineering), 9% to professional schools (e.g., medical school, pharmacy school, law

school, physician assistant program, prosthetics and orthotics – see Figure 3.6), and 18% were still searching or unknown status. Specific placements (i.e., graduate schools, professional schools, private industry companies) of BS BME graduates can be found at this webpage: http://webs.wichita.edu/?u=bme&p=/alumni/.

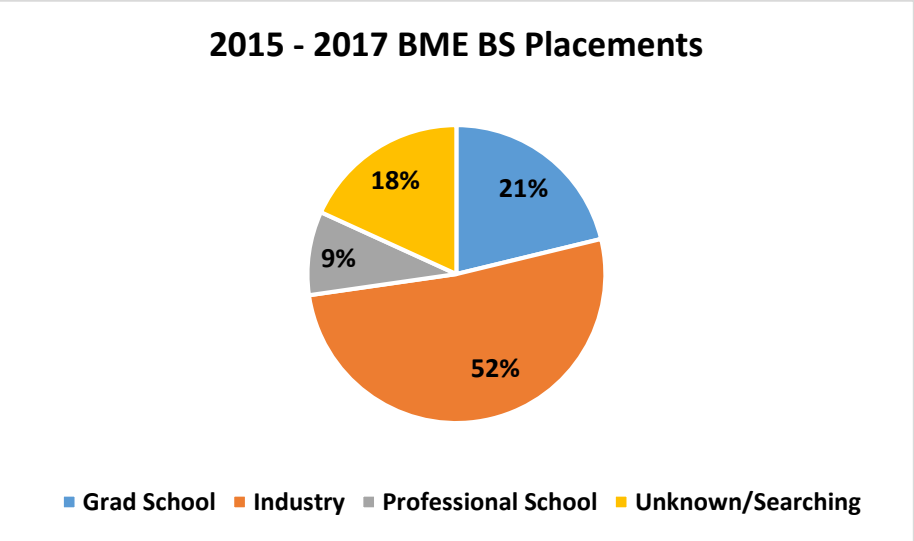

Figure 3.6 Placements of BS BME graduates from 2015 to 2017.

During the 2015-2017 program review period, 34 of the 66 graduates found employment in the private industry sector. Of the 34 graduates, 16 found employment in Kansas, 9 in surrounding States (OK, NE, CO, MO), 8 in other States, and one internationally. The employment sectors that BME graduates typically found employment in include Biomedical Devices, Pharmaceuticals, Hospitals/Clinics/Healthcare, Environmental Safety and Health, and General Manufacturing. Below is a list of some job titles of BME graduates in the various private industry sectors:

- Medical Devices: Biomedical Engineering, Biomedical Designer, Surveillance Engineer, Quality Engineer, Biomedical Sales Engineer, Junior Engineer
- Pharmaceuticals: Change Control Engineer, Process Engineer, Remediation Engineer, R&D Associate Scientist
- Hospitals, Clinics, Healthcare: Consulting Analyst, Healthcare IT Consultant, Biomedical Equipment Technician, Imaging Engineer, Lab Service Engineer, Biomedical Project Engineer, IOM Technologist, Lab Manager, Research Data Associate
- Environmental Health and Safety: Safety Coordinator, EHS Engineer
- General Manufacturing: Mechanical Design Engineer, Mechanical Designer, Diagnostics Engineer, Lab Technician, Engineering Data Administrator

5. **Analyze the service the Program/certificate provides to the discipline, other programs at the University, and beyond. Complete for each program if appropriate (refer to instructions in the WSU Program Review document for more information on completing this section).**

Evaluate table 16 from the Office of Planning Analysis for SCH by student department affiliation on fall census day.

a. Provide a brief assessment of the service the Program provides. Comment on percentage of SCH taken by majors and non-majors, nature of Program in terms of the service it provides to other University programs, faculty service to the institution, and beyond.

Provide assessment here:

The percent of SCH taken by majors in the Biomedical Engineering courses was 92.3% and 86.9% for 2015 and 2016, respectively. Since 2014, the trend is for more students outside the BME Department enrolling in BME courses (Figure 5.1), including students from Mechanical Engineering, Aerospace Engineering, Biological Sciences and Chemistry.

