# Developing a Departmental Assessment Program: North Dakota State University Mathematics

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## 0. Abstract.

*This article describes the process used to develop assessment in the mathematics programs at the North Dakota State University (NDSU). The Mathematics Department has developed a comprehensive assessment process that examines student learning in (a) services courses, (b) the major, and (c) the masters and Ph.D. program. The most ambitious component, established with external funding, examines the introductory mathematics courses in conjunction with the NDSU general education program. Assessment of the undergraduate and graduate programs involves many of the Department's faculty. All components of the project are designed to minimize extra demands on participants, to provide useful information for participants as well as the Mathematics Department and University, and to focus on assessment as an integrated part of departmental activities rather than an "add-on" activity done primarily for external purposes.*

## 1. Context and Setting.

North Dakota State University is a land grant, Doctoral I research university, and is the top institution in the state for graduating agriculture, engineering, mathematics and science students with baccalaureate through doctorate degrees. The number of undergraduate students (Fall 2002) is 9,874; and the number of graduate students is 1272. The average ACT composite score of all entering students (Fall1997) is 23.1 (the national average is 21.0). The student to teacher average ratio is 19 to 1. Most of the classes specifically relating to the majors typically have fewer than 25 students, and mostly research faculty with terminal degrees teach those courses. The normal teaching load for research faculty is four courses per year.

The Department of Mathematics at NDSU offers BS (mathematics and secondary mathematics education), MA, and PhD degrees. The Department also has a major service role for other science and mathematics-intensive programs in the institution, particularly in the Colleges of Science and Mathematics, Engineering, Business Administration, and Pharmacy. The Department offers a broad and balanced curriculum of courses with 15 tenure-track faculty and about 10 lecturers (Computer Science and Statistics are separate departments). In Fall 2002 there were 38 mathematics majors in sophomore-senior standing among 83 undergraduate majors. Many talented students participate in the EPSCoR-AURA program; mathematics faculty members frequently supervise the undergraduate research projects of talented mathematics students. The undergraduate mathematics major's degree program culminates with a capstone course, usually completed during the senior year. The Department, as the largest service department on the campus, enrolls 300-400 students each in calculus I and calculus II every semester (taught in a large lecture and recitation format) and 150-300 students per semester in each of calculus III and differential equations (taught in classes of about 35 students). The Department provides free tutoring services for all 100-300 level mathematics courses, staffed mostly by graduate students and talented undergraduate mathematics and mathematics education majors.

## 2. Assessment Project Goals.

Our goal is to develop and conduct a comprehensive assessment program to monitor the impact of all of our instruction on student learning of mathematics. We focus on three components of our instructional role: (a) Service courses through the first two undergraduate years, (b) the undergraduate program for mathematics majors, and (c) the graduate program. The assessment program is designed to involve many departmental faculty in our activities and to coordinate our departmental efforts with the work of the University Assessment Committee.

## 3. Assessment Program Description.

### 3.1. Development of the program.

Two components of our departmental assessment activities have been developed separately: (a) a campus-wide quantitative assessment project focusing on first- and second-year service courses through multi-variable calculus and differential equations and (b) departmental assessment of our undergraduate major and graduate programs. The campus-wide quantitative assessment project uses a model first developed by Martin and Bauman at the University of Wisconsin-Madison (Bauman and Martin, 1995; Martin, 1996) that originally was funded at NDSU by the Office of Assessment and Institutional Research. A recent, more extensive implementation occurred with support from the Bush Foundation of Minneapolis.

The departmental degree program assessment activities were developed to make use of existing instructional activities, reducing financial costs and time demands on faculty. Data is obtained from specific courses required of all undergraduate students, graduate program written and oral examinations, and advisor reports. Additionally, the Department has developed and begun to implement a peer review of teaching program, which will provide additional information about instruction and student learning.

### 3.2. Departmental service role assessment.

The most ambitious component of our assessment activities is the quantitative assessment project. Briefly, the purpose of the project is to gather information about (a) quantitative skills used in specific beginning upper-division courses and (b) the extent to which students can show these important skills at the start of the semester. Instructors play a key role in helping to design free-response tests reflecting capabilities expected of students from the first week and essential for success in the course. Two important characteristics of this form of assessment are (a) direct faculty involvement and (b) close ties to student goals and backgrounds. We have found that the reflection, contacts and dialogs promoted by this form of assessment are at least as important as the test results.

The process begins with the selection of beginning upper-division courses across the campus. These courses are selected either (a) by the Department Assessment Committee or (b) by the instructors themselves. Course instructors, selected from a range of departments, identify the specific quantitative skills their students need. The students are then given a test at the start of the semester designed to determine whether they have these skills. The tests, given early in the term,

undergraduate introductory proof course (Math 270, sophomore level) and our capstone course (Math 490, senior level); (b) Graduate qualifying and final examinations; and (c) Graduate student advisors. We developed forms to be completed by faculty members (a) teaching targeted courses, (b) preparing and grading departmental examinations, and (c) advising graduate students. Sample rating forms from each of the three programs are attached to this report in Appendix D.

### 3.4. Department Instructional Objectives.

The Department had previously adopted a list of objectives for student learning in its three degree programs (see Appendix B). We designed rating forms that list objectives that might be assessed through observations in a particular context (for example, the masters comprehensive exam or the capstone course–see Appendix D). Faculty are asked to rate students as fail, pass, or high pass on each outcome. They are then asked to provide descriptive comments about student performance as shown by this assessment or activity to provide evidence that supports their evaluations and to expand on the ratings. These forms are available for faculty members to complete while they conduct the targeted activities. Faculty ratings and comments are based on the standard tools of measurement used to assess and evaluate the student performance in a class, such as classroom tests, quizzes, written assignments, and group work reports. The Department has course descriptions (called TACOs for *Time Autonomous Course Outlines*) for instructors in all undergraduate courses and uses common exams and grading in most introductory courses. These are designed to help ensure a degree of uniformity for sections taught by different instructors and from semester to semester.

Completed forms are returned to the Department Assessment Committee, which analyzes results and prepares a summary report to the Chair, Graduate and Undergraduate Program Directors, and the Department. This process has ensured that a large majority of our Department's faculty are involved in assessment activities each year. At the same time, the extra demands made on individuals by assessment is minimized-most faculty are only asked to provide information they obtained for other reasons and to review and react to the summary assessment report. This is a welcome change for the Chair, in particular, who formerly took responsibility mostly alone for preparing the annual assessment report for the University Assessment Committee and university administration.

## 4. Implementation.

The assessment program implementation is being done in an ongoing fashion while focusing in one or more courses each year, and continuing the data gathering in the courses whose assessment has begun earlier. To illustrate our implementation process we provide the assessment activities for the academic year 2002-2003.

### 4.1. Aspect of Program to be Assessed.

We chose to focus this year on the three-semester engineering-calculus sequence, introductory linear algebra, and differential equations. The guiding question for our work was "Do students develop the quantitative skills they need for success in later studies in their chosen field?" To respond to this question we investigated three things:

1. What are the existing goals for our introductory service courses?
2. What are the quantitative expectations of our clients (for example, later math courses, engineering programs, physical science programs)?
3. To what extent do students meet the expectations of our clients?

**4.2. Status of learning goals for this subprogram.**
We have two kinds of goals for this program. The Department has an explicit objectives statement that covers the undergraduate program, including these courses. These objectives are described in Appendix B as:

1. Students will be able to analyze problems and formulate appropriate mathematical models
2. Students will understand mathematical techniques and how they apply.
3. Students will recognize phenomena and be able to abstract, generalize, and specialize these patterns in order to analyze them mathematically.
4. Students will be able to express themselves in writing and orally in an articulate, sound and well-organized fashion.

