"Surveying Majors in Developing a Capstone Course"

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Abstract
The Department of Mathematics and Statistics at Portland State University surveyed its undergraduate majors (and some graduate students) to gather information for the development of a senior mathematics capstone course. Students were asked about the importance of a list of performance objectives and their perceived competency in each objective. Demographic information was also collected. Results and analysis of the survey are presented, as well the role of these results in departmental decisions.

Background and goals: What did we hope to accomplish?
The design and implementation of courses in the Department of Mathematics and Statistics at Portland State University has traditionally been based on what mathematics departments in research universities do and what faculty in the department think might be needed. Removal of courses from the curriculum has been similarly based on what faculty believe is needed. Asking the students what they need in a controlled manner has not been done.

After lengthy discussions over several years, the department agreed in June of 2001 on a list of student learning objectives for the major. Those learning objectives were in six categories: *Mathematical tools, Connections, Technology, Communications, Independent learning,* and *Attitudes*. In mapping these objectives to the curriculum, the department discovered that many of the objectives were not effectively addressed by the curriculum in place at that time. The learning objectives that were not being met were largely in three areas: *Connections, Communication,* and *Independent learning*. See appendix for the list of those objectives.

At the same time, the dean of the College of Liberal Arts and Sciences urged the department to develop an assessment of the major as part of the universities assessment initiative. While developing strategies to assess student learning objectives, the department realized it needed new strategies to assess students at the senior level. The department has developed strategies to assess student skills as they begin abstract math courses, but the department does not have a way to measure the value added between their first abstract math course and completion of the undergraduate program. We realized that we could develop an end of program assessment and address student learning objectives not yet covered with a senior capstone experience.

In order to begin the design of a senior capstone course, we undertook a systematic survey of current and past undergraduate mathematics majors' needs. The intent was to ask students what they thought was most needed in their studies of mathematics and whether they would voluntarily take such a capstone course addressing those needs.

With the help of a graduating senior mathematics major, we designed, piloted and administered a survey of math students. The survey focused on ten particular learning objectives from the departmental list, that the department felt were not being well addressed or well assessed (See Appendix). The survey asked students how proficient they felt they were in the identified learning objectives and how important they thought each objective was. The survey also described a potential model for the capstone course and asked students for feedback on the course design and whether they would take such a course.

A pilot survey was administered in the winter of 2002. It provided valuable feedback on how students perceived the questions that were asked and how to improve the survey to get information we needed. The survey was subsequently redesigned, changing some of the column formatting and the phrasing of some questions. The survey was administered at the beginning of fall term 2002. The results of the survey will be discussed in subsequent sections.

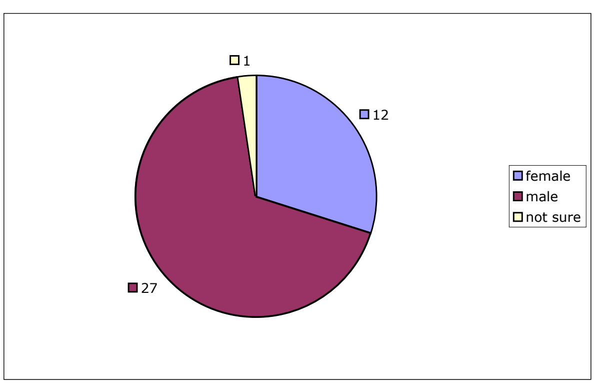
Survey Responses and Analysis

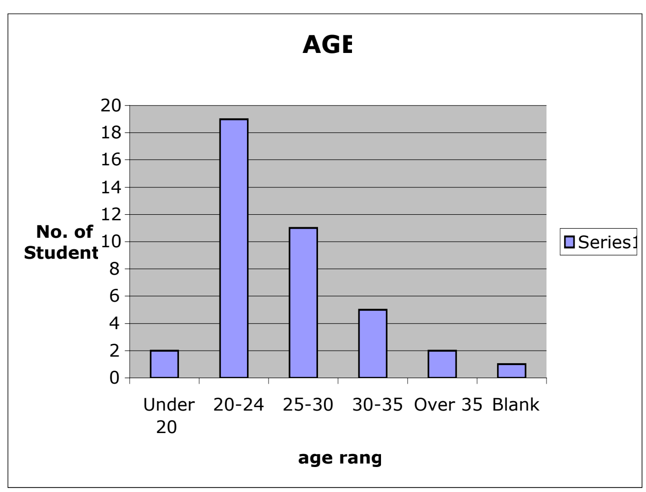
The survey was administered in two classes; a junior level advanced calculus and a senior real analysis course. The advanced calculus course is required of all majors, so thought we could get a good representation by surveying that class. The vast majority of students in the real analysis course are typically seniors, so we could be sure to get their voice by surveying that class. As advanced calculus is a pre-requisite for real analysis, we would not get any overlap.

