

Assessing the Mathematics Major: A Multifaceted Approach

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Abstract. The Saint Peter's College Department of Mathematics has developed a multifaceted assessment plan to better understand and improve student learning in the mathematics major. Key elements include departmental objectives, student portfolios, analysis of transcripts, and surveys of alumni; the latter three will be explored in detail in this case study. Our goal is to make informed decisions about potential changes in the major and provide a solid foundation of student learning data going forward.

Background

Saint Peter's College (SPC), founded in 1872, is a Jesuit liberal arts college of approximately 3,700 students located in Jersey City, New Jersey. The SPC Department of Mathematics has a long history of attention to assessing student learning, evidenced by Eileen Poiani's analysis of the developmental program [1].

The current effort is focused on the major program. How successful is the current course sequence? How is student success measured: in-class? after graduation? We decided that a multifaceted approach was required, considering classroom activities, college records, and alumni.

This assessment of student learning focusing on the major was requested by the academic dean in 2001. Conveniently, this coincided with the formation of the first "class" sponsored by the Supporting Assessment in Undergraduate Mathematics (SAUM) program of the Mathematics Association of America. Eileen Poiani, Katherine Safford, and Brian Hopkins were the three SPC faculty who participated in the first assessment workshop (three meetings) in 2002 and 2003. The leadership and colleagues in the program contributed greatly to our developing assessment efforts.

Description

The department began its assessment endeavor in 2001 with a department meeting dedicated to discussing our mission statement and goals (See Figure 1). We developed objectives for student learning by considering ways to complete the sentence "*The student, upon completion of the major, will be able to ...*" without asking for specific content knowledge such as "apply the Sylow theorems." The result

Department Mission Statement: The Saint Peter's College Department of Mathematics seeks to develop in our students the level of mathematical competence appropriate for their educational goals, to foster appreciation of mathematics as part of human culture and in relation to other fields of study, and to encourage the intellectual growth of students and faculty.

Department Goals: The Department of Mathematics seeks to equip all Saint Peter's College students with quantitative reasoning and critical thinking skills that enable them to be informed participants of an increasingly technical society. For majors, the department seeks to inculcate a significant amount of mathematical content and maturity in several areas; to foster logical thinking, creative problem solving, and precise communication; and to encourage the application of this content and methodology both within and outside mathematics.

Figure 1. Mission and Goals

is displayed in Figure 2. Then we discussed methods to measure the success in meeting these objectives, both practices currently in place and future possibilities (Figure 3). Cross-indexing the objectives and methods against specific major courses constituted our report to the college, which was well received. Appendix A shows the relation of objectives to courses and to assessment methods.

In 2002, as participants in the SAUM workshop, we decided to expand the department assessment endeavor by developing additional projects, using student transcripts, alumni surveys, and portfolios. The last major change in coursework for the major occurred in 1978, so we used 1980 as a baseline for our efforts. Analysis of math major transcripts from 1980 to 2003 (a total of 90 records) allowed us to see changing patterns in our students. With which courses did students begin their mathematics study? What were the other academic pursuits of our majors? Did they follow the system of prerequisites? For those who did not, how was their grade point average affected?

The Saint Peter's College Department of Mathematics has a long and rich history of communication with alumni, primarily through an annual newsletter and written responses. In the spring of 2003, we coupled the normal communication and a survey requesting information about particular classes and "their value to your post-graduation employment and educational experiences." (The survey instrument is Appendix 2 of our Case Study report on the SAUM web-

1. Think logically and analytically
2. Demonstrate a strong level of mathematical maturity
3. Solve problems creatively
4. Apply technology in solving problems
5. Produce concise and rigorous mathematical proofs
6. Appreciate the history of mathematics as a human endeavor
7. Recognize the interconnection of various fields in mathematics
8. Construct mathematical models
9. Apply mathematical content to other disciplines
10. Transfer mathematical thinking (logic, analysis, creativity) beyond cognate fields
11. Access relevant resources when posing and answering mathematical questions
12. Read and assimilate technical material
13. Produce cogent mathematical exposition
14. Communicate technical material effectively at an appropriate level
15. Succeed in mathematics graduate study, K-12 mathematics instruction, or other careers requiring computational or analytic skills

Figure 2. Student Learning Objectives

1. In-class tests and quizzes
2. Take-home tests
3. Homework
4. Collaborative projects done in small groups
5. Computer solutions and simulations
6. Papers
7. Presentations to faculty outside of class (of computer work, projects, papers)
8. In-class presentations (of homework, computer work, projects, papers)
9. Poster Day and Pi Mu Epsilon student presentations
10. Graduate surveys
11. Discussions with faculty colleagues

Figure 3. Means of Assessment

site.¹) Some 84 surveys were successfully delivered, and 24 were completed and returned.