This project additionally identifies implicit objectives for the introductory sequence of service courses. Part of the data analysis includes a review of the items that appear on tests. This analysis identifies implicit goals and objectives for the service program.

An important part of the project is for the Mathematics Department to review and respond to the findings, including these implicit goals. This took place at assessment committee and departmental meetings during April and May.

**4.3. Activities during 2002-03.**
Following the guidelines we set for this years' assessment program, we completed the following activities:

**4.3.1.** *Quantitative Assessment of general education and service courses.* This is the continuation of the assessment process we started seven years earlier and is an ongoing process for regular calculus sequence; and initiation of the assessment process for focus courses for this year (the three-semester engineering-calculus sequence, introductory linear algebra and differential equations). This part of the program implementation involved more assessment and reporting than analysis and response, particularly for the new courses.
**4.3.2.** *Undergraduate majors.* We had faculty members rate student performance in the introductory proof course and in the senior seminar capstone course.
**4.3.3.** *Graduate students.* Faculty members and advisors rated student performance on exams and progress toward their degree (see forms in Appendix D).
**4.3.4.** *Increased involvement of faculty.* We have wanted to increase faculty involvement in the assessment program for many years. It seemed that having the same small group of faculty conducting the assessment activities did not promote wider faculty involvement, since most assumed the people who had done it before would continue to take care of the work. Working with the Department administration, we adopted a new strategy to increase faculty involvement:

Each year a new group of 4-5 faculty (which includes at most two faculty from the previous year) would conduct assessment activities. This strategy worked well. The new members of this year's assessment committee took ownership of the program, carrying the bulk of the activities, but they were not intimidated by the task since they had a good model to use as a template for their activities and reports and experienced faculty members to provide guidance. Formation of the committee for the next year's assessment activities has been significantly easier since more faculty were willing to participate, recognizing that the task did not impose onerous expectations for additional work.

**4.3.5.** *Peer review of teaching.* Several faculty developed a proposal for a departmental peer review of teaching program to complement the limited information provided by student course evaluations. The committee that developed this program began their planning in Fall 2001. The program was adopted by the Department in Fall 2002 and has been piloted by four pairs of faculty or lecturers during 2002-3. (Appendix E)

**4.3.6.** *Connections to University Assessment Committee (UAC) activities.* One Department member, Bill Martin, has been actively involved in NDSU assessment activities as a member of the UAC steering committee, the University Senate Executive Committee, and the Senate Peer Review of Teaching Board. This institutional involvement has contributed to the integration of Department assessment activities with the assessment work being conducted at NDSU. Consequently, activities conducted in the Mathematics Department have helped to shape the assessment strategies adopted at the university level.

## 5. Insights and Lessons Learned.

### 5.1. Findings and success factors.

The process we have developed takes an ongoing, integrated approach that seeks to embed assessment activities in our instruction. We believe the process provides useful insights to the learning that takes place in our programs. To illustrate the sort of information we obtain, a recent summary report described findings of the annual quantitative assessment project, that focuses on service courses, in this way:

> The tests of greatest interest to the Department of Mathematics were given in [Calculus III] (235 students, four instructors), [Calculus III with vector analysis] (47 students, one instructor), and [Differential Equations] (264 students, five instructors). These courses include many students who are majoring in technical programs across the campus, including physical sciences, mathematics, and engineering. All require students to have successfully completed the first year regular calculus sequence. A sample course report, giving detailed information about the outcomes, is attached as Appendix A. Faculty members discussed reports of the Fall 2001 tests during a December faculty meeting. The discussions ranged over the nature of the assessment program (for example, whether the tests were appropriate) and the success rates. While there was a range of opinions expressed at the meeting, it was agreed that the program was potentially very useful and should continue. These initial results did not lead to specific proposals for course changes this year.
>
> Individual faculty who taught the courses in which assessments were given were asked for their reactions to the test results. The tests revealed areas of strength in student performance along with weaknesses that concern faculty. These patterns were reflected both in the comments at the meeting and in written responses to the reports. There was agreement by many that the information

was useful as an indicator of program strengths and weaknesses. More specific information about success rate patterns and their perceived significance is provided in the reports themselves.

So far, our assessment findings have not led to major changes in courses or programs at NDSU. A current focus of our work is on making better use of the information obtained from assessment activities. We plan to have a more extensive review and discussion of findings by departmental faculty, now that we have data from several years. The purpose of the discussion is to address several questions:

1. What do the findings show about student learning and retention from our courses?
2. What might account for these patterns? In particular, why do students seem to have specific difficulties?
3. What could and should the Department do to address areas of weakness?
4. Are we satisfied with the Department's stated goals and our assessment procedures, having attempted to assess student achievement in relation to the stated goals for several years?

While the focus of each test is on a particular course, we are able to gain a broader perspective on faculty expectations and student achievement by pooling results from different assessments and over several years. The table below illustrates the patterns that can be discerned in the results. The table also summarizes some generalizations we can make based on tests administered by the project. We have found three levels of mathematics requirements or expectations in courses across the campus. Within each level, patterns of students' success rates have become apparent over the years.

The course level is based on mathematics prerequisites. For example, Level 2 courses require just one semester of calculus (examples include Finance and Agricultural Economics courses). The success rates range from *High* (where more than two-thirds of the tested students in a class are successful) down to *Low* (when under one-third of the students are able to solve a problem correctly). Each cell reports a general trend we have observed. For example, typically any calculus problem administered to students in a Level 2 course will have a low success rate. The cell also mentions a specific problem to illustrate the trend. The example problem for typically low success rates in a Level 2 course is asking students to estimate the value of a derivative at a point given a graph of the function. The most important characteristic of this table is that it illustrates how the use of tests that are custom-designed for particular courses can still provide detailed and useful information about mathematics achievement on a much broader scale at the institution.

**Patterns of Student Results**

| | Level 1 (no math or stat prerequisites) | Level 2 (require 1 semester of calculus) | Level 3 (expect 3 semesters of calculus) |
|---|---|---|---|
| High success | Basic arithmetic, statistics and conversions (computational)<br>Example: temperature conversion | No common items for all subjects fit here–basic statistics is an example<br>Example: change in mean | Most precalculus, use calculus formulas and techniques (e.g., differentiate)<br>Example: evaluate integral |
| Mixed success | No common types across most courses at this level<br>Example: compare proportions | Precalculus material, such as solving 2x2 systems or reading values off a graph<br>Example: profit function | Concepts from calculus<br>Example: estimate a derivative or integral from graph |
| Low success | Extract information from tables and graphs<br>Example: 2x2 cross tabulation table | Nearly all calculus material<br>Example: estimate derivative at point | Complex numbers, ODE's, series, and more complex "word problems" (such as optimization)<br>Example: minimize can's surface area |

Appendix C contains a more complex table that illustrates how even more detailed information can be extracted from a large number of tests administered across many departments and years. The table illustrates that not only success rates on particular problem types, but even the distribution of types of problems can be analyzed to help identify how mathematics is used across the campus in different programs. This table compares the nature of tests and patterns of success rates in mathematics, engineering, and physical science courses, all of which require the full three-semester normal introductory calculus sequence.

The table is based on 240 individual problem success rates (PSR-success rates for each time a problem was used on a test). The three groups of courses were: (a) Mathematics (four distinct courses, including a differential equations course that was tested in successive semesters; with 58 PSR); (b) Physical Sciences (five distinct courses, including a two-course atmospheric science sequence with retested students in successive semesters; 68 PSR); and (c) Engineering (six distinct courses, two of which-electrical and mechanical engineering-were tested in successive semesters; 114 PSR). The table has been included not so much for detailed analysis of its content in this paper, but to illustrate the detailed information that can be provided by this assessment process.

