4. Assessment

4.1 Outcomes Assessment Plan (for the mathematics major program)

The department has been continuing to work under the Assessment Plan that was initiated in the Fall 2005 Semester; the plan included the following Goals for the Mathematics Major and the related objectives for each goal. It is expected that each undergraduate mathematics major, upon graduation from Fitchburg State University, should

1. possess an understanding of the breadth of the mathematical sciences and their deep interconnecting principles.
   To meet this goal each undergraduate mathematics major has:

   - demonstrated an understanding of the concept of a function and its related topics.
   - demonstrated an understanding of the basic concepts of calculus.
   - demonstrated a knowledge of the abstract structures in mathematics.
   - demonstrated competency in several mathematical subfields outside of abstract algebra.
   - demonstrated an understanding of the commonality of different branches of mathematics.

2. be able to apply mathematics to a broad spectrum of complex problems and issues by formulating and solving problems.
   To meet this goal each undergraduate mathematics major has:

   - demonstrated using mathematics as a tool in solving applied problems.

3. be able to read, write, listen, and speak mathematically, as well as to be able to read and understand technically-based materials and to contribute effectively to group efforts.
   To meet this goal each undergraduate mathematics major has:

   - given oral presentations on mathematical topics.
   - demonstrated the ability to write correct proofs.
   - demonstrated the ability to write expository mathematics.
   - participated in group assignments or projects

4. have an understanding of the appropriate use of technology in mathematics.

   To meet this goal, each undergraduate mathematics major has:

   - demonstrated correct use of technology in mathematical situations.

5. be adequately prepared for a mathematically-oriented career.

   To meet this goal, each undergraduate mathematics major has:

   - demonstrated adequate preparation for his/her postgraduate experience.

Evidence of student achievement in these goals (and each goal's related objectives) was to be compiled in a student dossier that would include:

- a proof involving the concepts of a function and its related topics
- lab report from Calculus I or Calculus II (or other writing assignment)
- a proof from Abstract Algebra, Linear Algebra, or Number Theory
- a problem from an area of mathematics that uses concepts from another area
- a solution of an applied problem from each of two different courses
- a proof from Abstract Algebra and Introduction to Mathematical Thought
- report of a group project
- an assignment from Calculus I, Calculus II, or Linear Algebra, and an assignment using technology from another mathematics course

Other tools used in the Outcomes Assessment Plan include: MTEL scores, skills evaluation report (including items on the concept of a function and the basic concepts of calculus), transcripts, presentations, exit interviews or surveys, and alumni surveys. Not all evidence may be present for each student. The implementation of this plan was left to the Mathematics Assessment Committee.

Summary of past work:

From 2005 to the last review the Mathematics Assessment Committee (MAC) developed rubrics to assess student progress on these goals, implemented these rubrics, and closed the loop by either modifying the rubric, developing new assignments for students, or modifying the plan. As of the last review the MAC had rubrics for technology lab report rubric, student presentation rubric, proof writing rubric. In addition the assessment committee has developed skills lists for Calculus II, Applied Mathematics and a proof reading quiz.

Work since 2012:

Since the last review the MAC has developed an exit survey for graduating majors, a rubric for the writing expository mathematics goal, and begun the process of revising the goals and assessment plan. See Appendix F for example reports to the University Office of Assessment.The latter was initiated by the large change in full-time faculty employed (five new faculty have joined the department in the last three years). The MAC sees this change as an opportunity to revisit the plan and goals to (a) make sure they align with faculty understanding of the mathematics major and (b) reflect lessons learned since the inception of the plan. This revision began with a survey of all faculty on attributes of a successful student in the program

and will continue in AY16/17. This revision will respond directly to the Mathematics Association of America's 2014 Curriculum Guide.

A. Assessment of the Initial Licensure program (including post-baccalaureate)

As part of the University's Education Unit the program for Initial Licensure in Secondary Education in Mathematics (8-12) is subject to both Council for the Accreditation of Education Programs (CAEP) and Massachusetts' Department of Education licensure requirements and assessment plans. Student work in education courses are assessed using unit rubrics (lesson plan rubric, and Teacher Work Sample) and the assessment data for this work is regularly reviewed. Mathematics department representatives have been involved in deepening the assessment work in the (shared) secondary courses aligning the courses, student work, and assessment plan with the newly adopted Professional Standards for Teachers. While changes to the state licensure or national accrediting standards can require changes to mathematics courses, no such changes have occurred in this review period.

