Assessing the Undergraduate Major in Mathematics

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When most faculty hear the word *assessment*, they think about assessment of the major rather than of general education or quantitative literacy. That's exactly what the members of MAA's Committee on the Undergraduate Program in Mathematics (CUPM) thought when a subcommittee on assessment was formed in the summer of 1990. Out of that effort came the report *Assessment of Student Learning for Improving the Undergraduate Major in Mathematics* (CUPM, 1995). That document contained a five-step assessment cycle which could serve as a template for mathematics departments as they struggled to build their own assessment plans.

Subsequently, a number of demonstration projects (case studies) by colleges and universities who "got in the game early" were highlighted in *Assessment Practices in Undergraduate Mathematics* (Gold et al., 1999). Over the past three years additional demonstration projects have been developed as part of the MAA's NSF-funded program "Supporting Assessment in Undergraduate Mathematics" (SAUM). Together, both sets of case studies help point the way to effective means of assessing majors in undergraduate mathematical sciences programs.

An effective assessment plan must be anchored in the department's mission statement. So the natural first step is for faculty to review and update (or if necessary, write) their mission statement. Once that's been accomplished, goals for student learning outcomes can be articulated. Goals are broadly-based descriptions of what competencies or skills students should have after completing the major.

One approach is to ask each faculty member to complete the statement "Upon completion of the major a student will be able to…." The many faculty suggestions should then be pared down to a relatively small number, say from four to six. Several case studies illustrate this process, including the Colorado School of Mines (p. 149), Columbia College (Hopkins 1999), Keene State College (p. 157), St. Mary's College of Indiana (Peltier 1999), Saint Peter's College (p. 183), and South Dakota State University (p. 191).

Once agreement is reached on goals, it will be easier to develop student learning objectives. The objectives themselves should not be stated broadly, but should be thought of in terms of measurable outcomes. That is, one needs to think about how one knows when a goal has been achieved (or not). Typically, a number of learning objectives must be developed for each goal. Case studies that illustrate this process include Colorado School of Mines (p. 149), Columbia College (Hopkins 1999), Mary Washington College (Sheckels 1999), North Dakota State University (p. 93), and University of Arkansas, Little Rock (p. 201).

When writing a learning objective, one should have some notion of how to measure it. One advantageous approach is to list a variety of possible assessment tools and determine which instruments would be appropriate for measuring which objectives. This does not mean that the department will have settled on which measures they are going to use, only that serious consideration will have been given to articulating objectives that are measurable. In addition, since measurable objectives can help clarify goals, studying assessment tools may cause departments to reexamine their goals to ensure that they really are the competencies the faculty wants their students to have attained.

When thinking about assessment measures, what comes first to the minds of mathematicians are grades and student performance on class tests. Tracking student grades over a number of years can provide some useful information. However, as a stand-alone tool it is not particularly good at revealing the kind of information faculty need in order to improve their program, and, after all, that's a major part of what assessment is all about. The case study from Colorado School of Mines (p. 149) illustrates how to incorporate traditional classroom testing into a comprehensive assessment process.

Cases studies gathered prior to and during the SAUM project include a wide variety of examples of assessment instruments including surveys, portfolios [Columbia College (Hopkins, 1999) and Northern Illinois University (Sons, 1999)], senior exit surveys [Colorado School of Mines (p. 149)], interviews and focus groups [Mary Washington College (Sheckels, 1999)], alumni surveys [St. Peter's College (p. 183)], employer surveys [University of Arkansas, Little Rock (p. 201)], senior capstone courses [Saint Mary's College of Indiana (Peltier 1999)], senior comprehensive exams—both written and oral [Franklin College (Callon, 1999) and Wabash College (Gold, 1999)], independent research projects [South Dakota State University (p. 191)], the Educational Testing Service's Major Field Test in Mathematics [University of Arkansas, Little Rock (p. 201)]and written and oral presentations of mathematics [Keene State College (p. 157) and Saint Mary's University of Minnesota (p. 177)].