For example, the table illustrates quite different patterns of mathematics usage across the three disciplinary areas: *Mathematics* courses emphasized non calculus material (60% of the problems that appeared on tests in those courses), *Science* courses drew most heavily on differential calculus material (56% of problems), while *Engineering* courses had a more balanced use of problems from across all the introductory areas (22% non calculus, 31% differential calculus, 16% integral calculus, 26% differential equations, and 5% probability and statistics). Much more detailed information is included about specific types of problems and typical success rates. For example, the first entry for *Mathematics* is *Graph Interpretation* problems which appeared on two different tests in one math course (2-1). These problems representede 3% of all problems that appeared on math course tests, and the median success rate across all problems of this type that were administered in a math course fell in the second quartile (2) representing 25-50% for students taking those tests.

### 5.2. Dissemination of Findings.

Our assessment findings have been shared with four distinct groups: (a) Mathematics faculty at NDSU, (b) NDSU departments who depend on mathematics, (c) other NDSU faculty interested in departmental assessment, and (d) mathematics faculty from other institutions involved in the MAA Assessment Project SAUM. The first two groups are most interested in student performance and its implications for their courses and programs. The second pair are interested in the assessment methods employed by our project.

A goal of our work, both in the design of assessment activities and the strategies used to involve faculty and disseminate results, has been to only do things that have value for participants. For example, when we ask students to take tests, we want it to have personal value for them at that time rather than just appealing for their participation for the good of the department or institution. Similarly, when we ask faculty to conduct an assessment in their class or to review reports, they should feel they have gained valuable insights as a result of their work rather than submitting a report because it is required for some external purpose.

## 6. Next steps and recommendations

Some of our work requires the assistance of a graduate student to help with test administration and data analysis and some financial support for duplication and test scoring. We have found support for this work through external grants and are working to institutionalize this support as a part of the University's institutional assessment and accreditation activities. The work is valued at the institutional level because the extensive service role played by mathematics is well recognized. Consequently, we expect to receive some level of institutional support for our general education assessment activities, the ones that require the most extra work to conduct and analyze.

We recognize that we have to date had more success gathering and disseminating assessment data than getting faculty to study and respond to the findings. This partly reflects the natural inclination of faculty to focus on their own courses than on the broader picture of how programs are working to develop student learning. We plan to concentrate our efforts now on ensuring that assessment findings are regularly reported and discussed by faculty, both in participating departments and in the Mathematics Department. We believe that regular conversations about the patterns of results will lead to the formulation and implementation of responses to shortcomings revealed by assessment activities. Our approach reflects the belief that faculty are in the best position to respond to findings and that our most important role is in providing accurate information about student achievement. Consequently, our reports focus on providing descriptive statements about student performance, rather than making detailed recommendations for changes in courses and instruction.

We also believe that widespread faculty involvement in assessment activities is a necessary condition for an effective assessment program. Our strategy has been to adopt a non judgmental approach that seeks to minimize special effort required of participants and to ensure that participants clearly see that they stand to benefit from the activities in which they are involved. Our efforts to increase departmental and university faculty involvement and impact will continue. The strategies initiated during the last academic year seem to work. The Department's assessment committee will continue to work with UAC and General Education Committee to increase the impact of the departmental assessment activities to a broader audience.

## References

Bauman, S. F., & Martin, W. O. (May 1995). Assessing the Quantitative Skills of College Juniors. The College Mathematics Journal, 26(3), 214-220.

Martin, W. O. (1996). Assessment of students' quantitative needs and proficiencies. In T. W. Banta, J. P. Lund, K. E. Black, & F. W. Oblander (Eds.), Assessment in Practice: Putting Principles to Work on College Campuses. San Francisco: Jossey-Bass.

## Appendix A. Sample report for Math 265 ( Calculus III), Spring 2002.

Preliminary Assessment Results

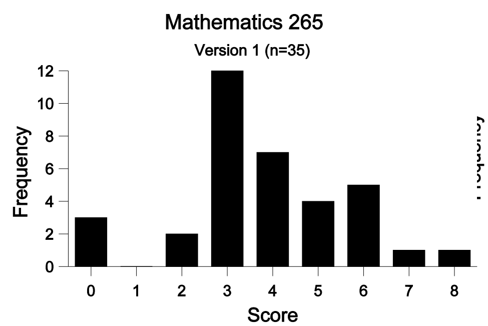
Mathematics 265: Calculus III

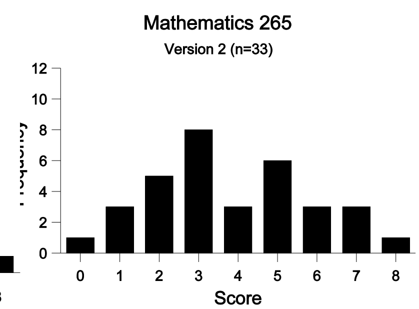
Spring 2000-02

Sixty-eight students took two versions of a eight-item free-response test in Mathematics 265 (Professor Sherman) during the second week of the Spring 2002 semester. The test was designed to see the extent to which students had quantitative skills required for success in the course. Students were not allowed to use calculators while completing the assessments. Graduate students from the Department of Mathematics graded the papers, recording information about steps students had taken when solving the problems. The graders also coded the degree of success achieved on each problem using the following rubric:

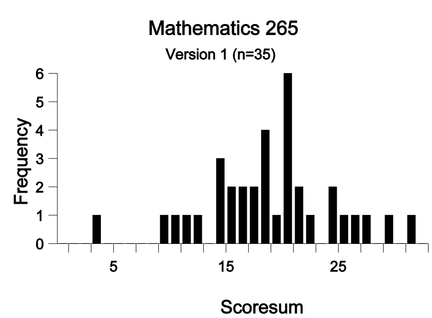
A Completely correct
B Essentially correct—student shows full understanding of solution and only makes a minor mistake (e.g., wrong sign when calculating a derivative or arithmetic error)
C Flawed response, but quite close to a correct solution (appears they could do this type of problem with a little review or help)
D Took some appropriate action, but far short of a solution
E Blank, or nothing relevant to the problem

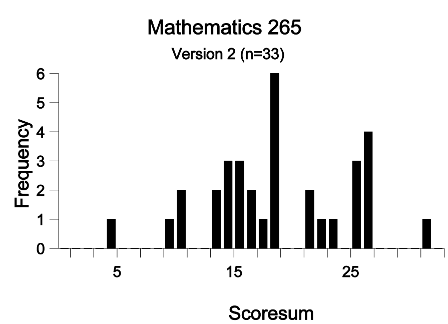
Corrected papers, along with suggested solutions to the problems, were returned to students the following week. Summaries of the grader's coding are included on the attached copy of the test.
A test score was computed by awarding one point for each A or B code and zero points for each C, D, or E code. This score reflects the number of problems that each student had essentially or completely correct. The distributions of test scores are shown in these figures.




The second pair of charts gives the distribution of partial credit scores called scoresum (each problem was awarded 0-4 points, E=0 to A=4).




It appears that many students will need to review some mathematics covered on the test, since a majority were successful on less than half the problems. Almost two-thirds of the students (44 of the 68) achieved overall success on four or fewer of the eight problems.

The problems are ranked according the degree of success students achieved on each problem in the following table.

