

Assessing the Mathematics Major Through a Senior Seminar

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Abstract. At South Dakota State University (SDSU), assessment of the Mathematics Program is achieved during the Senior Seminar (capstone) course. In this course, students participate in activities to develop their communication skills (both oral and written), prepare a portfolio, write a Major Paper, and give a Major Presentation. We describe the Senior Seminar course and the assessment tools used, and give data based on three semesters of assessment in the course. We also discuss pitfalls of the current assessment system and changes which have occurred because of information obtained through the assessment process.

South Dakota State University (SDSU) is the largest university in a regional system of six universities in South Dakota. Enrollment over the last five years has ranged from 8,000 to 10,000 students. The Department of Mathematics and Statistics is in the College of Engineering. The number of mathematics majors has varied over the last few years from 60–75 students, with approximately 15 majors graduating each year. SDSU also has a Master’s program which has ranged from 10–16 students enrolled per year. The department currently has 17 full time faculty.

Background

Beginning in the 1980s, in addition to regular coursework, students were required to read 15 articles from mathematics journals and write reaction papers for each article. In the early 1990s, a departmental competency test, with no grade attached, was added to requirements for graduation. In 1996, in response to the university assessment requirement, a senior seminar (capstone) course replaced both the reading and competency test requirement. The main activity of this course was to have students write a major paper and give a presentation based on that paper. In 2002, in order to better align with departmental and university mission statements as well as the department learning objectives, and to more accurately collect assessment information, Senior Seminar was revamped. In addition to a major paper and presentation, students engage in activities that give them experience researching, writing, and presenting. At this time, the Senior Seminar instructors along with the Department Head formed the Assessment Committee which reports regularly to the University Assessment Committee. The course is still in constant revision, and in fact beginning in the Fall of 2004, the course will be expanded to be a two semester, two credit course.

Departmental Goals

The following are student attainment goals taken from the Department Standards Documents. These goals are assessed throughout the student’s academic career (demonstration of competence is documented when a student earns at least a “C” in mathematics courses) as well as in the requirements for Senior Seminar.

1. Demonstrate competence in all core areas of undergraduate mathematics.
2. Use contemporary mathematical and presentation software and technology.
3. Apply research methods to mathematical problems.
4. Communicate clearly and succinctly in writing in the discipline.

5. Articulate complex ideas to an audience.
6. Reflect on learning experiences over an extended period of time period to identify areas for further learning.

Senior Seminar as an assessment tool

Senior Seminar is required of all graduating mathematics majors. Majors take it in their final semester on campus (education students must take it the semester before they student teach). An example of a sample schedule for this one-semester course is found in Appendix A. Starting in the Fall of 2004, majors will take it in the last two semesters they plan to be on campus. Since the degree earned by our students is a Bachelor of Science in Mathematics (even if they are earning their teaching certification), the emphasis in senior seminar is in pure and applied mathematics. Education issues are addressed in the math education courses. The major focus of Senior Seminar is to help the students develop the skills needed to write a solid mathematics expository paper and make a presentation based on this paper. During the first semester, students will participate in several activities (we will discuss these later), choose a topic for their major paper and start research for this topic. During the second semester, students will continue to work with their paper advisors to research, write, revise and present their papers. At the conclusion of the course, students will also submit a portfolio which documents their academic career at SDSU. Contents of this portfolio will be discussed later. Prior to Fall of 2004, all of this was completed in one semester.

Each student paper, presentation and portfolio is assessed by faculty members. The data obtained from these assessments are the groundwork for assessing the mathematics major at SDSU. Though transcript data is necessarily a part of assessment, it is not included as part of our assessment of the major. The understanding is that students will not be considered for graduation unless they have satisfied all course requirements.

First semester Senior Seminar activities

The first semester of Senior Seminar is a time for students to develop some of the skills which will enable them to research and prepare a major paper and presentation. It is also used to assess some of the learning objectives for the major.

To develop research skills:

- History quiz: Students are given a list of important historic mathematical events and they are to determine the dates, people involved and significance of the event.

- Journal article: Students are assigned a journal article to read. They are given the source and can find the article either in the University library or by using an on-line source. They are to read the article and write a paper discussing their thoughts on the topic involved. Sometimes this assignment will also include some mathematics problems to be solved.
- Web research project: Students choose one of two possible projects. If they plan to go to graduate school, they research a math field, describe the field, how it started, people who originated the field, and who is working in that field now. Other students research a math career and write a short paper outlining what is involved in the career, how to prepare, prospects for the career, and what kind of growth they might expect in that career.
- Web Research project: Students are to find a proof of some non-trivial mathematical statement on the web. They are to read and understand the proof, verify that it is valid, then rewrite the proof in their own words.

