Section II – Assessment of Student Learning

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1. **Student Learning Outcomes (SLOs)**
    a. Students will be able to effectively communicate mathematical ideas.
    b. Students will be able to apply basic algebra and calculus skills to compute solutions to mathematical problems.
    c. Students will be able to demonstrate critical thinking skills to solve real world mathematical applications.
    d. Students will be able to construct valid mathematical proofs.
    e. Students will be able to utilize technology to solve mathematical problems.
2. **General Studies Integration**
    The Mathematics Program is incorporating the following General Studies SLOs into our assessment plan.
    i. Critical thinking – covered in Mathematics SLO(c) and SLO(d)
    ii. Effective Oral Communication – covered in Mathematics SLO(a)
    iii. Effective Writing – covered in Mathematics SLO(a) (and SLO(d) to some extent)
    iv. Technology Literacy – covered in Mathematics SLO(e)
    v. Proficiency in Basic Mathematics – covered in SLO(b)

    Data collected from MATH 480 (Mathematics Capstone) can be used to assess the General Studies SLOs addressing "Effective Oral Communication" and "Effective Writing". In this course, students are required to present their solutions to weekly problem sets multiple times throughout the semester, and they are required to complete a research project for which they must write a formal paper and present their findings to the class. The weekly nature of the problem sets allows for the observation of trends not only year-to-year, but also within a particular semester.

    The General Studies SLO addressing "Technology Literacy" will be assessed in many of our classes in the near future. Currently, this SLO is addressed mainly in MATH 175 (Computer Programming for the Sciences) in which students utilize a computer programming language to solve mathematical problems. Graphing calculators and online homework systems are currently utilized in many of the courses offered by the Mathematics Program, especially 100- and 200-level courses. So, many non-Mathematics majors are gaining knowledge in these various technologies. Additionally, the Mathematics faculty are currently working to increase the use of mathematical software and online programs (e.g., Mathematica and GeoGebra) in many courses. We

plan to determine appropriate assessment measures (and locations) in the coming months.

A pre- and post-test of basic algebra and Pre-Calculus skills given in MATH 210 (Calculus I) is being used to assess "Proficiency in Basic Mathematics". There has been discussion of developing and implementing a pre- and post-test of basic arithmetic and algebra skills in MATH 140 (College Algebra) and possibly MATH 145 (Pre-Calculus). Implementation of such measures in MATH 140 and MATH 145 will allow us to assess the proficiency of non-Mathematics majors in basic Mathematics skills.

Additionally, we believe it may be beneficial to develop additional measures for the assessment of General Studies SLOs in our general studies courses. To some degree, it seems "unfair" to assess only our majors on these SLOs. Being that these are General Studies SLOs, our goal should be for *all* of our students to demonstrate proficiency in these areas, not just Mathematics majors. This will be a focus of the Mathematics faculty in the Spring and Fall 2015 semesters.

These General Studies SLOs are (or will be) assessed using the assessment measures the Mathematics faculty have developed to assess the Program SLOs. The descriptions of these measures can be found in Section 3. For General Studies SLOs that may be assessed in general studies courses, new methods of assessment may be necessary.

3. **Assessment Method (Measures/Instruments)**
   a. **Direct Measures**
      i. SLO(a) – Students will be required to complete project-based learning assignments and report their results in both written and oral formats in MATH 375 (Differential Equations). The instrument for evaluating these problems will be a rubric assessing Organization, Subject Knowledge, and Mathematical Language. For each category, there are three tiers of scoring – Limited, Adequate, and Proficient – where Limited indicates a very limited ability (and possibly complete inability) to effectively interpret and communicate mathematical concepts, and Proficient indicates a mastery of written and oral communication of mathematical concepts. While the Mathematics faculty would like to use a numerical scale, such a scale has not yet been decided upon. The Mathematics faculty is also debating a possible four-tier grading system, but have decided to use the current rubrics before adding another tier. The

criteria for each tier will be defined so that any instructor may properly apply the rubric.