In some instances one particular assessment tool might be effective in measuring a specific learning objective, while for other objectives a combination of instruments might work best. One lesson learned by SAUM participants is not to overwhelm the assessment program with so much data that it is not feasible to interpret the results. Point Loma Nazarene University's report, "Keeping Assessment Simple" (p. 163) addresses just this issue. In addition to keeping it simple, I would add, manageable.

Having developed a list of instruments that are associated with measurable objectives, it is likely that some tools will serve more than one purpose. That makes it easier to whittle down the potential instruments to a manageable number. It is also likely that not all of the department's objectives for mathematics majors can be measured. This poses a dilemma: either consider different or additional assessment tools, or decide that certain objectives can be measured in different ways, or (once again) revise the objectives.

Implementation of an assessment program leads to yet more decisions. Once the data has been collected it needs to be analyzed. The first issue is *who* should do it. Will it be the department chair, a subcommittee, or the entire department? Each choice comes with some advantages and disadvantages. Just as important, if not more important, is *how* to make sense of all of the data that has been gathered. Here's where rubrics and benchmarks are helpful to ensure consistency and faithfulness to the purposes of the assessment program. Assessment data is gathered by use of one or more instruments that were chosen to measure certain student learning objectives associated with particular departmental goals. Hence the department needs to (a) develop a rubric by means of which individual student responses can be judged and (b) establish a benchmark against which the composite of all those individual judgments can be measured. Case studies that describe this process include those from American University (p. 143), Colorado School of Mines (p. 149), Columbia College (Hopkins, 1999), and Northern Illinois University (Sons, 1999).

The final stage is the feedback loop. What do the results tell the department about whether students are meeting the goals the faculty has set forth and whether the program for mathematics majors is designed in such a way that the students can meet those goals? In other words, if students are falling short, is it the students who are underperforming or is it the program that is deficient? Whichever it is, in the final analysis the faculty must figure out how to improve the department's program so that mathematics majors are successful in developing the competencies the faculty desires for their majors. Sometimes (rarely) nothing needs to be done; sometimes the assessment plan needs to be fine-tuned; sometimes small changes in the major are sufficient; and sometimes the assessment results suggest significant curricular issues that need to be dealt with. After all, assessment is all about making the major better for our students. Examples of the variety of responses to assessment results can be seen in the case studies from American University (p. 143), Colorado School of Mines (p. 149), Columbia College (Hopkins 1999), Mary Washington College (Sheckels 1999), Point Loma Nazarene University (p. 163), and Wabash College (Gold 1999).

If developing a full-blown assessment plan seems daunting (as it did to several SAUM participants), one can proceed in stages. For example, once goals and learning objectives are established, it may be prudent to choose just one goal and its learning objectives to guide and pilot test the assessment process. Then assessment tools can be built to measure these objectives only. Analyzing these results, refining the plan, and making recommendations to improve the mathematics program in this one area can serve as a prototype for more comprehensive assessment in the future. Sometimes it is easier to see if one is on the right track by taking smaller steps, and often these lead to a better overall plan. The smaller-steps approach is discussed in case studies from Keene State College (p. 157), Point Loma Nazarene University (p. 163), Portland State University (p. 171), Saint Mary's University of Minnesota (p. 177), and Washburn University (p. 213).

One case study addresses a serious problem that is not altogether uncommon: what to do if assessment is mandated but the department faculty do not see any useful purpose in developing a plan? Such was the case at the University of Nevada, Reno (p. 207). Since the department chair is ultimately responsible, he or she can (and usually must) proceed alone. One approach is for the chair to assess a part of the curriculum that everyone agrees is problematic. The results of the analysis might lead to some good suggestions for improvement. In itself this might convince others to see the efficacy of assessment. But even if it doesn't, it will solve one problem that needs resolution.

Each undergraduate mathematics program is unique, yet there is enough commonality that we can learn from others' experiences. The case studies presented in this volume and its predecessor (Gold, et al., 1999) offer considerable variety of approaches to assessing the mathematics major. Even though none will be a perfect match for any other department, all offer ideas worth considering as departments plan to develop their own assessment programs.

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