Degree of Success on Test Problems

| %AB | %A | %C | No | Problem description |
|---|---|---|---|---|
| 85% | 12% | 3% | V2#3 | Integration using Fundamental Theorem of Calculus |
| 73% | 58% | 3% | V2#2 | Solve using property of differences for logarithms (same as V1#2) |
| 69% | 66% | 6% | V1#2 | Solve using property of difference for logarithms (same as V2#2) |
| 66% | 31% | 20% | V1#3 | Set up a definite integral to compute the area enclosed by a parabola and line (same as V2 |
| 61% | 55% | 18% | V2#1 | Complete the square to find center and radius of an equation (same as V1#1) |
| 60% | 31% | 11% | V1#8 | Use substitution to evaluate an indefinite integral |
| 57% | 51% | 14% | V1#1 | Complete the square to find center and radius of an equation (same as V2#1) |
| 52% | 46% | 18% | V2#7 | Use integration by parts to evaluate definite integral |
| 52% | 33% | 46% | V2#4 | Set up a definite integral to compute the area enclosed by a parabola and line (same as V1 |
| 49% | 29% | 9% | V1#7 | Use substitution to evaluate an integral |
| 42% | 30% | 21% | V2#5 | Use a sign table for a function and its derivative to sketch a graph of the function |
| 40% | 26% | 23% | V1#5 | Estimate the derivative of a function at a point from its graph |
| 23% | 17% | 11% | V1#4 | Solve using implicit differentiation |
| 17% | 11% | 20% | V1#6 | Maximize area of a rectangle inscribed in a semicircle (same as V2#6) |
| 15% | 12% | 21% | V2#6 | Maximize area of a rectangle inscribed in a semicircle (same as V1#6) |
| 6% | 3% | 39% | V2#8 | Area enclosed by one-loop of four-leaved rose |

The problems are primarily sorted in this table by proportion of students who received a code of A or B, indicating t at least essentially correct. For reference, the second and third columns report the proportion of students who had th completely correct (A, column 2) and the proportion who made good progress (C, column 3).

The problems have been divided into three groups. At least two-thirds of the students could integrate using the Fundamental Theorem of Calculus, and solve using properties of logarithms. About three-quarters of the students successfully set up a definite integral to compute the area enclosed by a parabola and line.

Fewer then three-fifths of the students completed the square to find the center and radius of an equation, or used substitution to evaluate an integral and/or indefinite integral. Similarly they successfully used a sign table of a function and its derivative to sketch a graph of the function and estimate the derivative of a function at a point from its graph. Under a quarter of the students could solve using implicit differentiation, or calculate the area enclosed by one-loop of a four-leaved rose.

Mathematics Backgrounds

University records provided information about the mathematics courses that had been taken by students in these classes. The following tables report up to the four most recent mathematics courses recorded on each student's transcript. Every student with available records indicate exposure to at least one mathematics course. The median for Math 166 was a B, but one should notice that almost half of the students received and A in the course. Calculus III is a retake for seven students that were tested, of these seven, two have no record of taking the prerequisite.

College Level Mathematics Courses (Four Most Recent Courses)

| Score (max=8) | Scoresum (max=32) | Version | Math Courses (Course—Semester—Grade*) | | | |
|---|---|---|---|---|---|---|
| 8 | 31 | 1 | M166 021 A | | | |
| 7 | 29 | 1 | M270 021 A | M229 014 A | M166 013 A | M165 011 A |
| 6 | 27 | 1 | M166 021 A | | | |
| 6 | 26 | 1 | M166 021 A | | | |
| 5 | 25 | 1 | M166 021 A | | | |
| 6 | 24 | 1 | M166 021 B | | | |
| 5 | 24 | 1 | M166 013 A | M165 011 A | | |
| 6 | 22 | 1 | M166 013 A | | | |
| 5 | 21 | 1 | M166 021 B | M165 013 B | M105 011 A | |
| 4 | 21 | 1 | M229 021 D | M265 021 F | M166 013 D | M165 011 C |
| 6 | 20 | 1 | M166 021 C | M229 021 B | M165 013 C | M105 011 B |
| 5 | 20 | 1 | M166 021 A | M165 013 A | M105 011 A | |
| 4 | 20 | 1 | M166 021 A | M229 021 A | M165 013 A | M105 011 B |
| 4 | 20 | 1 | M166 021 A | M229 021 A | M154 013 A | M105 011 A |
| 4 | 20 | 1 | M166 013 C | M165 011 A | | |
| 4 | 20 | 1 | M229 021 D | M265 021 D | M166 013 I | M165 011 B |
| 3 | 19 | 1 | M166 021 C | M229 021 C | M166 013 D | M165 011 B |
| 4 | 18 | 1 | M166 021 B | M229 021 B | M165 013 B | M105 011 B |
| 3 | 18 | 1 | M166 021 A | M229 021 C | M165 013 B | M105 011 A |
| 3 | 18 | 1 | M166 021 B | M165 013 A | M105 011 B | |
| 3 | 18 | 1 | M166 021 A | M165 013 C | M105 011 C | |
| 4 | 17 | 1 | No Data Available | | | |
| 3 | 17 | 1 | M166 021 C | M165 013 B | M165 011 D | M229 011 B |
| 3 | 16 | 1 | M166 021 A | M165 013 A | M105 011 B | |
| 3 | 16 | 1 | No Data Available | | | |
| 3 | 15 | 1 | M166 021 B | M165 013 B | M146 011 B | |
| 3 | 15 | 1 | M166 021 C | | | |
| 3 | 14 | 1 | M166 021 B | M165 014 A | M165 013 F | M105 011 B |
| 3 | 14 | 1 | M229 021 C | | | |
| 2 | 14 | 1 | No Data Available | | | |
| 3 | 12 | 1 | No Data Available | | | |
| 2 | 11 | 1 | M166 021 C | M229 021 B | M165 013 A | M105 011 B |
| 0 | 10 | 1 | M265 021 F | M265 013 D | M166 011 C | M229 011 C |
| 0 | 9 | 1 | No Data Available | | | |
| 0 | 3 | 1 | M166 021 C | M165 013 C | M105 011 C | |
| | | | | | | |
| 8 | 31 | 2 | M166 021 A | M229 021 A | | |
| 7 | 26 | 2 | M166 021 A | M105 013 A | M165 013 A | M103 011 A |
| 7 | 26 | 2 | M166 021 A | | | |
| 7 | 26 | 2 | No Data Available | | | |
| 5 | 26 | 2 | M166 021 A | | | |
| 6 | 25 | 2 | M166 021 A | M165 013 A | M105 011 B | |
| 6 | 25 | 2 | M166 021 C | M165 013 B | M105 011 B | |
| 6 | 25 | 2 | No Data Available | | | |
| 5 | 23 | 2 | M166 021 A | M165 013 A | M105 011 A | |
| 5 | 22 | 2 | M166 021 A | | | |
| 5 | 21 | 2 | M166 021 A | | | |
| 5 | 21 | 2 | No Data Available | | | |
| 4 | 18 | 2 | M166 021 A | M165 013 A | M105 011 A | |
| 4 | 18 | 2 | M166 021 A | M165 013 A | M105 011 A | |

College Level Mathematics Courses (Four Most Recent Courses)