Students are required to complete weekly problems and present their solutions (in MATH 480 – Capstone). The focus of the weekly problems for assessment purposes with respect to SLO(a) is the oral communication techniques of our students. The instrument used to evaluate these problems will be the same on mentioned above.

Students are required to complete a faculty-guided research project for which they must report their results in both written and oral formats in MATH 480 (Mathematics Capstone). The instruments used to evaluate both the written and oral portions of this project are rubrics that assess five criteria (Written: Controlling Idea/Focus/Purpose, Mathematical Representation, Mathematical Reasoning, Problem Solving, Mechanics; Oral: Organization, Delivery, Central Message, Subject Knowledge, Questions and Answers), each of which is graded on a scale from 2 to 10. There are separate rubrics for the written paper and the oral presentation.

ii. SLO(b) – Students are given pre- and post-tests in MATH 210 (Calculus I) that measure the ability to properly utilize computational algebraic properties to solve problems. The exam will consist of 30 multiple-choice questions. This exam will provide the Mathematics faculty with a base level for the algebraic skills of incoming Mathematics students.

Students will be required to take a Program Entrance Exam following MATH 212 (Calculus III) that tests the algebra and calculus skills necessary to succeed in the Mathematics program. A student's performance on this exam will determine his or her formal acceptance (or denial) into the Mathematics Program. The Mathematics faculty will be deciding on an appropriate exam, as well as appropriate grading criteria, during the Spring 2015 Semester so that a "trial-run" of this exam can be implemented at the end of the Spring 2015 MATH 212 course.

Students are given an embedded exam problem in MATH 375 (Differential Equations), which assesses their mastery of basic algebra and calculus skills necessary to solve a given differential equation. The

three-tier rubric described for SLO(a) will be the assessment tool for this measure.

iii. SLO(c) – Students are given embedded exam questions in MATH 373 (Finite Mathematics) and MATH 375 (Differential Equations) which assess their ability to synthesize their mathematical knowledge to complete all stages of an application problem – setup, selection and implementation of solution method, interpretation of the result. The assessment tool of these measures will be the three-tier rubric described for the assessment under SLO(a).

iv. SLO(d) – The students will be required to complete embedded exam problems in MATH 374 (Discrete Mathematics) on the midterm and final exams. The assessment tool for this measure will be the three-tier rubric described under SLO(a).

Students will also be required to complete at least one weekly problem set in MATH 480 (Mathematics Capstone) that addresses this outcome. One problem will be chosen from the weekly problem set to be used for assessment purposes from year-to-year. This measure will be evaluated using the three-tier rubric similar to that described under SLO(a). The Mathematics faculty are also considering using the proof-based question from MATH 374 (described above), so that student progress over multiple years can be tracked rather than the progress over the course of a semester only.

v. SLO(e) – Students will be required to complete a project-based final exam in MATH 175 (Computer Programming for the Sciences). The assessment tool for this measure will (mostly likely) be the three-tier rubric described for SLO(a). However, as this course is currently being offered, the Mathematics faculty may wish to develop a different rubric for this project that more appropriately addresses the use of technology.

The Mathematics faculty recently purchased two Mathematica licenses, which provide more opportunity to incorporate technology into our courses. Two of the new Mathematics faculty members are also well versed in other mathematical computer programs, including GeoGebra, and utilize them regularly in their classes. With these new resources, we

are able (and eager!) to increase the use (and assessment) of technology in our courses, especially MATH 210 (Calculus I), 211 (Calculus II), 212 (Calculus III), 309 (Calculus and Geometry for General Mathematics 5-9), 341 (Linear Algebra), 375 (Differential Equations), and 464 (Probability and Statistics).

vi. Students are also required to take the Major Field Test for Mathematics at the completion of MATH 480 (Mathematics Capstone). This national exam assesses the knowledge and skills students would have acquired throughout their undergraduate Mathematics career. Their performance on this exam provides a general indication of the overall knowledge base of our students upon graduation relative to students across the nation. The students' performances are an overall indication of the success of our program in preparing students for graduate school or for their future careers.