B. **Assessment of service to other programs**

Much of the work of the Mathematics department during the review period has focused on courses not required for the major, but those that serve other programs on campus (including the general education requirements by means of the Mathematics Readiness Requirement). As noted in the Curriculum Trends section above, the department has redesigned the developmental mathematics program and piloted a form of supplemental instruction.

The table below shows how pass and AB rates in applied statistics (math 1700) increased with the pilot . The slight drop in pass rate (and rise in AB rate) after going all modular and tracking may be due to the fact that the modular format required a higher passing standard (students had to pass all tests with an 80% instead of only 70% as in the lecture sections).

	Pass rate in math 1700 (rounded to the nearest %)	**AB rate in math 1700 (rounded to the nearest %)**
AY 13/14 (after raising BM standards and implementing MPR)	76%	37%
AY 14/15 (after making all BM sections modular and tracked)	73%	40%
AY 15/16 (with alternate math placement and SI pilot)	78%	42% (this was for fall only)

Pass, withdrawal, failure and D rates for freshmen cohorts only are shown below. This includes both

students who were placed by HS GPA (and did not pass the math placement test) as well as those who pass the math placement test. ACPM refers to the math placement test.

Entering freshmen cohort	n	Ave. HSGPA	Ave. ACPM	Pass rate in Math 1700 (rounded to the nearest %)	Withdrawal rates in Math 1700	Failure rate in Math 1700	D rate in Math 1700
Fall 2013	233	3.17	91	81%	8.36%	10.93%	13.83%
Fall 2014	234	3.22	92	84%	6.84%	8.55%	14.1%
Fall 2015	311	3.21	83	86%	5.15%	8.15%	17.6%

After changes to MATH 0200 Basic Mathematics and the implementation of the MPR, pass rates in MATH 1700 increased from 60% (before fall 2013) to over 70% (over 80% for freshmen cohorts).

Below is similar data for those students who did NOT pass the ACPM and had HSGPA at or above 2.7. Those in Fall 2015 were placed directly into applied statistics (with an extra hour) and those in previous years went through developmental mathematics as a prerequisite before taking math 1700.

Entering freshmen cohort	n	Ave. HSGPA	Ave. ACPM	Pass rate in Math 1700 (rounded to the nearest %)	Withdrawal rates in Math 1700	Failure rate in Math 1700	D rate in Math 1700
Fall 2013	46	3.22	66	80%	4.35%	15.22%	23.91%
Fall 2014	35	3.29	64	83%	8.57%	8.57%	14.29%
Fall 2015	46	3.19	60	80%	10.87%	8.7%	26.09%

The SI pilot results show that this co-requisite model is comparable (in terms of pass rates) to the pre-requisite model for developmental mathematics for students with sufficient HS GPA. Withdrawal rates went up slightly which may be due to the fact that the pilot included students with very low math placement test scores. We adjusted the pilot thereafter to student with a higher range of math placement test scores. There was also an increase in D rates which shows that more students are just passing with the co-requisite model.

4.2 Effectiveness of the Curriculum

All of our available evidence indicates that overall the mathematics program at Fitchburg State is sound, the teaching/learning process is usually satisfactory and sometimes exemplary, and students are quite satisfied with the time and attention they receive from their mathematics instructors. Recent survey

information obtained from both current students and alumni of our program support these conclusions. Students and alumni alike are satisfied with the Fitchburg State mathematics program. They rate the mathematics faculty members as knowledgeable, caring and respectful instructors who are available to students and go the extra mile to insure student success.

Moreover, current students and current faculty have very similar perceptions concerning those characteristics of the Fitchburg State mathematics program that foster students' success and those that can be viewed as program limitations. The most often cited strength of the Fitchburg State mathematics program is the personal attention students receive from the faculty. The minimal number of advanced level required or elective courses that can be offered each semester is cited as a definite limitation of the program.

The small number of mathematics majors at Fitchburg State contributes to both the availability of instructor's time for giving personal attention to students, and the lack of choice for elective classes. The recruitment and retention of qualified mathematics majors is an ongoing goal of the department. For the past 5 – 10 years, the number of mathematics majors has hovered around 40 give or take but has recently increased to an at an all time high of 57. The number of minors doubled from 2011 – 2013 and then decreased in 2015. The number of minors is now about 50% higher than it was back in 2011 with approximately 30 minors total.