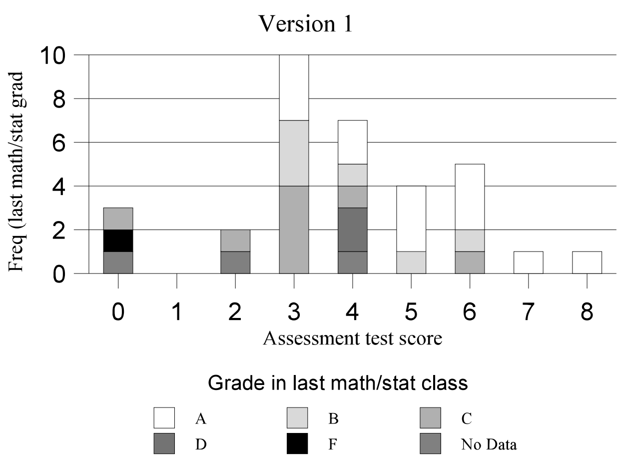
| Score (max=8) | Scoresum (max=32) | Version | Math Courses (Course—Semester—Grade*) | | | |
|---|---|---|---|---|---|---|
| 4 | 18 | 2 | M166 021 A | | | |
| 3 | 18 | 2 | M229 021 B | M265 021 F | M166 014 B | M166 013 F |
| 3 | 18 | 2 | M166 021 C | M105 011 B | | |
| 3 | 18 | 2 | No Data Available | | | |
| 5 | 17 | 2 | M166 021 A | | | |
| 3 | 16 | 2 | M166 021 B | M229 9021 B | M165 014 A | M105 013 A |
| 2 | 16 | 2 | M166 013 B | M105 011 B | M165 011 B | |
| 3 | 15 | 2 | M166 021 C | M165 013 C | M105 011 A | |
| 3 | 15 | 2 | M166 021 B | M165 013 A | M105 011 A | |
| 2 | 15 | 2 | M105 021 A | M166 021 B | | |
| 3 | 14 | 2 | M229 021 C | M265 021 C | M270 021 C | M166 013 B |
| 3 | 14 | 2 | M166 021 C | | | |
| 2 | 14 | 2 | M166 021 C | M165 013 C | M105 011 C | |
| 2 | 13 | 2 | M265 021 D | | | |
| 2 | 13 | 2 | M166 021 C | M165 013 C | M105 011 B | |
| 1 | 10 | 2 | M166 021 C | M165 014 C | M105 011 C | M103 004 C |
| 1 | 10 | 2 | M229 021 D | M265 021 F | M166 013 D | M165 011 C |
| 1 | 9 | 2 | M260 003 F | M161 993 C | M142 991 C | M160 991 B |
| 0 | 4 | 2 | M229 021 C | M265 021 F | | |

## NDSU Mathematics Courses

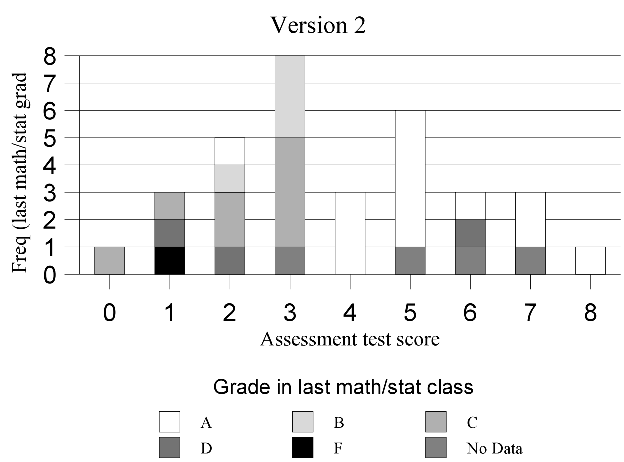
100-102 Pre College Algebra
103 College Algebra
124 Finite Math (now 104)
142 Trigonometry (now 105)
146-147 Business Calculus Sequence

160-161, 260 Regular Calculus Sequence (now 165-166, 259)
261 Differential Equations (now 266)
263 Vector Calculus (now in 265)
228, 229 Basic Linear Algebra
329 Linear Algebra

Most recent math grade by test score




Most recent math grade by test score




These histograms help to illustrate possible connections between test score and grade in the most recently completed mathematics or statistics course. On version one students with higher grades (lighter shades in divided frequency bars) in most recent course generally scored somewhat higher on this assessment test, as one might expect.

Reactions
We asked the instructor five questions about the test results. Her responses are summarized below.

Instructor:

1. Are you surprised by students' performance on particular test items?

2. Did you do anything different this semester because of your students' performance on the test?

3. How well do you think the tests reflected the quantitative demands of your course? Is it accurate to say that the skills we testes were essential for survival in the course?

4. Would you suggest any changes in prerequisites, student preparation, or the nature of this course based on what you have learned from the preparation and administration of these tests?

5. If this or another course in your department was tested again in another semester, would you suggest any changes in the testing program?

Department:

Reactions to these results:
Suggested responses(action plans):

Percentages refer to the proportions of the 35 students who took the test.

1. The circle with radius r given by the equation $(x-h)^2+(y-k)^2=r^2$ has its center at the point (h,k). Find the center and radius of the circle given by $x^2+6x+y^2-2y=15$.

| | |
|---|---|
| Demonstrated knowledge of the technique of completing the square: | 71% |
| Correctly completed the square: | 57% |
| Gave center correctly: | 66% |
| Gave correct radius: | 51% |

Degree of Success: A 51% B 6% C 14% D 26% E 3%

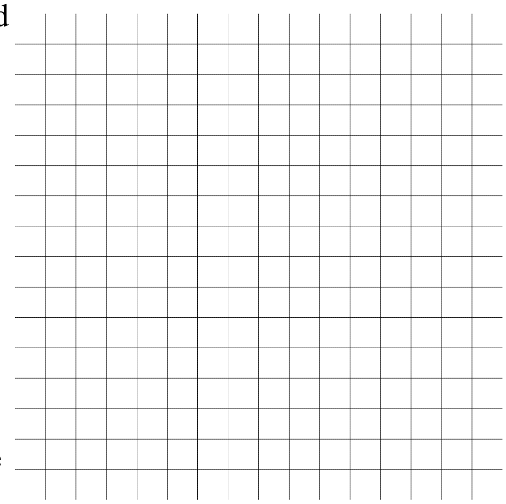
2. The expression $e^{\ln u-\ln v}$ can be simplified to one of the following expressions. Circle the correct one and show why it is correct:

(a) $u-v$ (b) $e^{\frac{u}{v}}$ (c) $e^{u-v}$ (d) $\frac{u}{v}$ (e) $\frac{\ln u}{\ln v}$

| | |
|---|---|
| Selected correct answer (D): | 69% |
| Correctly used property for difference of logarithms in simplification: | 63% |
| Gave valid justification for correct answer: | 60% |

Degree of Success: A 66% B 3% C 6% D 23% E 3%

3. (a) Find the points of intersection of the curves $y=2x-3$ and $y=4x-x^2$.



| | |
|---|---|
| Correctly solved quadratic (x=-3,1): | 83% |
| Gave points (-1,-5) and (3,3): | 71% |

(b) Sketch a graph that shows the area enclosed by the two curves.

| | |
|---|---|
| Graphed line correctly: | 94% |
| Graphed parabola correctly: | 89% |

(c) Set up a definite integral that could be used to calculate the area enclosed by the curves $y=2x-3$ and $y=4x-x^2$.

Set up correct integral: 69%

(d) Use your integral from (c) to calculate the enclosed area.

Founds correct antiderivative:66%

Evaluated correctly $\left(\frac{32}{3}\right)$: 43%

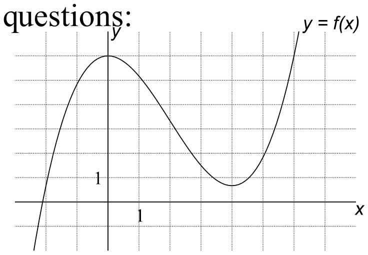
Degree of Success: A 31% B 34% C 20% D 11% E 3%

4. Suppose y is a differentiable function of x satisfying $x^2 + xy^2 + 3y = 11$ for every x in its domain. What is the numerical value of $\frac{dy}{dx}$ at the point (1,2)?