b. Indirect Measures

i. Upon the completion of project-based learning assignments mentioned in Section 3 Part (a), students will be required to complete a survey regarding their learning experience throughout the duration of the project.

ii. The students are required to complete a Program Evaluation at the end of MATH 480 (Mathematics Capstone). Students are asked to rate a variety of aspects of the Mathematics Program (e.g., curriculum, teaching quality, preparedness for solving various types of problems, overall experience) on a scale from 1 to 5 and to provide comments for each.

iii. The use of an exit interview (with the entire group of students participating in MATH 480 at the time) of the Mathematics Program has been mentioned. This interview would address student responses to questions on the survey described in (ii).

4. Location of Measures

a. SLO(a) location and method

i. MATH 375 (Differential Equations) – Class project(s)

ii. MATH 480 (Mathematics Capstone) – Weekly problems

iii. MATH 480 (Mathematics Capstone) – Research project with written and oral presentation components

b. SLO(b) location and method

i. MATH 210 (Calculus I) – Pre- and post-tests of algebra skills

ii. Post MATH 212 (Calculus III) – Program Entrance Exam

iii. MATH 375 (Differential Equations) – Embedded exam question

c. SLO(c) location and method
   i. MATH 373 (Finite Mathematics) – Embedded exam question
   ii. MATH 375 (Applied Differential Equations) – Embedded exam question and possible project
   iii. MATH 480 (Capstone) – Question on a weekly problem set

d. SLO(d) location and method
   i. MATH 374 (Discrete Mathematics) – Embedded exam question
   ii. MATH 480 (Capstone) – One question on a weekly problem set

e. SLO(e) location and method
   i. MATH 175 (Computer Programming) – Class project
   ii. Possibly MATH 210 (Calculus I), 211 (Calculus II), 212 (Calculus III), 341 (Linear Algebra), 375 (Differential Equations), and/or 464 (Probability and Statistics) in the near future – Homework set and/or class project depending on the course

5. Timeline for Assessment Implementation

The Mathematics Program currently has data on SLO(a) collected from the research projects completed during MATH 480 (Mathematics Capstone) in Fall 2010, Fall 2011, Fall 2012, Fall 2013, and Fall 2014. A change to the numerical scores associated with each rubric tier during the Fall 2014 semester necessitates the review and updating of previous scores so that data can be compared. Data on SLO(a) was to be collected in MATH 375 (Differential Equations) during the Fall 2014 semester via a project-based assignment that included written and oral presentation components. This project was not fully developed in time to be effectively implemented. While a presentation of work was required of students in MATH 375, no useful data was obtained. However, the implementation of student presentations was a valuable experience that will aid us in effectively implementing this measure in the future. Additional data on SLO(a) will be collected during the Fall 2015 when MATH 480 and MATH 375 are offered again.

Assessment of SLO(b) began in the Fall 2014 semester with the implementation of an embedded exam question on the MATH 375 (Differential Equations) final exam. This question was graded according to the aforementioned rubric and data is currently being reviewed. During the Spring 2015 semester, students in MATH 210 (Calculus I) were administered a pre-test of algebra (and Pre-Calculus) skills and scores were recorded. However, there is only one Mathematics major in the course this semester (the rest are mostly biology), so there is limited data available from this semester. We will continue to utilize this pre-test in future MATH 210 courses. The Mathematics faculty will be

developing a draft of a Program Entrance Exam that is to be administered at the end of MATH 212 during the Spring 2015 semester.

Data for SLO(c) was collected in both MATH 373 (Finite Mathematics) and MATH 375 (Differential Equations) via an embedded final exam question. In grading these problems, it came to light that the general rubric used to assess written work needs adjustment for application problems. A category addressing the interpretation of a solution in the context of the given problem is necessary and must be added to the rubric for use in these problems. We plan to implement the other measures for SLO(c) during the Fall 2015 semester.