4.3 Effectiveness from the Perspective of our Students

In Fall 2016 the department conducted a survey of the Mathematics Department Curriculum and Advising for Mathematics Majors. See Appendix A. The advising data is addressed in the Student Data Section and the curriculum results are summarized here. All the respondents were satisfied with the overall mathematics program and felt their questions to instructors would receive a prompt, accurate, courteous and respectful response. The weakness that was mentioned the most was regarding course offerings, over 30% of respondents were dissatisfied with course offerings. Concerns were expressed about frequency of course offerings and the fact that some desirable courses are not offered often enough. Currently most upper division mathematics majors must take any mathematics elective offered each of their last three or four semesters and hence they are not selecting courses based off of their interests. This has been a persistent problem, one that is hard to solve given our size.

Two students raised the issue of lecture style teaching but based on other responses, most were satisfied with the teaching techniques used by the mathematics faculty. This is highlighted in the following responses from the question about the strengths of the program: "Amazing and approachable faculty; most every professor I have had here I can feel their love of the subject and/or specific course come through in their lecture.". Other responses include: "I think one strength of the mathematics program is that since the program has a small amount of students compared to other programs, you connect frequently with your fellow students and with all of the professors. You also feel like anyone in the department is there to help you and are always willing to give their service to help you succeed.". Some suggestions were to offer evening or online courses, increase the number of mathematics related activities, and to improve transfer and first year advising.. Most of the respondents said they would recommend the Fitchburg State

mathematics program to others with comments including “absolutely”, “of course” and “without a doubt”, but this responses was lower than when the survey was last deployed.

See the **Student Data** section under *Assessment of Mathematics Program Effectiveness* for more details.

4.4 Effectiveness from the Perspective of our Alumni

Our most recent survey of Alumni (which was run from May 2016 through September 2016) garnered 35 responses from alumni who graduated between 1974 and 2014. See Appendix A. The responses were overwhelmingly positive, especially given the diversity of post-baccalaureate experiences reflected in the alumni responses. Of those alumni providing information on their current profession 37% were in the education field and 31% were doing some form of data management or analysis. 94% of the respondents indicated that their experiences at Fitchburg State adequately prepared them for their professional needs. 94% also indicated that they would recommend the Mathematics program at Fitchburg State to someone whom they cared about. Comments offered by our alumni were very positive.

When prompted to identify weaknesses or suggestions for improvement a few themes appear. Firstly, there is the call for more guidance on the role mathematics can play in various careers. Secondly, there is advice to offer more courses that highlight the applications of mathematics. There were also roughly equal calls for additional courses that would help students with actuarial sciences and computer science. Here students also expressed frustration with the cancelling of classes.

See the **Student Data** section under *Assessment of Mathematics Program Effectiveness* for more details.

4.5 Effectiveness from the Perspective of our Faculty

In addition to the student survey discussed in section 6.1, the department also conducted a survey of the Mathematics Department Curriculum and Advising for Faculty. Once again, the advising data is addressed in the Student Data Appendix and the curriculum results are summarized here. There were 17 respondents, including 9 full time tenure track faculty and 8 part time faculty. All of the respondents felt that students’ questions to instructors would receive a prompt, accurate, courteous and respectful response and 94% were satisfied with the overall mathematics program. Most faculty were satisfied with the course offerings which is an improvement from the last time the survey was deployed, however this is not met with equal satisfaction from students past and present.

Areas for improvement mentioned included the need for more student choice in upper-level courses, more connection to students’ future work plans, and increased internship opportunities.

A reoccurring theme in the responses for strengths of the program is our dedicated and accessible faculty. Our faculty members are certainly competent and talented instructors who love to teach and it shows. In addition to putting copious amounts of time and effort into their regularly scheduled classes, faculty routinely give encouragement to students who have expressed the desire to continue the study of mathematics at the graduate level. When such students are identified early, several of our faculty members

endeavor to offer support via independent study projects designed to introduce these particularly capable and motivated students to more advanced topics and more rigorous development of these topics than would be possible for most of our other students. This adds greatly to the strength of the program and is especially notable since this type of faculty work is on top of a full teaching load and not regularly compensated.