Used implicit differentiation (even if not completely correctly):63%
Correctly used product rule for second term: 29%
Solved for $\frac{dy}{dx}$ correctly: 14%
Substituted x=1, y=2 to find numerical value 51%

Degree of Success: A 17% B 6% C 11% D 43% E 23%

5. Here is the graph of a function $y = f(x)$. Use the graph to answer these questions:




(a) Estimate $f'(4)$

Sketched tangent line at each point (not necessary) 29%
Commented on local minimum and/or horizontal tangent at x=4: 17%
Stated m=0: 60%

(b) Estimate $f'(2)$.

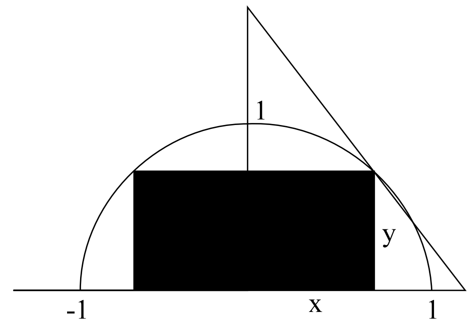
Observed that gradient at x=2 is negative: 43%
Estimated at x=2, -3 < m < -1: 26%

(c) On which interval(s), if any, does it appear that $f'(x) < 0$?

Gave correct estimate for interval: 46%

Degree of Success: A 26% B 14% C 23% D 20% E 17%

6. Find the rectangle of largest area that can be inscribed in a semicircle with radius 1 as shown in the figure.




| | |
|---|---|
| Found relationship between x and y: | 44% |
| Found function for the area of the rectangle in terms of one variable: | 29% |
| Differentiated correctly: | 11% |
| Found zero of $A'$ : | 11% |
| Used multivariable approach (such as Lagrange Multipliers): | 11% |
| Gave values for x and y or dimensions of the rectangle: | 31% |
| Gave area of the rectangle (1) –not necessary: | 26% |

Degree of Success: A 11% B 6% C 20% D 34% E 29%

7. Evaluate: $\int \frac{\cos t}{\sin^3 t} dt$

Used substitution correctly to obtain integrand $\frac{du}{u^3}$ 54%

Integrated correctly: 40%

Degree of Success: A 29% B 20% C 9% D 26% E 17%

8. Simplify: $\int \frac{x}{2+3x^2} dx$

| | |
|---|---|
| Used substitution correctly: | 66% |
| Integrated correctly | 57% |
| Included constant of integration: | 37% |

Degree of Success: A 31% B 29% C 11% D 26% E 3%

Percentages refer to the proportions of the 33 students who took the test.

1. The circle with radius r given by the equation $(x-h)^2+(y-k)^2=r^2$ has its center at the point (h,k). Find the center and radius of the circle given by $x^2+6x+y^2-2y=15$.

| | |
|---|---|
| Demonstrated knowledge of the technique of completing the square: | 85% |
| Correctly completed the square: | 58% |
| Gave center correctly: | 73% |
| Gave correct radius: | 61% |

Degree of Success: A 55% B 6% C 18% D 15% E 6%

2. The expression $e^{\ln u-\ln v}$ can be simplified to one of the following expressions. Circle the correct one and show why it is correct:

(a) $u-v$ (b) $e^{\frac{u}{v}}$ (c) $e^{u-v}$ (d) $\frac{u}{v}$ (e) $\frac{\ln u}{\ln v}$

| | |
|---|---|
| Selected correct answer D: | 78% |
| Correctly used property for difference of logarithms in simplification: | 58% |
| Gave valid justification for correct answer: | 61% |

Degree of Success: A 58% B 15% C 3% D 15% E 9%

3. Simplify: $\int\frac{-2}{x}dx$

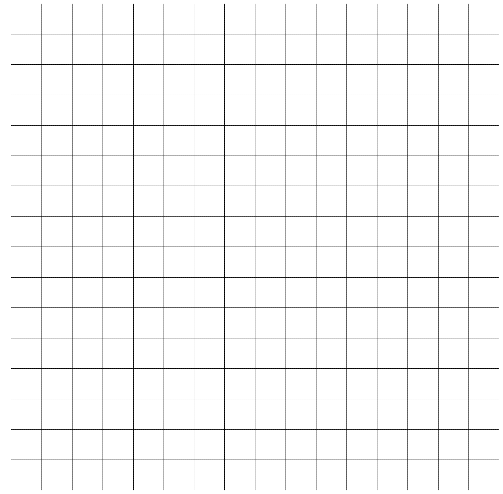
| | |
|---|---|
| Integrated correctly: | 42% |
| Included absolute value sign: | 24% |
| Included constant of integration: | 58% |

Degree of Success: A 12% B 73% C 3% D 6% E 6%

4. (a) Find the points of intersection of the curves $y = 2x - 3$ and $y = 4x - x^2$.

Correctly solved quadratic (x=-1,3): 61%

Gave points (-1,-5) and (3,3): 61%



(b) Sketch a graph that shows the area enclosed by the two curves.

Graphed line correctly: 88%
Graphed parabola correctly: 85%

(c) Set up a definite integral that could be used to calculate the area enclosed by the curves $y = 2x - 3$ and $y = 4x - x^2$.

Set up correct integral: 76%

(d) Use your integral from (c) to calculate the enclosed area.

Found correct antiderivative: 79%

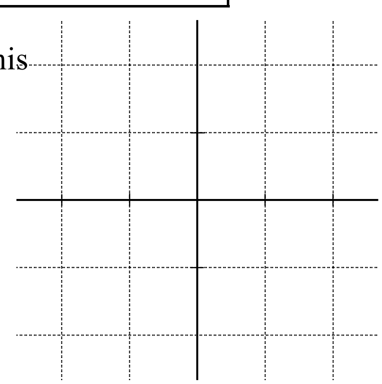
Evaluated correctly $\left(\frac{32}{3}\right)$: 42%

Degree of Success: A 33% B 18% C 46% D 3% E 0%

5. Here is a sign chart for a function, $y = f(x)$, and its first and second derivatives, $f'$ and $f''$.

| | $x < -1$ | $x = -1$ | $-1 < x < 1$ | $x = 1$ | $x > 1$ |
|---|---|---|---|---|---|
| $f$ | + | does not exist | + | 0 | – |
| $f'$ | + | does not exist | – | 0 | – |
| $f''$ | + | does not exist | + | 0 | – |

(a) Sketch a possible graph for a function that satisfies the conditions in this table.



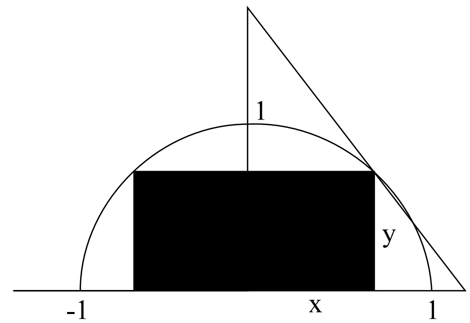
Appropriate graph for x < -1: 58%
Appropriate graph for -1 < x < 1: 46%
Appropriate graph for 1 < x: 55%

(b) For which values of x is the function decreasing?