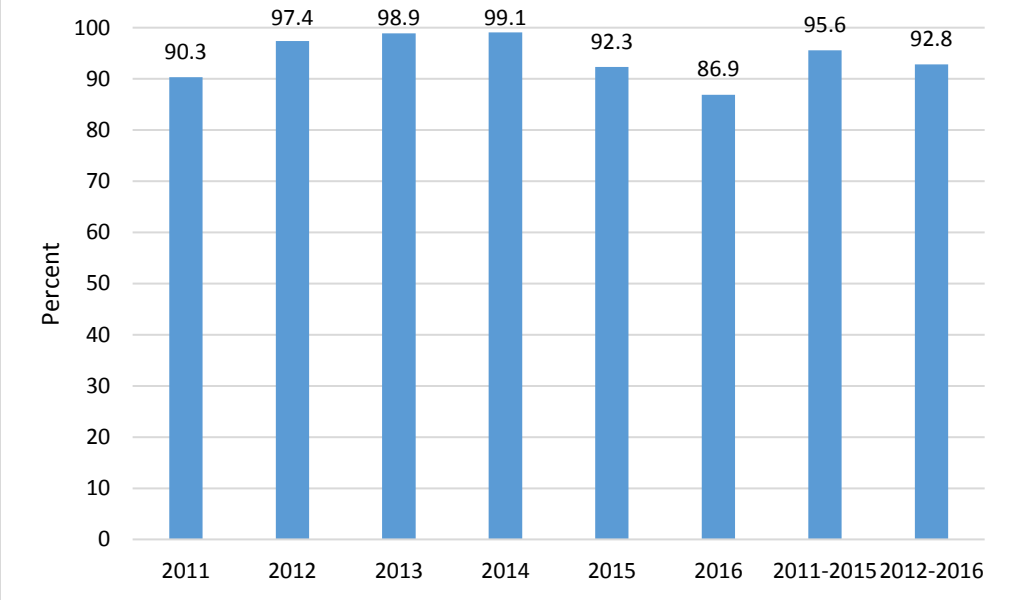

Figure 5.1 Percent BME Department Student Credit Hours taken by BME Majors

The faculty of the BME Department provides service to the Department, the College of Engineering, the University, and outside the University.

Dr. Michael Jorgensen, who previously served as the Coordinator of the Bioengineering program and now serves as the founding Chair of the BME Department, is also a tenured Associate Professor in the ISME Department in the College of Engineering. Within the BME Department, Dr. Jorgensen developed and teaches a BME first year seminar class (BME 115), directed the successful initial ABET accreditation for the BME program, directs the faculty and staff recruitment and evaluation, performs the majority of the student recruitment efforts, advising of students, accreditation and assessment efforts for the program, leads the curriculum development, and budgetary decisions and maintenance. Within the College of Engineering, Dr. Jorgensen sits on the Curriculum committee, previously sat on the College

Assessment committee, the Strategic Planning committee, the Scholarship committee, and has served on various search committees. At the University level, Dr. Jorgensen was the Chair of the Intercollegiate Athletic Advisory Board (ICAA), participated in the Coleman Foundation Fellowship Program with the Center of Entrepreneurship, as well as the WSU Leadership Academy. Outside the University, Dr. Jorgensen is on the Editorial Board of one peer-reviewed journal (*Human Factors*), is a Scientific Editor for one peer-reviewed journal (*Applied Ergonomics*), and routinely reviews manuscripts for other peer-reviewed journals.

Dr. Anil Mahapatro joined WSU in August 2011. Within the BME Department, Dr. Mahapatro has served on faculty search committees, participated in ABET accreditation assessment activities, and collaborates with faculty on research from several departments (e.g., Mechanical Engineering, Human Performance Studies, Biology, Chemistry), currently serves as the first Graduate Coordinator for the new MS in BME program, serves as a College of Engineering senator in the Faculty Senate, and founded and serves as the faculty advisor for the Society of Biomaterials student chapter. Outside the BME Department, Dr. Mahapatro serves on the College of Engineering Strategic Planning committee. Outside the University, Dr. Mahapatro reviews manuscripts for several peer-reviewed journals, and served as an Associate Editor for one peer-reviewed journal (*Nanomaterials and Tissue Regeneration*).