To develop communication (oral and written) skills:

- History quiz: Students present findings from the history quiz to the class and also write a short paragraph for each event assigned.
- Calculus problem: Students are given a multi-faceted problem which can be solved using calculus. Students solve the problem, write their solution (including proper notation and appropriate diagrams) using mathematical software, then present the solution of their problem to the class.
- Faculty Talks: Faculty members from SDSU and invited speakers make presentations to the senior seminar class. Presentations are generally on topics the students have not yet seen. Students learn about varied fields of mathematics, as well as observe some good and bad presentation techniques. Students are to write reaction papers discussing their thoughts on the topic and the presentation techniques.

Assigning Grades:

- The class assignments count as 25% of the student's final grade. Each is weighted depending on the amount of work required to complete the assignment. Grades are very subjective, and reflect the mathematical accuracy of the work, where applicable, but more importantly reflect the student's ability to communicate effectively.

The Major Paper

The major paper is an expository paper in which the student explains a mathematical topic. This paper counts as 35% of

Categories for Assessing Mathematics Majors' Papers	Assessment Criteria
<p>Presentation:</p> <ol style="list-style-type: none"> 1. How well written is the report (e.g., correct grammar, spelling, etc.)? [4] 2. How effectively does the student use graphics/figures (e.g. placement, neatness, etc.)? [2,4] 3. How effectively does the student use examples to clarify points made in the paper? [4] <p>Technical Report:</p> <ol style="list-style-type: none"> 4. How well does the student explain the purpose of the project? [4] 5. How well does the student explain the history of the topic? [3,4] 6. How well does the student explain the background mathematics needed to understand the problem? [3,4] 7. How well does the student use and cite both print and electronic sources? [3] <p>Mathematics/Statistics</p> <ol style="list-style-type: none"> 8. How in depth does the student explore the topic? [1,3] 9. How accurate are the mathematical/statistical statements? [1,3] 10. How well does the student justify the mathematical/statistical statements? [1,3,4] 11. How consistent and effective is the student's use of notation? [1,3,4] <p>Overall</p> <ol style="list-style-type: none"> 12. How well does the student demonstrate that he/she understands the mathematics/statistics? <p><i>(Learning objectives are listed in brackets.)</i></p>	<p>7 – Excellent—has no mathematical errors may need some minor rewording</p> <p>6 – Very Good—needs minor revisions in a few places</p> <p>5 – Good—needs minor revisions sporadically throughout the paper</p> <p>4 – Satisfactory—minor revisions needed throughout the paper</p> <p>3 – Poor—needs major revisions in a few places</p> <p>2 – Very Poor—needs major revisions sporadically throughout the paper</p> <p>1 – Unsatisfactory—paper has little or no merit</p>

Figure 1. Criteria for assessing senior mathematics majors' research papers.

the student's course grade. The paper contains "significant mathematics" and at least one major proof. It is word processed, with appropriate mathematical symbols and diagrams. The body of the paper is eight to twelve pages. Students are expected to follow a prescribed format which includes title page, abstract, bibliography, and biographical statement. The paper is based on a topic chosen by the student in consultation with a mathematics faculty member who supervises the paper. Students are required to meet once a week with their advisor in order to discuss and ensure progress on the paper throughout the semester.

The topics of the papers vary greatly. Some students integrate their paper with some outside interest (for example, math and music, mathematics of castle defense, statistical model of a baseball park) while others choose a purely mathematical topic (for example, circle inversion and the shoemaker's knife, cubic equations, linear programming, differential equations involving repeated eigenvalues). The most important aspect of the paper is that the topic is beyond the student's coursework. The student gathers sources, learns about the topic, and writes a summary of information gathered and learned. This work is done independently. The faculty member's role is that of guidance—the student does not learn the material primarily from his or her advisor. Emphasis is both on learning new material as well as proper written presentation of a paper— including proper formatting and notation, citation of sources, and good mathematical exposition.