In order to have evidence of longer-term student development, we have begun to collect work for student portfolios. Colleagues with portfolio experience strongly recommended against collecting too much paperwork, which can easily become unwieldy. We are collecting one document per student per major class, with specifics determined by the instructor. In discrete mathematics, for instance, I asked students to submit "a proof you're proud of." After starting with the 2002–2003 sophomore classes, and then expanding to all major courses, we will have portfolio documents from twelve classes by spring 2004.

Also, we have incorporated the student learning objectives in regular surveys of students and instructors for each class. In addition to the college's student evaluation, we have students rate how much each departmental objective was addressed in the course (making clear that there is no expectation that every class will address every objective). Likewise, the instructor fills out the same survey and provides additional narrative on how various objectives were addressed and what methods were used for assessment.

Insights

Beginning with a full faculty discussion helped involve all instructors and prevent our assessment efforts from becoming compartmentalized within the department. The discussion of methods of assessing student learning was very enlightening and gave several faculty new ideas that have since been incorporated. For example, at least one instructor started having students give in-class presentations on supplementary articles, and several began using Excel much more widely in various courses. Student and instructor sur-

¹ www.maa.org/saum/cases/StPeters_A.html

veys based on the objectives have kept the assessment program alive in our regular work of teaching.

The transcripts partitioned easily into four six-year periods (see Appendix B). Of particular interests are the trends into the most recent period, 1998–2003. Encouragingly, the number of mathematics majors is increasing. Also, the proportion of female majors is now slightly more than 50%. In terms of minors and double-majors, the only frequent combinations are with computer science and education. But while more than half of the mathematics majors in the 1980s also focused on computer science, the last period shows an equal percentage of students focusing on education as computer science. Looking at our current students, it appears that these changes will continue: fewer students studying mathematics and computer science (especially since the Department of Computer Science was recently moved to the School of Business), more students studying mathematics and education (with the intent of teaching K–12).

Transcripts also show a change in how students begin the major. Earlier, most students (about 75%) started with the calculus sequence dedicated to math and science majors or at a higher level. For the most recent period, that figure is down to about 60%, which means that some 40% of our majors of the last six years started with elementary calculus, finite mathematics, or math for humanities. This is great news in terms of recruiting majors, but makes completing the required coursework in four years challenging, as our upper division courses are offered every other year. It is not surprising, then, that there has also been a significant rise in the percentage of students who did not follow our prerequisite system. However, there was also no statistically significant difference in the grade point averages of students who did or did not follow the prerequisites, another provocative datum.

On a practical note, acquiring and analyzing the desired transcripts was tedious. Getting the proper records from the registrar took time, especially for students whose records were on hold because of outstanding financial issues. Due to FERPA regulations, student workers could not help enter or analyze the data. More frustrating, the format of the college's records did not allow us to track students who had left the major. More complete tables of the results mentioned above are provided in Appendix B.

The alumni surveys gave consistent feedback on which courses proved helpful or less so for the post-college careers of former math majors. Several courses were deemed “very valuable” by more than half of the respondents: mathematical modeling, probability, various calculus courses, statistics, linear algebra, and discrete mathematics. Some of these same classes were listed as “courses you think were most helpful in your career choice.” On the other end of the scale,

only two classes were deemed “not valuable” by more than half the respondents: numerical analysis and modern algebra. Common responses for “courses you think were least helpful in your career choice” were modern algebra and advanced calculus (real analysis). More complete results are provided in Appendix C.

Surveys can also be frustrating, trying to balance the information you want with a form that is not overwhelming, waiting for the results, and dealing with low return rates. Although our 29% return rate is respectable, we are hesitant to place too much weight on the feedback of 24 alumni. Looking at a particular result, how do we respond to the negative feedback on modern algebra? Could the class be altered to more directly tie in to high school algebra? Should we expect it to play a role in the vocations of graduates, or does it serve a different function? Also, the course-by-course structure may work against a holistic view of the major; one respondent attached a letter explaining how the problem-solving skills and critical thinking developed by the major were very helpful, but she could not tie them to particular classes.² Nonetheless, we were very pleased to receive her letter.