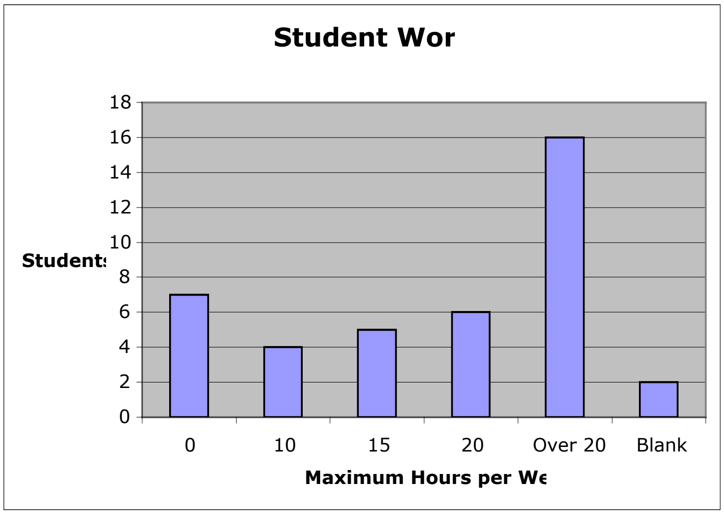
Student Demographics

A total of 40 students were surveyed; 30 undergraduate and 10 graduates. As the chart below indicates, 12 students identified themselves a female; 27 identified themselves as male. One student did not declare a gender. For the purposes of statistical analysis we decided to declare that student as "not sure".

As can be seen in the AGE chart, the majority of students were between the ages of 20 and 24. The work chart shows that the majority of students worked over 15 hours per week At least one student worked full time.







Student Responses
Students were asked about the importance of student learning objectives in three areas: *Connections, Communication* and *Independent learning*. The most interesting result of the survey was that the majority of students felt each student learning objective was important. The tables below are labeled by key words of the learning objectives. The master key is supplied in the appendix.

Importance Table

	Applications	History	Connections	Models	Statistics	Delivery	Teamwork	Independence	Library	Questioning
Blank	0	0	3	1	1	1	2	1	3	1
Skill not needed	1	0	0	0	0	0	1	0	1	0
Very little of the skill is useful	2	7	0	1	3	0	2	0	3	0
Some aspects of this skill are useful	9	14	4	9	5	3	7	1	9	2
Much, though not all, of the skill is useful	13	15	12	14	14	12	10	8	10	13
Essential skill	15	4	21	15	17	24	18	30	14	24

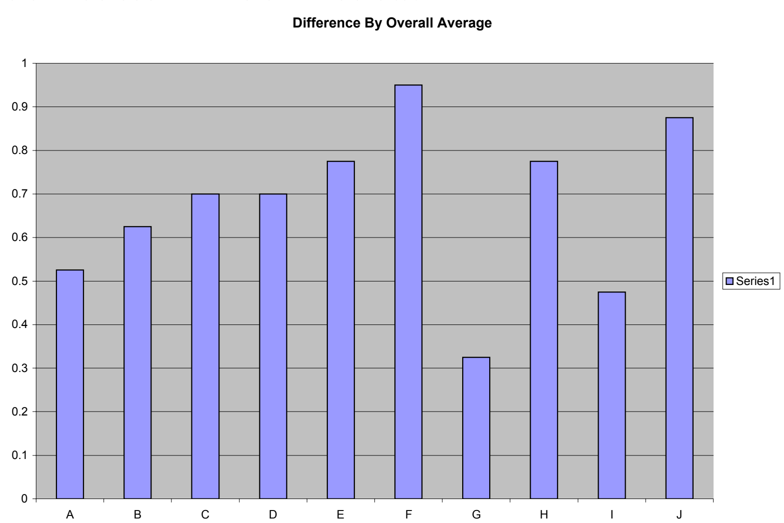
The most important objective to the students was "Proficiency as an independent and critical thinker". The second most important objective was "Proficiency in oral and written communication of mathematics". The lowest scoring objective was "Familiarity with historical/social contexts of mathematics". It is not surprising that students valued this objective less. What is surprising is that they still thought it was important. The department's mathematics history course is taught only in the summer and only by non-regular faculty. The course is not required of majors. The social context of mathematics is not well addressed either. Students infrequently encounter the relevance of the historical or social contexts of mathematics.