The major paper is assessed by at least two faculty members, and the papers are judged on physical presentation, technical preciseness and the student's demonstration of their understanding of the mathematics involved. (See the Insights section below for a discussion of evaluator consistency.) Assessment categories and criteria are shown in Figure 1; a copy of the actual assessment form can be found in Appendix B of our expanded case study on the SAUM website.¹

The major presentation

The major presentation is based on the major paper described above. The presentation counts as 25% of the student's course grade. Each student prepares a Microsoft PowerPoint presentation based on a portion of her/his major paper. This is delivered to their peers in Senior Seminar as well as to faculty who assess the presentation. The presentation is about fifteen minutes long with an additional ten minutes allowed for questions. Due to time limitations, students are advised to select only a portion of their paper for the presentation. Many students include other technology tools in their presentation such as Geometer's Sketchpad, Maple, and applets downloaded from the Web. Students are evaluated on both their ability to engage the audience with an interesting presentation and their demonstration of understanding of their chosen topic.

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

Categories for Assessing Major Presentations	Assessment Criteria
<p>Delivery</p> <ol style="list-style-type: none"> 1. How well did the student explain the purpose of the project? [5] 2. How well did the student organize the material? [5] 3. How well did the student’s presentation make use of overheads, PowerPoint, and/or other technology? [2] 4. How would you judge the student’s presence? (voice, delivery, etc.)? [5] 5. How well did the student answer/respond to questions and comments? [5] <p>Content</p> <ol style="list-style-type: none"> 6. How well did the student communicate his/her understanding of the mathematics? [1,3,5] 7. How well was the mathematics developed through logical presentation, justification of assumptions and examples? [3,5] <p>Overall</p> <ol style="list-style-type: none"> 8. How well did the student demonstrate that he/she understands the mathematics/statistics? 	<ol style="list-style-type: none"> 7 – Excellent—ready for presentation at a conference 6 – Very Good—needs refinement before presenting at a conference 5 – Good—needs 1–2 minor changes before presenting at a conference 4 – Satisfactory—needs 3–5 minor changes before presenting at a conference 3 – Poor—needs 1–2 major changes before presenting at a conference 2 – Very Poor— needs 3–5 major changes before presenting at a conference 1 – Unsatisfactory—presentation has little or no merit

Figure 2. Criteria for assessing major presentations.

The major presentation is assessed by at least three faculty members, but can be assessed by any faculty or graduate teaching assistant who chooses to attend the presentation. The presentations are judged on delivery, content and overall presentation. Assessment categories and criteria are shown in Figure 2; a copy of the actual assessment form can be found in Appendix C of our expanded case study on the SAUM website.²

The portfolio

The Portfolio is turned in at the end of the student’s final semester at SDSU and counts as 15% of the student’s course grade. The students are given a copy of portfolio requirements in the Logic and Set Theory course; this is the first course required of all Mathematics Majors. This would normally happen during the Sophomore year, but there are always exceptions. The portfolio is used as an assessment tool by the Senior Seminar Instructors, used by the Department Chairman to guide the Exit Interview, and used by the Students when they begin searching for a job. In the portfolio, students include documents which demonstrate competency in five mathematics courses. Included with each of these submissions is a paragraph explaining how each item included demonstrates competence. In addition, students include their major paper, a resume, and several essays reflecting on their mathematics career so far and the mathematics program at SDSU. Specific requirements and the assessment criteria can be found in Appendix B at the conclusion of this paper.

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

Insights: Thoughts on the data and the cycle of assessment

A summary of the data obtained can be found in Appendix C. The data has been drawn from three semesters of data collection. Though Senior Seminar has been in place for several years, we only began collecting numerical data in the Fall of 2002.

First, we feel the data we have obtained is not necessarily consistent. Suggestions for normalizing these evaluations are to make the scale smaller, train evaluators and to give examples of what should be graded as 1, 2, etc. We are currently rewriting the evaluation criteria and hope that this will enable the faculty evaluators to be more consistent in grading. An example of the new format can be found in Appendix D. Because of this inconsistency, it is hard to justify changes based only on the data obtained. Therefore, many changes we have made are based on observations made by faculty members and students.

One major change brought about by the assessment cycle is the addition of a second semester of Senior Seminar. This change came about based on information in the Student Portfolios, as well as evaluation of papers and presentations. A second semester gives the student more time to practice writing in the first semester and more time to actually do their writing in the second semester. This also gives the student more opportunity to evaluate oral presentations in the first semester and more time to prepare their own presentation in the second semester. The hope is that this will result in better quality papers and presentations.