Gave correct interval where f is decreasing: 49%

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Degree of Success: | A | 30% | B | 12% | C | 21% | D | 24% | E | 12% |

6. Find the rectangle of largest area that can be inscribed in a semicircle with radius 1 as shown in the figure.




| | |
|---|---|
| Found relationship between x and y: | 49% |
| Found a function for the area of the rectangle in terms of one variable: | 36% |
| Differentiated correctly: | 15% |
| Found zero of $A'$ : | 12% |
| Used multivariable approach (such as Lagrange Multipliers) | 9% |
| Gave values for x and y or dimensions of the rectangle: | 49% |
| Gave area of the rectangle (1) –not necessary: | 39% |

Degree of Success: A 12% B 3% C 21% D 36% E 27%

7. Evaluate this integral: $\int_0^2 te^{-t}dt$ .

| | |
|---|---|
| Used "guess and check" method: | 21% |
| Used integration by parts: | 61% |
| Found correct antiderivative: | 61% |
| Substituted limits of integration correctly: | 61% |
| Found correct approximate value: | 58% |

Degree of Success: A 46% B 6% C 18% D 18% E 12%

8. Find the area enclosed by one loop of the four-leaved rose $r = \cos 2\theta$ .

| | |
|---|---|
| Used correct limits of integration: | 9% |
| Used correct integrand: | 9% |
| Used trig double-angle identity to reduce degree of cosine term | 6% |
| Found correct anti-derivative: | 6% |
| Evaluated correctly: | 3% |

Degree of Success: A 3% B 0% C 3% D 39% E 55%

## Appendix B. Department mission statement and program objectives.

**Mission Statement.**
The mission of the Department of Mathematics is teaching, research and other scholarly activities in the discipline; providing quality education to our B.S., M.S. and Ph.D. students and post-doctoral associates; and influencing the mathematical climate of the region positively. The Department strives for excellence in teaching its majors and service courses, while providing stimulating and informative courses. The Department's research activities include pure and applied mathematics.

**Program Objectives.**
**A.** *Bachelors program*
1. Students will be able to analyze problems and formulate appropriate mathematical models.
2. Students will understand mathematical techniques and how they apply.
3. Students will recognize phenomena and be able to abstract, generalize, and specialize these patterns in order to analyze them mathematically.
4. Students will be able to express themselves in writing and orally in an articulate, sound and well-organized fashion.

**B.** *Masters program*
1. Students will have experienced both breadth and depth in the study of advanced mathematics so that they: (a) can recognize and create good mathematical arguments, (b) have knowledge of fundamental topics in both classical and modern mathematics, (c) can create and pursue new ideas and application in and of mathematics.
2. Students will have experience as a teaching assistant with classroom experience or as a research assistant.

**C.** *Doctoral program*
1. Students will have experienced both breadth and depth in the study of advanced mathematics so that they: (a) can recognize and create good mathematical arguments, (b) have knowledge of fundamental topics in both classical and modern mathematics, (c) can create and pursue new ideas and application in and of mathematics.
2. Students will have exposure to and experience with current research.
3. Students will develop ability to understand and create new mathematical ideas and applications.
4. Students will have experience as a teaching assistant with classroom experience or as a research assistant.

## Appendix C. Patterns of Test Results in Mathematics, Science, and Engineering

Summary of Problem Types by Course Group

| Problem Groups | Math | | Science | | Engineering | | Row Totals | |
|---|---|---|---|---|---|---|---|---|
| | *# times problems used — # distinct courses using problems<br>**column % (median quartile of success rate: 2 means 26-50% success) | | | | | | | |
| Graph | *2-1 | **3%(2) | 4-3 | 6%(2½) | 8-4 | 7%(1½) | 14-8 | 6% |
| Vector and matrix | 0-0 | | 4-2 | 6%(2) | 6-4 | 5%(1½) | 10-6 | 4% |
| Systems | 3-2 | 5%(4) | 1-1 | 2%(4) | 6-3 | 5%(3) | 10-6 | 4% |
| Solve exponential equation | 1-1 | 2%(2) | 1-1 | 2%(4) | 0-0 | | 2-2 | 1% |
| Complex arithmetic | 6-4 | 10%(2) | 1-1 | 2%(3) | 5-3 | 4%(1) | 12-8 | 5% |
| Series | 4-2 | 7%(1) | 0-0 | | 0-0 | | 4-2 | 2% |
| Math reasoning | 13-2 | 22%(2) | 0-0 | | 0-0 | | 13-2 | 5% |
| Polynomials | 6-4 | 10%(3) | 0-0 | | 0-0 | | 6-4 | 3% |
| Non Calculus Total | 35 | 60% | 11 | 16% | 25 | 22% | 71 | 30% |
| Graphical interpretation | 5-3 | 9%(3) | 11-5 | 16%(2) | 15-6 | 13%(3) | 31-14 | 13% |
| Series | 4-2 | 7%(2) | 7-5 | 10%(2) | 10-5 | 9%(2½) | 21-12 | 9% |
| Differentiation techniques | 5-2 | 9%(3) | 14-5 | 21%(2) | 1-1 | 1%(2) | 20-8 | 8% |
| Optimization | 0-0 | | 6-3 | 9%(2) | 9-6 | 8%(2) | 15-9 | 6% |
| Differential Calc Total | 14 | 24% | 38 | 56% | 35 | 31% | 87 | 36% |
| Graphical interpretation | 1-1 | 2%(3) | 4-4 | 6%(3½) | 8-5 | 7%(3) | 13-1 | 5% |
| Integral as sum | 1-1 | 2%(2) | 1-1 | 2%(2) | 3-3 | 3%(2) | 5-5 | 2% |
| Integration techniques | 5-2 | 9%(3) | 7-4 | 10%(3) | 7-3 | 6%(3) | 19-9 | 8% |
| Function defined by integral | 1-1 | 2%(2) | 0-0 | | 0-0 | | 1-1 | 0% |
| Integral Calculus Total | 8 | 14% | 12 | 18% | 18 | 16% | 38 | 16% |
| Test potential solution | 0-0 | | 3-2 | 4%(3) | 11-6 | 10%(3) | 14-8 | 6% |
| Solve 1st and 2nd order linear | 1-1 | 2%(3) | 2-2 | 3%(2) | 13-6 | 11%(1½) | 16-9 | 7% |
| Transforms and approximation | 0-0 | | 0-0 | | 5-3 | 4%(1) | 5-3 | 2% |
| Write and solve first order ODE | 0-0 | | 2-2 | 3%(1½) | 1-1 | 1%(1) | 3-3 | 1% |
| Differential Equations Total | 1 | 2% | 7 | 10% | 30 | 26% | 38 | 16% |
| Probability and Statistics | 0 | | 0 | | 6 | 5% | 6 | 3% |
| Column Totals | 58 | 100% | 68 | 100% | 114 | 100% | 240 | 100% |

*The number before the hyphen is the number of problems of that type that appeared on a test. The number after the hyphen is number of distinct courses that used at least one such problem.

**Percentages are of all problems listed in that column. Because success rates vary somewhat, median quartile of success rates was used rather than median success rate. The quartiles range from group 1: 0-25% to group 4: 76-100%. Numbers including halves, such as 1½, represent a median success rate spanning the first and second quartile, such as from 13-38%.