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5. FIVE YEAR PLAN/PLANS FOR CHANGE

5.1 Five-Year Plan

In the future, the mathematics department would like to work on its interconnectedness with other departments, local community colleges, and organizations that can provide career opportunities for our students. In addition, we plan to focus on the needs of our students and how we can better meet those needs.

In particular, we are discussing the following:

1) **STEM resource center (math and science) --** we are talking with other departments and offices on campus about the possibility of a STEM resource center. This would be similar to the math center, but it would also serve students in science classes, who often face mathematical hurdles in their courses.
2) **Math Center--** We are also interested in collaborating more with the Math Center, which often seems disjoint from the department. The math center is located in a beautiful new facility in Hammond, but it is physically and practically detached from our department. One possible solution to help with collaboration is to have a Math Center Liaison from the department.
3) **Careers—**We are working on collecting information for career-based advising and internships. Specifically, we are interested in what particular skills and dispositions industry is currently looking for and what careers and jobs are in demand and are well suited for our students. We can use this information to inform advising and curriculum decisions. This work is also part of Dr. Barbato's sabbatical in Spring 2017.
4) **Assessment Plans**—Our current assessment plan was written almost 15 years ago. In that time, our department has almost completely turned over. It has become clear that our assessment plan needs to be revisited and revised. Therefore, beginning this year the Assessment Committee is working on a reboot of our Assessment Plan.
5) **Math Software**—The department currently uses Maple and several other mathematics software programs. We now have many new faculty, some of whom have experience with other software. We will be reevaluating what software we would like to retain and which we would like to remove, replace, or add.
6) **QR requirement** – The University is currently working on a LAS program. The new requirements may include a quantitative reasoning course. Quantitative reasoning is also gaining attention in the mathematical community and the country as a whole. We will be discussing how to address the need for a quantitative reasoning course. This may involve transforming developmental math into a QR requirement, transforming our current Finite Mathematics into a QR course, or creating a new QR credit-bearing course.
7) **Supplemental Instruction**—We are currently looking at adjusting and expanding supplemental instruction (SI). This may involve including Supplemental Instruction sections in more of our courses. As SI expands, we will be in need of a Developmental Math and SI coordinator position, which would ideally be a staff position. One possible adjustment to SI is to include longer sessions and/or giving students credit for the extra time spent in class.
8) **BHE plans for Developmental Math**—Our current SI program is a response to the guidelines from the BHE regarding math placement testing. We are currently using student's high school GPA

to place students into courses supported by SI sessions. We will continue to respond to recommendations and requirements dispensed by the BHE.

9) **Grad programs in STEM ED**—We are in discussions about streamlining graduate programs for in-service teachers for professional licensure. We have eliminated the inactive MAT program that has been lingering on the books for more than 10 years, and are considering replacing it with a program that will service in-service teachers in mathematics and other sciences, such as biology, chemistry or physics.
10) **Statistics** – Although some faculty in the department have taken some statistics classes, we do not currently have a statistician on the faculty in this department. Since statistics is an area of mathematics that is highly useful in industry, we will be looking for ways to strengthen our department in that area.
11) **Collaboration with other Departments—**With the inception of the division of Natural and Health Sciences, there have been more opportunities for the mathematics department to communicate with other departments, such as the STEM Summit, which was held in January, and the STEM Working Group, which is an interdisciplinary group tasked with improving the student experience in STEM on this campus. We plan to continue discussions with our cognate fields on things such as what mathematics their students need to know prior to taking their courses, what mathematics courses their students should take to get that material, and other ways to support students in STEM courses to facilitate their success.
12) **Collaboration with Mount Wachusett Community College**—For the past few years, we have been in greater communication with our colleagues at Mount Wachusett. This communication has been through meetings organized by the chair of the Biology and Chemistry department, work on assessment organized by the director of assessment, and work on the Mass Transfer program organized by the BHE. We would like to continue our connections with our closest community college neighbor and continue to collaborate for student success in transfer between our two colleges.

5.2 Strengths/Weaknesses

Background information for this section is based on observations, informal conversations and surveys of current faculty members and current and former students. See Appendix A survey results.