Next Steps

There remains more to do on all of our assessment projects. The transcript data can be mined to address more questions. There are qualitative responses on the survey that should be compiled and summarized. Student portfolios are accreting at a steady rate, but we will have to devise a rubric before they can yield helpful information (the first portfolios will be completed spring 2005).

Our next large goal is using all of the assessment data to help make informed decisions about the major: courses, sequence, prerequisites, etc. Another resource guiding any potential change will be the *CUPM Curriculum Guide 2004* [2]. This reconsideration of the major program is planned for 2005.

Looking farther into the future, continuing portfolios, transcript analysis, attention to goals, and subsequent surveys will provide invaluable longitudinal data. An ongoing attention to assessment will give the department an even richer foundation for improving student learning in the mathematics major at Saint Peter's College.

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² www.maa.org/saum/cases/StPeters_B.html

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References

1. Poiani, Eileen. "Does Developmental Mathematics Work?" in *Assessment Practices in Undergraduate Mathematics*, edited by Bonnie Gold, Sandra Z. Keith, and William A. Marion. Washington, DC: Mathematical Association of America, 1999.
2. *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004*, Committee on the Undergraduate Program in Mathematics. Washington, DC: Mathematical Association of America, 2004.

Appendix B. Results of Transcript Analysis

	1980–1985	1986–1991	1992–1997	1998–2003	1980–2003
Majors	33	16	18	23	90
F / M*	21-Dec	10-Jun	11-Jul	11-Dec	37 / 53
API / H / W*	1 / 5 / 27	4 / 1 / 11	0 / 2 / 16	3 / 1 / 19	8 / 9 / 73
Math GPA	3.22	3.59	3.34	3.32	3.34

* Demographic data includes female/male and Asian – Pacific Island/Hispanic/White (non-Hispanic). Hispanics and blacks are significantly underrepresented in comparison to the statistics for the overall student body.

Also, 27 of these 90 graduates have gone on to complete advanced degrees (30%), including four Ph.D.s (all women).

(All subsequent tables give percentages, not actual numbers of students.)

First math course	1980–1985	1986–1991	1992–1997	1998–2003	GPA
Below calculus	3	6	0	13	3.34
Elem. calculus	21	6	28	26	3.14
Major calculus	67	69	61	39	3.36
Above calculus	9	19	11	22	3.54

Min. & 2nd Maj.	1980–1985	1986–1991	1992–1997	1998–2003
C.S.	27	63	33	34
Ed.	0	0	11	34

Prerequisites	followed / didn't	followed GPA / didn't GPA
Overall	74 / 26	3.33 / 3.34
1980–1985	70 / 30	3.24 / 3.19
1986–1991	75 / 25	3.56 / 3.67
1992–1997	94 / 6	3.37 / 2.81
1998–2003	65 / 35	3.26 / 3.44

Appendix C. Results from Alumni Survey

Course	% "very valuable"	Course	% "not valuable"
Math Modeling	85	Numerical Analysis	60
Probability	81	Modern Algebra	59
Differential Calculus	75	Modern Geometry	50
Mathematical Statistics	69	Discrete Math	46
Linear Algebra	69	Elementary Calculus	43
Elementary Statistics	67	Advanced Calculus	42
Intermediate Calculus	63	Complex Variables	40
Elementary Calculus	57	Differential Equations	38
Multivariable Calculus	56	Intermediate Calculus	25
Discrete Math	54	Multivariable Calculus	25
Pascal/C++/Other Programming	50	Pascal/C++/Other Programming	25
Differential Equations	46	Differential Calculus	17
Topics in Applied Math	43	Mathematical Statistics	15
Complex Variables	40	Topics in Applied Math	14
Advanced Calculus	33	Linear Algebra	13
Modern Geometry	25	Math Modeling	8
Modern Algebra	24	Probability	6
Numerical Analysis	20	Elementary Statistics	0

Courses Most Helpful in Career	Teachers	Non-teachers	Total
Math Modeling	2	3	5
Mathematical Statistics	2	3	5
Differential Calculus	3	1	4
Linear Algebra	3	0	3
Probability	1	2	3

Course Least Helpful in Career	Teachers	Non-teachers	Total
Modern Algebra	5	6	11
Advanced Calculus	4	3	7
Pascal/C++/Other Programming	2	2	4
Intermediate Calculus	2	1	3
Discrete Math	1	2	3