Skill Table

	Applications	History	Connections	Models	Statistics	Delivery	Teamwork	Independence	Library	Questioning
Blank	0	1	3	1	1	1	2	1	3	1
Do not have this ability	0	6	0	2	1	0	1	0	2	1
Some understanding	9	7	3	5	6	4	4	1	5	0
Mostly OK	8	16	10	11	14	10	7	9	13	15
Proficient for my needs	19	8	19	18	14	24	17	20	11	18
Expert	4	2	5	3	4	1	9	9	6	5

Students felt that they were most skilled in "Proficiency as an independent and critical thinker", the same objective they felt was most important. Students rated "Ability to work as part of a team to do math" second in their perceived skill level. A focus group study of two years ago told us why students might feel they are good at working in groups; the department's atrium is full of students all day long collaborating on mathematics together. The atrium may be our greatest asset. The objective scoring lowest in skill level was "Familiarity with historical/social contexts of mathematics". This result is not a surprising from our earlier comments. The department does not offer much in these areas, hence students do not have the skill.

By subtracting the average responses on skill from those on importance, we get a sense of areas where students feel the need for the most improvement. The difference is the highest for "Proficiency in oral and written communication…" and the lowest at "Ability to work as part of a team to do math". We conclude that students feel that their oral and written communication need the most improvement. Other skill/importance differences can be seen in the chart below.



Notice that even where students felt they were skilled in a particular objective, they still expressed a need for further improvement.

Course Comparison

While both the junior level advanced calculus and senior level analysis students felt "Proficiency as an independent and critical thinker" was the most important skill, the students surveyed from advanced calculus did not rate the skills overall as important as the analysis students did. When comparing their skill level, the students from advanced calculus felt more confident about their skills than the analysis students. (Makes you wonder what happens to students to make them less confident about their skills between advanced calculus and analysis classes!) Overwhelmingly, the analysis students felt they lacked "Proficiency in oral and written communication".

Gender Differences

Females rated "Awareness of applicability of math in other disciplines", "Familiarity with historical/social contexts of mathematics", and "Ability to build and use mathematical models" as the areas where they would like to improve on most. Males, on the other hand, rated these as the lowest differences. That is, the men felt that the rest of the areas needed more improvement. Females felt they had sufficient skills in **"**Ability to work as part of a team " and "Ability to use the library and other non-classroom resources to solve a problem in math". These gender differences may be attributable to the women being older than the men.

Graduate versus undergraduate

The graduate students felt **"**Proficiency in oral and written communication of mathematics to peers as well as to people with less math background" and "Proficiency as an independent and critical thinker" were most important, while the undergraduates felt "Proficiency as an independent and critical thinker" and "Ability to ask the right questions to learn something new or apply something known to a new situation" were most important. The graduates felt "Proficiency in oral and written communication" was where they needed improvement. The undergraduates felt "Ability to ask the right questions" was most needed. Neither the graduates nor the undergraduates felt they had as much skill as they would like in any category.

Open Ended Questions

After asking students to rate importance and skill level on the objectives, the survey asked them specifically for areas in which they would like to improve their proficiency, from the list and in other areas not on the list. We also asked them why it was important to become more proficient in these areas. Of the 40 respondents, 27 students answered this question. Of objectives from the list, "Proficiency in oral and written communication" was the favorite with 13 out of 27. When asked about areas not on the list, only 6 students out of 40 answered. Writing proofs was the favorite choice here with

4 of them. These answers seemed to reflect a desire of students to see more of the objectives we listed in the survey as part of the departmental curriculum.