Data for SLO(d) will be collected for the first time during the Spring 2015 semester in MATH 374 (Discrete Mathematics). Formal collection of data for this SLO will continue in the fall semesters in MATH 480 (Mathematics Capstone) as described above and in the spring semesters in MATH 374.

Collection of data on SLO(e) will be taking place this semester with the offering of MATH 175 (Computer Programming for the Sciences).

The main focus of the Mathematics faculty in the coming months is to complete initial data collection of all measures during the Spring and Fall 2015 semesters. Completion of initial data collection will allow us to identify issues or shortcomings with our SLOs and/or measures. Because it is likely that the Mathematics SLOs will need modification in the future, research into the SLOs of other institutions and their success, or lack of success, with collection of data from various measures will be beneficial.

It is also our goal in the coming months to solidify the rubrics that will be used to assess various measures. For example, after one round of data collection we have identified that the rubrics need an “Interpretation” category for proper assessment of application problems.

In looking ahead to the coming years, the Mathematics faculty would like to utilize assessment data to identify trends in the performance of our students. Our goal is to track student performance (both individually and on a class basis) from year-to-year. This will serve multiple purposes. First, it will allow the Mathematics faculty to observe the performance of individual students and track their progress from freshmen to seniors. Second, it will allow us to track the performance of an entire incoming class. For the most part, an incoming class will take the same courses at the same time, so we

will be able to see their performance in various areas. Having class data that can be compared from year-to-year may help us to determine whether performance issues are do to a problem with a specific course or if the issues are a shortcoming of a particular group of students. Sometimes sub-par performances across an entire class are due to deficiencies in pre-requisite knowledge of the class, and sometimes they are due to a poor experience in a particular class. Being able to identify the cause would be extremely beneficial in trying to address such issues in order to strengthen our program.

6. Implementation of Program Revision

As most of our assessment measures are in the early stages of implementation, the Mathematics faculty is currently in the process of determining appropriate collection strategies for the various measures. For embedded exam questions, it has been decided that multiple (and, in the future, possibly all) faculty will take part in the collection of data. During the Fall 2014 semester, each course (for which there was an embedded exam question) was assigned two faculty members – the instructor of record and one additional faculty member – to assess student responses. These faculty members graded student responses according to the rubric individually and then discussed any differences in grading to come to an agreement on the appropriate grade. (We opted for this method to ensure appropriate use/interpretation of the rubric, and to identify any shortcomings of our rubrics so that they may be addressed and modified for future use.)

For measures such as class projects and presentations, the instructor of record for the course will carry out the data collection according to the stated collection method.

All data will be reported to the Mathematics Program Assessment Coordinator who will maintain electronic copies of all records in Microsoft Excel. Hard copies of all data will also be maintained in a central location in the Mathematics Department in case of corruption of electronic copies. When possible, hard copies of student work from which assessment data was collected (e.g., final exams containing embedded exam questions) will also be maintained. This will allow for the update of data in the case of changes to assessment rubrics.

Once appropriate numerical values have been determined for the new rubrics described in Section I, the Mathematics faculty will examine the distribution of the data for each category of the rubric to analyze student performance. Important statistical measures such as mean, median, mode, and standard deviation will be considered. As more data becomes available in future semesters, it may be possible to determine trends and/or

correlations that may exist among student performance on various types of problems. As we currently have a fairly small data set for our new measures, detailed analysis will not yield much information.

All collected data is shared among members of the Mathematics faculty once data has been collected and compiled. A meeting will take place during the first half of the semester to discuss data collected during the previous semester. The discussion should focus on student performance and the contributing factors to their performances. We will aim to identify factors that contributed positively to their performance so that we may continue to foster these elements. We will also identify factors that may have negatively affected student performance so that we may address these issues and continue to improve our program. For example, it is evident that many students have a difficult time effectively communicating mathematical ideas, especially orally. Because we have pinpointed this as a significant issue, we have discussed ways of incorporating student presentations into a variety of our courses.