Dr. Nils Hakansson joined WSU in January 2012. Within the BME Department Dr. Hakansson has served on faculty search committees, participated in ABET accreditation assessment activities, and collaborates with faculty on research from several departments (e.g., Mechanical Engineering, Electrical Engineering, Industrial Engineering, Exercise Science, Physical Therapy). Within the University, Dr. Hakansson served on the ADA Review Committee for the Experiential Engineering Building, and has guest lectured for Human Performance Studies and Physical Therapy courses.

Dr. Kim Cluff joined WSU in January 2013. Within the BME Department Dr. Cluff has served on faculty and staff search committees, participated in ABET accreditation assessment activities, and collaborates with faculty on research from several departments (e.g., Mechanical Engineering, Electrical Engineering, Human Performance Studies, Anthropology). Within the College of Engineering, Dr. Cluff served on the Awards committee. At the University level, Dr. Cluff serves as the Chair of the IUCU committee. Outside the University, Dr. Cluff has served as a reviewer for a peer-reviewed journals and a judge for high school design projects, and serves on the Industrial Advisory Board for the University of Nebraska Biological Systems Engineering Department.

Dr. Gary Brooking joined WSU in August 2014. Within the BME Department Dr. Brooking has served on the ABET accreditation committee, taught and enhanced our two-semester sequence of Capstone Design, served as the faculty advisor for student chapter of the Biomedical Engineering Society, Engineers Without Borders, and the University Innovation Fellows. Within the University, Dr. Brooking was active as a Coleman Foundation Fellow, and has served as an observer for the Distinguished Scholarship Invitational. Dr. Brooking left the BME Department in August 2017 to serve as the Director of the WSU Engineering Technology program.

Dr. David Long joined WSU in January 2017. Within the BME Department, Dr. Long has participated in student recruitment activities and lab tours, and served on a faculty search committee.

Dr. Jaydip Desai joined WSU in August 2017. Within the BME Department, Dr. Desai has participated in student recruitment activities and serves on the Awards committee. For the College of Engineering, Dr. Desai serves on the Awards committee.

6. Report on the Program's/certificate's goal (s) from the last review. List the goal (s), data that may have been collected to support the goal, and the outcome. Complete for each program if appropriate (refer to instructions in the WSU Program Review document for more information on completing this section).

(For Last 3 FYs)	Goal (s)	Assessment Data Analyzed	Outcome
	Development of a graduate program		A MS in BME program started in January 2017, and currently has 7 MS students enrolled
	Increase co-op and internship placements for BME students	Data from the WSU Career Development Center	2015 – 6 placements 2016 – 13 placements 2017 – 23 placements
	Increase undergraduate research for BME students	Number of undergraduate research presentations at research conferences and forums	2015 – 23 presentations 2016 – 29 presentations 2017 – 30 presentations
	Increase research dissemination of BME faculty	Track journal article publications in annual faculty activity record	2012-2014: 0.94 journal publications per faculty 2015-2017: 1.83 journal publications per faculty
	Increase research expenditures	Data from WSU Office of Research and Technology Transfer	2015: $73,522 2016: $215,004 2017: $345,311

7. Summary and Recommendations

a. Set forth a summary of the report including an overview evaluating the strengths and concerns. List recommendations for improvement of each Program (for departments with multiple programs) that have resulted from this report (relate recommendations back to information provided in any of the categories and to the goals and objectives of the program as listed in 1e). Identify three year goal (s) for the Program to be accomplished in time for the next review.

Provide assessment here:

Strengths: The strengths of the Biomedical Engineering undergraduate program centers around sustained growth, quality of students and faculty, and excellence.

The BME Department has experienced sustained growth and improvement during this program review period (2015-2017) in the following key areas:

- BS student enrollment: 179 in 2015 to 237 in 2017, an annual 12% increase over past 3 years; 57% female in 2017, ~20% pre-med
- Student Credit Hours: 699 in 2015 to 1,274 in 2017
- Conferred BS degrees: 16 in 2015 to 23 in 2017; anticipated 36 in Spring 2018 alone
- Satisfaction with the BME program (satisfied or very satisfied) from WSU Senior Exit Surveys: higher than satisfaction from overall College of Engineering graduates (2.8% in 2015, 16.7% in 2016, 9.6% in 2017)
- Research expenditures: $73,522 in 2015 to $345,311 in 2017
- Research dissemination: 0.94 journal articles per faculty during 2012-2014 to 1.83 journal articles per faculty during 2015-2017

- Undergraduate student research conference presentations: 23 in 2015 to 30 in 2017
- MS student enrollment in new MS BME program: 2 in Spring 2017, 5 in Fall 2017
- Student Credit Hours taken by non-BME students: 0.9% in 2014 to 13.1% in 2016

Other strengths of the BME Department include the quality of its faculty and students, as well as the activities of the BME Department personnel and students.