Other changes that included a revamping of the Mathematical Applications in Computers course which

came about because of feedback found in the Student Portfolios. Students commented in their department evaluation that they did not feel they worked with enough software in the course, that the emphasis was on linear algebra, not computers, and that the 7:00 AM meeting time was too early. Therefore, the revamping included more computer use, more variety of topics, updated software, and a time change. Based on assessment of the Major Paper and Presentation, more specific guidelines in the topic choice and interaction requirements with the paper advisor as well as more specific guidelines for writing the Major Paper and giving the Presentation were outlined. In addition, based on feedback from all three sources, more frequent deadlines

were arranged to better monitor progress on the Major Paper. We found that involvement of more faculty in the assessment process made more faculty aware of the need to improve student Papers and Presentations.

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Appendix A. Senior Seminar Class Schedule (Fall 2003)

(Each entry below represents one class period; the class meets once a week for 50 minutes.)

Plan:	Math History Quiz
Assignment:	Journal article: read, write reaction paper, be prepared for discussion “A Discrete Look at $1+2+\dots+n$ ” by Loren C. Larson
Due Today:	Paper Topic and Advisor and Math History Quiz
Plan:	Discuss History Quiz and Calculus problem
Assignment:	Write-up of the Calculus problem (hand-written)
Due Today:	Hand-written write-up of Calculus problem
Plan:	Computer lab: Learn Scientific Notebook , MS Word, WinPlot to write-up Calculus problem
Assignment:	Complete word processed write-up of Calculus problem including the mathematics
Due Today:	Reaction paper for Journal Article: Three sources for major paper, one from the web
Plan:	Student led discussion based upon Journal Article
Due Today:	Word Processed outline of major paper/ Word Processed write-up of Calculus problem
Plan:	Student presentations of outlines of papers- peer comment
Due Today:	Word processed bibliography for major paper
Plan:	Complete student presentations.
Assignment:	Write a resumé (or update your current resumé)
Due Today:	Word Processed “very rough draft” of major paper
Plan:	Resumé discussion and Computer lab web research
Assignment:	Write a 1–2 page paper describing career or field of mathematics
Due Today:	Assigned paper
Plan:	Faculty talk: Assignment: Reaction paper/ assignment
Due Today:	Math career or math field paper
Plan:	Faculty talk: Assignment: Reaction paper/ assignment
Due Today:	Draft of major paper submitted to your advisor and Reaction paper/assignment
Plan:	Faculty talk: Assignment: Reaction paper/ assignment Advisor comments due to student and senior seminar advisors
Due Today:	MAJOR PAPER and Reaction paper/assignment
Plan:	Faculty talk: Assignment: Reaction paper/ assignment
Due Today:	Reaction paper/assignment
Plan:	Faculty talk: Assignment: Reaction paper/ assignment
Plan:	MAJOR PRESENTATIONS (Evening)
Due today:	Reaction paper/assignment
Plan:	Program Evaluation

Final Exam Day — Portfolio is due by 5:00

Appendix B. Portfolio Requirements

Student: _____ Faculty Reviewer: _____

This portfolio will be assessed on selection of material (how well it satisfies criteria) and your reflection upon that material. Each item will be given a rating on a scale. The numbers in brackets represent the departmental goal measured by this criteria.

- 4 – excellent (good choice/thoughts insightful),
- 3 – good (good choice/needs more reflection)
- 2 – poor (poor choice/very little or no reflection)
- 1 – not included

A. Materials from the Mathematics courses you have taken that illustrate the following, with paragraphs for each explaining how what you have chosen demonstrates your competency:

- i. Competence in Calculus _____ [1]
- Competence in Linear Algebra _____ [1]
- Competence in upper level course _____ [1]
- Competence in upper level course _____ [1]
- Competence in upper level course _____ [1]
- ii. Ability to write a clear and correct proof _____ [1,4]
- iii. Use of mathematical software _____ [2]
- iv. Example of a test on which you did well; discuss why you think you did well _____ [6]
- v. Example of a test on which you did poorly; discuss what you think you did wrong in preparing for this test _____ [6]

B. Your revised Senior Seminar Research Paper _____ [1,3,4]

C. A current Resume _____ [6]

D. A letter of application for a job _____ [6]

E. A written summary of general University extra curricular activities _____ [6]

F. A written evaluation of the mathematics program at SDSU _____ [6]

G. An essay reflecting upon your career as a student in Mathematics _____ [6]

H. An essay written in your sophomore year discussing your plans for your academic career. _____ [6]

I. Other materials:

Mathematics Majors with teaching certification:

 An essay on your student teaching experience _____ [6]

 A letter from your cooperating teacher (not graded)

 Report of your grade on the PRAXIS exam _____ [1]

Mathematics Majors without teaching certification

 An essay on how your mathematics training will be used after graduation _____ [6]

Total: _____ / 68 or 72 (ed)

J. Additional materials: maximum of 5

Total: _____ / _____

Appendix C. Three Semesters' Data

The data below has been compiled from Fall 2002 (4 students), Spring 2003 (2 students), and Fall 2003 (10 students).