7. Previous Reviews

In response to Comment #3 from the Committee's February 26, 2014 review, we would like to clarify that weekly problem sets are implemented only in MATH 480, our Mathematics Capstone course. The weekly problem sets are one of two major components of the course – weekly problem sets covering topics from the main courses of their undergraduate Mathematics studies as well as a research project. As noted in Section 3(a), the main focus of the weekly problem sets is the students' oral deliveries of the solutions to these weekly problem sets. Each week, multiple students present their solutions to a selection of the problems that they completed that week, and they are assessed on such categories as organization, board work, and clarity of explanation. A "rough draft" of a rubric for this grading was put into effect during the Fall 2014 semester, but the Mathematics faculty plan to update and formally develop the rubric so that it is more closely aligned with the more in-depth rubric used to assess their project presentations and so that it may be used to assess presentations in other mathematics courses. Ideally, the Mathematics faculty would utilize the written solutions for the weekly problem sets for assessment purposes. However, this poses some issue because new problem sets are written each year, so year-to-year data would not necessarily be comparable. One possible solution to this issue is to have one common question on each weekly problem set that is included each year, and to utilize this question for assessment purposes.

In Comment #4 of the February 2014 review, the committee raised concerns about the specificity of the SLOs of the Mathematics Program. In deciding upon SLOs for the Mathematics Program, the faculty identified key characteristics and skills that we felt a Mathematics major should have upon graduation, and we designed the SLOs to address these skills. Being that the approach to student assessment in the Mathematics Program was completely overhauled during the 2013-2014 school year, at this time we have chosen to maintain our SLOs (with slight modification to some of the wording). The Mathematics faculty believed it was more important to begin collection of assessment data and to determine after some initial collection if additional modifications to the SLOs should be made. As we begin the process of data aggregation, it is likely that we will update our SLOs to more accurately align with the skills we are assessing. Having researched student-learning objectives for other undergraduate Mathematics programs, it seems that a common approach is to state broad learning objectives and then to have multiple "sub-objectives" that are more specific in the outcomes. This structure may prove more suitable for the Mathematics Program as many of the stated SLOs have many things that must be assessed. For example, SLO(c) addresses students' abilities to solve real-world application problems. However, there are many aspects of solving real-world applications that must be assessed – the ability to identify the problem that must be solved and to appropriately convert it to a mathematical problem; the ability to select an appropriate solution method and correctly implement this solution method; and the ability to correctly interpret the solution in the context of the problem. In Mathematics, it is important that we identify which step of the process students struggle with the most.

The Mathematics faculty have addressed Comment #5 from the Committee's February 2014 review by expanding upon the integration of General Studies SLOs. There has been clarification as to where and how these SLOs are, or will be, assessed. While data has been collected that can be used to assess some of the General Studies SLOs, it is the case that some of the SLOs will be assessed in the near future with data that will be collected shortly.

In response to Comment #6, assessment of SLO(e) of the Mathematics Program is currently in progress in MATH 175 (Computer Programming for the Sciences), which is being offered this semester. Plans for future assessment in other courses using a variety of technology are being discussed and should be ready for formal implementation in Fall 2015.

We have hopefully made evident the fact that data collection for assessment purposes is underway. In the last report on Assessment of Student Learning for the Mathematics Program, many of the measures were described in the future tense because data collection had not yet begun. At that time, we were in the beginning stages of completely re-drafting our SLOs and assessment measures, and the Mathematics Program was not in a position to begin data collection. Some of this was due to the fact that many of the courses in which we planned to collect data are offered once a year, or possibly one every three semesters. Therefore, we had to wait until the courses were offered again to implement assessment measures. During the 2014-2015 school year, we have implemented, and will continue to implement, as many measures as possible so that we can appropriately update our assessment plan. We expect significant usable data by the end of this school year, and we are hopeful we can achieve complete implementation for the 2015-2016 school year.