- Quality of students as demonstrated by:
  - Mean composite ACT score approximately 2.5 points higher than overall WSU students
  - Approximately 20% of BME students identify themselves as pre-med
  - 68.2% of BME graduates between 2015 and 2017 were awarded minors
  - Percent of conferred degrees to underrepresented minorities higher than the College of Engineering
  - Placement of BS graduates in professional schools (medical school, physician assistant, therapy, law, prosthetics) and MS and PhD programs in various Engineering disciplines
  - Immersion of BME students in Wichita community for student chapter activities, Capstone Design process
- Quality of faculty as demonstrated by:
  - Perceived BME course value compared to all other Engineering courses based on SPTE assessments: mean 47.7 percentile during 2012-2014 to 63.5 percentile during 2015-2017
  - Recognition by WSU and the College of Engineering of BME faculty for excellence in teaching, research and service

The main concerns for the Biomedical Engineering Department include:

- Lack of research/teaching laboratory space to accommodate future sustained growth in students and faculty. This is especially important as there are many hands-on laboratory exercises in our BME courses and faculty do primarily experimental research.
- BME faculty salaries: compared to BME programs around the U.S., WSU BME faculty salaries for assistant and associate professors are near the bottom of the range of salaries among public institutions with undergraduate and graduate programs. This represents a challenge when recruiting new faculty, and may turn into a challenge for retaining current faculty.
- A new BME undergraduate program is starting at Kansas State University in Fall 2018, thus, we will have increased competition for undergraduate students.
- Lack of a PhD program. We are currently developing a proposal for a PhD program in Biomedical Engineering, which will help increase research expenditures, attract future quality faculty.
- There are no female faculty in BME Department. Our first faculty hire was a female, who left WSU after one year. We have tried unsuccessfully since then to hire female faculty.
- The Biomedical Engineering Department has the lowest number of co-op/internship placements in the College of Engineering.

The three-year goals to be completed by the next program review include:

- Implement a PhD program in Biomedical Engineering
- Increase BME departmental research expenditures
- Increase BME departmental research dissemination
- Achieve ABET reaccreditation in 2020
- Increase co-op and internship placements for BME students

Appendix 1. Biomedical Engineering Faculty Mentoring, Workshops and Professional Development Activities

Dr. Michael Jorgensen, Associate Professor and Department Chair
Faculty Workshops:
Professional Development: Coleman Faculty Fellow in Entrepreneurship; WSU Leadership Academy; Biomedical Engineering Council of Chairs annual meetings; Kansas Leadership Center workshop

Dr. Anil Mahapatro, Associate Professor (2011 to present):
Mentoring: WSU Pre-tenure club, CoE Faculty Mentoring Program
Faculty Workshops: NSF CAREER Award planning and writing seminar; SBIR Road Tour; Developing a winning SBIR/STTR proposal; Kansas Leadership Center workshop; Brenton Myers lecture and workshop (Divergent thinking in the classroom); SBIR Road Tour;

Dr. Nils Hakansson, Assistant Professor (2012 to present):
Mentoring: WSU Pre-tenure club, CoE Faculty Mentoring Program
Faculty Workshops:
Professional Development: NSF CAREER Award training; COMSOL software training; NIH grant writing training; NSF I-Corp training; KEEN training webinar; Kansas Leadership Center workshop; Brenton Myers lecture and workshop (Divergent thinking in the classroom); KEEN BME training webinar;