5.2.1 Strengths

- The Mathematics Department continues to be student-centered. All relevant decisions are made with students in mind and the way that the faculty conduct classes and other activities have the students first in mind.
- Faculty members are dedicated to their students and are very creative in the classroom. Many utilize a variety of teaching techniques and foster active learning in the classroom. Each semester we hold a Math DoT (Discussion on Teaching) to share best practices and new ideas.
- The full-time tenure track faculty to math major ratio is about 1:4 and this lets the faculty get to know the students in class well and give ample attention to majors.
- Faculty are active in research and improving teaching. Currently, all faculty attend at least one national meeting and many go to other meetings that focus on general mathematical topics, specific research or teaching-focused topics. At least half attend local conferences that have

specific campus goals in mind. In particular, our faculty members have attended and participated in conferences and workshops on STEM education, general education, supplemental instruction and inquiry based learning which has been used to enhance their own teaching techniques.

- Many faculty work with undergraduate students in research. During the past 5 years, at least 10 students have benefitted from independent studies/research projects with faculty members.
- The numbers of applied mathematics majors, secondary education majors and mathematics minors (including math ed. minors) has grown over the past 5 years (see Student Data Appendix). This shows that 1) students are increasingly interested in mathematics and 2) we have strong attractive programs with supportive faculty.
- The faculty are active on campus committees. All of our faculty members serve on at least one departmental committee and in most cases two. Each also serves on at least one university committee, working group and/or taskforce. Each year the department ensures representation on certain committees (e.g. Curriculum, Academic Policies, LA&S) as well as pertinent working groups and task forces (e.g. STEM working group, Student Success Task Force)
- We have several new and enthusiastic faculty members who have brought lots of good energy to the department. In particular, we have hired 4 new faculty members in the past 2 years.

5.2.2 Areas for Improvement

- Some students are seeking out internships, however the Mathematics Department does not have a program to facilitate this. Also, more guidance is needed for students, on the role mathematics can play in various careers.
- The upper division course offerings are very restricted leaving majors little choice of what mathematics electives to take. In any given semester, there are typically 3 courses above Multivariate Calculus.
- The class sizes for some lower-level service courses are too large, making it difficult to give individual attention to the students that need it most.[[this has actually improved quite a bit – now our largest cap is 30 but most courses are at 25 or lower]]
- Only a few of the faculty members have recently pursued their scholarly activity to the point where the results were submitted for peer review and eventual publication. That said, faculty members continue to be active professionally despite the limited time available to them as members of an institution focused on teaching.
- In the 2012 self-study, it was indicated that alumni had wished for more computing to help with their career prospects. This has improved with the increasing enrollment in Applied Mathematics, many of whom fulfill a Computer Science minor. In addition, all majors now take a 3-credit Symbolic Computation course (which was formally embedded in the Calculus sequence) and twice over the past three years, a topics class in Computational Mathematics. Except for the required course, only a few majors have increased their computational skills. The Mathematics Department should continue to require or advise students of the marketability of such skills.
- There could be more widespread use of technology for the mathematics classes. In particular, appropriate computer algebra systems should be used as often as appropriate to better prepare the students for careers in industry. Such programs are already being used in Calculus I & II, Linear

Algebra and some applied mathematics courses but they could be useful in other courses as well.

- The large number of part time faculty members creates considerable strain on the Department in many ways. While these faculty members are well qualified for their teaching assignments, they are not easily integrated into the life of the Department.
- As noted in the Five-Year Plan section, none of our faculty members has a strong background in advanced statistics which is a field with high demand in industry.
- Although the department currently has a developmental mathematics coordinator who also handles SI coordination, this is a temporary position and there is no current plan for long term support.

5.3 Plans for Change

Future plans and changes for the Department of Mathematics will, as in the past, be designed to enhance and improve strengths of the Department and to rectify and eliminate those things which are seen as weaknesses. Survey results indicate that the quality of the course offerings is high and that, especially for upper level major courses, the relatively small class size provides for a good learning environment. Complaints about cancellation of upper level electives and a perceived lack of planning of upper level courses need to be addressed. However, a study of the surveys reveals that what is considered a major weakness in the Department is a lack of career planning. Procedures and potential actions to address some of these shortcomings are addressed in the Five-Year Plan section. After our program review sit visit the department plans on developing a five-year strategic plan to prioritize our efforts to improve both the major programs as well as our service offerings.