## Appendix D: Sample Rating Forms

| Senior Seminar Rating Form–NDSU Department of Mathematics | | |
|---|---|---|
| Based on the performance of the _____ students who participated in the Senior Seminar during the _________________________ semester, I am able to make the following observations about achievement of intended student outcomes based on the objectives listed in the Chart for the Department of Mathematics Bachelors Degree Program.<br>Examiner:________________________________________ Date:____________________________ | | |
| **Outcome** | **Rating of student performance on this outcome (give number of papers or candidates rated at each level for each outcome)** | **Descriptive comments about student performance shown by this assessment instrument (attach additional pages if more space is required)** |
| 1. Students will be able to analyze problems and formulate appropriate mathematical models. | High Pass _____<br>Pass _____<br>Fail _____ | |
| 2. Students will understand mathematical techniques and how they apply. | High Pass _____<br>Pass _____<br>Fail _____ | |
| 3. Students will recognize phenomena and be able to abstract, generalize, and specialize these patterns in order to analyze them mathematically. | High Pass _____<br>Pass _____<br>Fail _____ | |
| 4. Students will be able to express themselves in writing and orally in an articulate, sound and well-organized fashion. | High Pass _____<br>Pass _____<br>Fail _____ | |

| **Master's Comprehensive Exam Grading Form–NDSU Department of Mathematics** | | |
|---|---|---|
| Based on the performance of the _____ students who took the exam on _________________<br>I am able to make the following observations about achievement of intended student outcomes based on the objectives listed in the Chart for the Department of Mathematics Masters Degree Program.<br><br>Examiner:_______________________________________ Date:___________________________ | | |
| **Outcome** | **Rating of student performance on this outcome (give number of papers or candidates rated at each level for each outcome)** | **Descriptive comments about student performance shown by this assessment instrument (attach additional pages if more space is required)** |
| 1. Students will have experienced both breadth and depth in the study of advanced mathematics so that they | | |
| (a) can recognize and create good mathematical arguments | High Pass _____<br>Pass _____<br><br>Fail _____ | |
| (b) have knowledge of fundamental topics in both classical and modern mathematics | High Pass _____<br>Pass _____<br><br>Fail _____ | |
| (c) can create and pursue new ideas and application in and of mathematics | High Pass _____<br>Pass _____<br><br>Fail _____ | |

| **Masters Final Oral Exam Grading Form–NDSU Department of Mathematics** | | |
|---|---|---|
| Based on the performance of the _____ students who took the _________________________exam on _________________________I am able to make the following observations about achievement of intended student outcomes based on the objectives listed in the Chart for the Department of Mathematics Masters Degree Program. (Also indicate if this assessment does not provide evidence of learning related to the state outcome)<br><br>Examiner:__________________________________________ Date:_____________________________ | | |
| **Outcome** | **Rating of student performance on this outcome (give number of papers or candidates rated at each level for each outcome)** | **Descriptive comments about student performance shown by this assessment instrument (attach additional pages if more space is required)** |
| 1. Students will have experienced both breadth and depth in the study of advanced mathematics so that they | | |
| (a) can recognize and create good mathematical arguments | High Pass _____<br>Pass _____<br><br>Fail _____ | |
| (b) have knowledge of fundamental topics in both classical and modern mathematics | High Pass _____<br>Pass _____<br><br>Fail _____ | |
| (c) can create and pursue new ideas and applications in and of mathematics | High Pass _____<br>Pass _____<br><br>Fail _____ | |

| **PhD Final Oral Exam Grading Form–NDSU Department of Mathematics** | | |
|---|---|---|
| Based on the performance of the _____ students who took the ______________exam on ________________________I am able to make the following observations about achievement of intended student outcomes based on the objectives listed in the Chart for the Department of Mathematics Doctoral Degree Program. (Also indicate if this assessment does not provide evidence of learning related to the state outcome)<br>Examiner:_________________________________________ Date:____________________________ | | |
| **Outcome** | **Rating of student performance on this outcome (give number of papers or candidates rated at each level for each outcome)** | **Descriptive comments about student performance shown by this assessment instrument (attach additional pages if more space is required)** |
| 1. Students will have experienced both breadth and depth in the study of advanced mathematics so that they | | |
| (a) can recognize and create good mathematical arguments | High Pass _____<br>Pass _____<br>Fail _____ | |
| (b) have knowledge of fundamental topics in both classical and modern mathematics | High Pass _____<br>Pass _____<br><br>Fail _____ | |
| (c) can create and pursue new ideas and application in and of mathematics | High Pass _____<br>Pass _____<br>Fail _____ | |
| 2. Students will have exposure to and experience with current research. | High Pass _____<br>Pass _____<br>Fail _____ | |
| 3. Students will develop ability to understand and create new mathematical ideas and applications. | High Pass _____<br>Pass _____<br>Fail _____ | |
| 4. Students will have experience as a teaching assistant with classroom experience or as a research assistant. | | |

| **Doctoral Program Advisors Annual Rating Form–NDSU Department of Mathematics** | | |
|---|---|---|
| Based on the performance of the _____ students who were candidates in the Doctoral Program during the ________________________ school year, I am able to make the following observations about achievement of intended student outcomes based on the objectives listed in the Chart for the Department of Mathematics Doctoral Degree Program. (Also indicate if this assessment does not provide evidence of learning related to the state outcome)<br>Advisor:________________________________________________ Date:______________________ | | |
| **Outcome** | **Rating of student performance on this outcome (give number of papers or candidates rated at each level for each outcome)** | **Descriptive comments about student performance shown by this assessment instrument (attach additional pages if more space is required)** |
| 1. Students will have experienced both breadth and depth in the study of advanced mathematics so that they | | |
| (a) can recognize and create good mathematical arguments | High Pass _____<br>Pass _____<br>Fail _____ | |
| (b) have knowledge of fundamental topics in both classical and modern mathematics | High Pass _____<br>Pass _____<br>Fail _____ | |
| (c) can create and pursue new ideas and application in and of mathematics | High Pass _____<br>Pass _____<br>Fail _____ | |
| 2. Students will have exposure to and experience with current research. | High Pass _____<br>Pass _____<br>Fail _____ | |
| 3. Students will develop ability to understand and create new mathematical ideas and applications. | High Pass _____<br>Pass _____<br>Fail _____ | |
| 4. Students will have experience as a teaching assistant with classroom experience or as a research assistant. | Superior _____<br>Satisfactory _____<br>Unsatisfactory _____ | |

# Appendix E: Mathematics Department Peer Review of Teaching Program

**Peer Evaluation of Teaching Proposal**
**NDSU Department of Mathematics**

The Department of Mathematics believes that the purpose of peer evaluation is to help faculty recognize and document both strengths and weaknesses in their teaching. The word “peer” means that this activity should involve reciprocal observation and discussion of teaching and learning by small groups of 2-3 faculty who exchange visits in each other's classes. The committee believes that the members of the department have all the qualifications necessary to make this process reach its intended goal. The committee proposes that:

1. Tenure-track faculty be reviewed at least once each year; Tenured associate professors be reviewed at least once every other year; Tenured full professors be reviewed at least once every three years.

2. The process begin with the identification of the faculty to be evaluated by the chair. Then the faculty member identifies his/her teaching goals and strategies (in writing). These objectives are discussed with a peer colleague or colleagues, with a view to developing evidence that supports the individual's claims. This evidence could come from classroom observations, student evaluations, and review of written course materials, such as tests and assignments. It should include multiple sources (i.e., not a single classroom observation). After reviewing this evidence, the group prepares a report that describes the activities and the extent to which the evidence supports the original claims. The report should include plans for future teaching strategies, including possible changes or enhancements that the faculty member plans to try.

3. A team of 2-3 faculty members will complete the work described in (2) for each member of the team. This helps to ensure that peer evaluation does not become a one-way process that involves one person observing and evaluating another primarily for external purposes. Instead, the process is designed primarily to increase collegiality and reflective practice within the department, while providing documentary evidence of the regular review of teaching that can be used for external purposes (such as annual reviews, PT&E).

4. Observers of a faculty member should include at least one member of the department PT&E committee.

5. The observation process should always include a Pre-Observation Conference between the observee and observer to discuss the objectives of the class to be observed and other relevant issues (see Peer Review Observation Instrument). Following the in-class observation, a Post-Observation Conference must also be held to discuss the observations as documented by the Peer Review Observation Instrument.

**Attachments:** Peer Review Observation Instrument (sample), Characteristics of Effective Observers/Things to Avoid (sample guide), Tips for Observers and Observees (sample)