Major Paper (Scale is 1-7):

<u>Learning Objective:</u>	Average Score Based on Faculty Responses		
	<u>Fall 2002</u>	<u>Spring 2003</u>	<u>Fall 2003</u>
1 (competence)	5.47	4.97	5.59
2 (technology)	5.64	6.00	5.52
3 (apply research methods)	5.50	5.18	5.67
4 (communicate in writing)	5.54	5.39	5.67
5 (communicate verbally)	N/A	N/A	N/A
6 (reflect on learning experiences)	N/A	N/A	N/A

Major Presentation (Scale is 1-7):

<u>Learning Objective:</u>	Average Score Based on Faculty Responses		
	<u>Fall 2002</u>	<u>Spring 2003</u>	<u>Fall 2003</u>
1 (competence)	5.81	4.18	5.1
2 (technology)	6.10	6.64	5.65
3 (apply research methods)	5.71	4.32	5.16
4 (communicate in writing)	N/A	N/A	N/A
5 (communicate verbally)	5.92	5.32	5.55
6 (reflect on learning experiences)	N/A	N/A	N/A

Portfolio (Scale is 1-4):

<u>Learning Objective:</u>	Average Score Based on Faculty Responses		
	<u>Fall 2002</u>	<u>Spring 2003</u>	<u>Fall 2003</u>
1 (competence)	3.69	3.958	3.917
2 (technology)	4	4	4
3 (apply research methods)	4	3.5	3.5
4 (communicate in writing)	3.76	3.833	3.813
5 (communicate verbally)	N/A	N/A	N/A
6 (reflect on learning experiences)	3.78	3.958	3.917

Appendix D. Revamped Assessment Tools (Sample)

Student: _____

Faculty Reviewer: _____

Overall Paper grade: _____

You are assessing a senior Mathematics Major student's research paper. This paper was written with the supervision of a Mathematics Faculty member. You should assess the paper based on the following criteria. Please circle the number which best describes the paper. Please note the even numbers can be used to show that the paper shows qualities of both neighboring categories (feel free to circle relevant characteristics). Learning objectives are listed in brackets. Please add additional comments for the student on a separate sheet of paper. Finally, assign an overall grade (A, B, C, D, F) to the paper. Students will only see averages of all readers and comments, but will not know the names of readers.

1. How well written is the report (e.g., correct grammar, spelling, etc.)? [4]

1	2	3	4	5	6	7
Many grammatical or spelling errors Frequent misuse of mathematical language Use of Slang		Periodic grammatical or spelling errors Periodic misuse of mathematical language Periodic use of slang		Few or no grammatical or spelling errors Some misuse of mathematical language Slang mostly avoided		No grammatical or spelling errors Precise mathematical language used Slang avoided

2. How effectively does the student use graphics/figures (e.g. placement, neatness, etc.)? [2,4]

1	2	3	4	5	6	7
Many missed opportunities for necessary graphics Graphics included are sloppy, unnecessary, and/or unjustified		Occasional missed opportunity for appropriate graphics Not labeled correctly Inclusion of the graphics not justified in the text		Graphics used where appropriate Labeled correctly Inclusion of some graphics not well justified in the text		Graphics used where appropriate Labeled correctly Easy to read Inclusion of graphics justified in the text.

3. How effectively does the student use examples to clarify points made in the paper? [4]

1	2	3	4	5	6	7
Many missed opportunities for necessary examples Trivial or unimportant examples included Examples not explained well		Occasional missed opportunity for appropriate examples Unnecessary examples included Examples not thoroughly explained nor accurate		Examples used where appropriate Examples explained clearly Some examples not necessarily relevant Some examples not necessarily accurate		Examples used where appropriate Examples explained clearly and accurately

4. How well does the student explain the purpose of the project? [4]

1	2	3	4	5	6	7
Purpose not explained Purpose not reasonable Not explained in a reasonable part of the paper		Purpose explained in a cursory manner Purpose is contrived Not explained in a reasonable part of the paper		Purpose explained reasonably well Purpose is reasonable Purpose explained in appropriate part of the paper		Purpose explained thoroughly Purpose is reasonable Purpose explained in appropriate part of the paper