Dr. Kim Cluff, Assistant Professor (2013 to present):
Mentoring: WSU Pre-tenure club, CoE Faculty Mentoring Program
Faculty Workshops:
Professional Development: NIH Meet the Experts Webinar R01, R15; Writing a winning proposal for NSF CAREER Award; IP and Tech Transfer seminar; SBIR Road Tour seminar; Trip to NSF to meet program managers; Developing a winning SBIR/STTR proposal workshop; Kansas City Medical Device & Healthcare Technology Showcase; Kansas Leadership Center workshop; Early Career Development workshop at AHA conference; IACUC Chair training;

Dr. David Long, Assistant Professor (2017 to present):
Mentoring: WSU Pre-tenure club, CoE Faculty Mentoring Program
Faculty Workshops:
Professional Development:

Dr. Jaydip Desai, Assistant Professor (2017 to present):
Mentoring: WSU Pre-tenure club, CoE Faculty Mentoring Program
Faculty Workshops:
Professional Development:

Dr. Gary Brooking, Engineering Educator (2014 to 2017):
Mentoring: Dr. Jorgensen
Faculty Workshops: NSF I-Corps training; Capstone Design Conference; BME IDEA workshop; MEEN/I-Corp Regional conference; Coleman Fellow Workshop; KEEN webinars; VentureWell webinars; BMES webinars; CEO conference; WSU Simulations and Grading workshop; VentureWell OPEN conference;

Appendix 2: Specific Learning Outcome and Results in each of the BME Courses, 2015, 2016, 2017 (top, middle, bottom number in each cell, respectively).

Learning Outcome	BME Courses*								
	BME 335	BME 452	BME 462	BME 477	BME 480	BME 482	BME 585	BME 595	Overall
1. Ability to apply knowledge of mathematics, science, and engineering		84.0 84.4 83.2	93.0 96.0 97.9		N/A 83.0 91.6				88.5 87.8 90.3
2. Ability to design and conduct experiments, as well as to analyze and interpret data		85.7 88.0 87.9		96.8 89.9 95.8	91.9 90.6 91.7			93.5 88.1	92.0 89.2 91.3
3. Ability to design a system, component or process to meet desired needs with realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	N/A 88.9 86.2					94.1 88.1 94.5		93.8 90.0	93.9 89.0 90.6
4. Ability to function on multidisciplinary teams							92.0 89.0 94.3	95.7 89.8	93.9 89.4 92.0
5. Ability to identify, formulate and solve engineering problems	N/A 92.9 89.3		89.2 86.3 88.0					92.4 91.3	90.8 90.2 89.6
6. Understanding of professional and ethical responsibility				93.7 92.7 95.0			88.4 89.0 88.5	92.5 94.1	91.5 91.9 90.6
7. Ability to communicate effectively		87.6 N/A N/A				93.8 89.9 89.9	87.1 92.0 89.7	94.6 92.1	90.8 91.3 91.2
8. Broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context							84.2 91.0 89.6	93.7 91.8	89.0 91.4 89.6
9. Recognition of the need for, and an ability to engage in life-long learning		81.7 N/A N/A			95.3 89.7 89.3	N/A 89.0 89.1	86.1 83.0 93.3	94.0 94.3	89.3 88.3 90.2
10. Knowledge of contemporary issues							85.0 92.0 91.7	94.6 89.0	89.8 90.5 90.0
11. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	N/A 91.6 89.7					95.6 89.2 93.1	86.7 86.0 87.7	93.8 91.7	92.0 89.6 90.4
12. An understanding of biology and physiology			97.5 89.1 92.7	93.0 96.8 97.6	90.1 89.0 96.5				93.5 91.6 95.6
13. The capability to apply advanced mathematics to solve problems at the interface of engineering and biology		87.3 83.0 85.5	81.4 83.6 96.2		91.8 89.1 87.7				86.8 85.2 89.8
14. The ability to make measurements on and interpret data from living systems		N/A 77.3 83.2			94.1 89.2 93.2				94.1 83.3 88.2
15. Address problems associated with the interaction between living and non-living materials and systems				80.8 82.8 93.3	N/A 91.3 92.0	99.0 86.9 87.1		93.9 92.1 90.5	91.2 88.3 90.7

*BME 335: Biomedical Computer Applications; BME 452: Biomechanics; BME 462: Intro to Biofluids; BME 477: Intro to Biomaterials; BME 480: Bioinstrumentation; BME 482: Design of Biodevices; BME 585: Capstone Design I; BME 595: Capstone Design II.