Lastly, the survey asked students to critique a senior capstone course described to them as follows:

> "*We are proposing a two-term course—worth two credits per term. Topics for the two terms would include the history of mathematics, the application of mathematics, and the applicability of mathematics to specific disciplines. Each student would be required to give oral presentations and written reports. All students would help give feedback to presenters throughout the entire process.*
>
> *During the first term, students would work in groups to do a variety of short research activities. The second term would consist primarily of two activities:*
> 1) *Assisting students going through their first term*
> 2) *Creating an independent research project around one of the topics addressed in the previous term (or a topic suggested by the faculty).*
>
> *Second term students would present their work at a public event. This two-term course could potentially satisfy the University Studies capstone, but approval would be discretionary and would require the addition of a community service component."*

They were also asked if they would take such a course. Only 11 students responded to those questions. Critiques were not significant, although many felt that the course needed to offer more course credit and should satisfy the university's capstone requirement. Nine of the 11 students said that they would take such a course.

Survey Issues

The ethnicity category was omitted from the analysis because of the lack of diversity in those surveyed. 75% of the students surveyed were white with the other categories holding either 4 or 1. Since only 3 surveys were from non-math majors, this category was also omitted. Due to the invalid and often incorrect answers to the question of the number of credits a student had, this category was omitted. GPA estimates were mostly above a 3.0 and also were omitted from the analysis due to the lack of diversity.

Insights: What did we learn?

In any study like this, results include the questions that arise. One immediate question we had was, "If we gave the same survey to linear algebra students, would the responses be different?" The two courses surveyed are very difficult for our students. Their perceived need for these skills may be underlined by the difficulty of the material they are trying to learn.

The Senior Capstone

Our declared purpose of the survey was to help us design the senior capstone course. Based on the survey results, what should be included in the senior capstone course? Keeping in mind that students considered all of the listed objectives important, they all need to be incorporated into this course to some degree. The survey indicated that students feel confident about their communication skill level. At the same time, their responses also indicated that they would like to be more proficient in this area. Hence written and oral communication will drive the format of this course, with students presenting foundational information as well as solutions to problems. With "proficiency as an independent and critical thinker" rated the highest in importance, a discovery format would best serve the students. The discovery process could include meta-cognition addressing the objective of "asking the right questions to learn something new." As far as course content, it will be important to explore connections within mathematics and between mathematics and other disciplines.

Because several student responses emphasized the desire for a senior capstone course which would satisfy the university's capstone requirement, we are incorporating the required community-based component. Specifically, the course (to be offered for the first time as a 2-quarter sequence starting January 2004) will include presentations to inner city high school students. Integrating community-based learning into this course will involve readings and discussions about the role of mathematics in our society, thereby addressing the "social context of mathematics" learning objective.

A one-quarter "pilot" capstone course (with no community-based component) was offered Spring 2003, in which students explored applications of mathematics independently, made presentations in class, and wrote a final paper. Experience with the pilot course demonstrated the need for a 2-quarter experience, both for exploration and in order to incorporate community-based learning.

Appendix

Student Learning Objectives
For the BS/BA Degree in Mathematics
Department of Mathematics and Statistics
Portland State University

Connections

Applications=Awareness of applicability of math in other disciplines
History=Familiarity with historical/social contexts of mathematics
Contexts=Ability to make connections in math from one context to another
Models=Ability to build and use mathematical models of concrete situations or real phenomena
Statistics=Ability to use data an Essential skill d statistical techniques to solve a problem or make a supportable conclusion

Communication

Delivery=Proficiency in oral and written communication of mathematics to peers as well as to people with less math background
Teamwork=Ability to work as part of a team to do math

Independent learning

Independence=Proficiency as an independent and critical thinker
Library=Ability to use the library and other non-classroom resources to solve a problem in math
Questioning=Ability to ask the right questions to learn something new or apply something known to a new situation