IDEA Research Report #3

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Are Quantitatively-Oriented Courses Different?

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This study examined classes within each of four disciplines that differed in the degree to which they emphasized math/quantitative skills. A number of distinctive characteristics of such courses were discovered.

Overall, those teaching classes emphasizing math/quantitative skills are more likely than their colleagues in similar disciplines to have poorly motivated students who regard their courses as difficult and demanding and who offer relatively negative evaluations of the course, its instructor, and course outcomes. However, these conclusions vary with discipline.

Implications of these findings are discussed.

Courses differ in the types of skill or background they emphasize. Some stress writing skills, others computer skills, and others creative/artistic skills. The focus of this study is on classes that stress mathematical/quantitative work. Of course, almost all classes in mathematics and statistics place a heavy emphasis on such work, but courses in other disciplines differ widely in the degree to which quantitative skills are required. In business, the social sciences, the physical sciences, and several other disciplinary groups, the curriculum usually includes courses that have a quantitative emphasis as well as courses that rely on other kinds of academic skills or background.

To increase the dependability of the findings, this study was restricted to classes enrolling at least 10 students for which a response rate of at least 75% was obtained. These restrictions ensured minimally acceptable levels of reliability and representativeness. Because response rate is related to student attendance, which, in turn, is related to teaching effectiveness, our sample probably excluded a disproportionate number of classes that were taught with low levels of effectiveness.

Faculty members participating in the IDEA program complete a *Faculty Information Form* and are asked to indicate, on a volunteer basis, the degree to which each of seven academic skills[1] are required in their class (None, Some, Much). During the 1998-99 year (September 1998 through August 1999), approximately 80% of all participants responded to this question.

In this study, we first explored three types of potential differences between quantitatively-oriented classes and other kinds of classes not emphasizing quantitative skills.

- Student motivations for enrolling in the class
- Course characteristics (types of assignments; difficulty)
- Global outcome measures (student ratings of teaching effectiveness)

Secondly, we made comparisons within each of four broad disciplinary groupings, chosen because IDEA results were available for at least 50 classes at each of the three levels of quantitative involvement (None, Some, Much).

- *Social/Behavioral Sciences* (including economics, history, political science, psychology, public administration, social science, social work, and sociology)
- *Business* (including general business, business administration and management, accounting, finance, information/data processing, and marketing)
- *Physical Sciences* (including chemistry, physics, and other physical sciences)
- *Applied Mathematics* (including computer and information sciences, engineering, and engineering technologies)

In addition to comparing classes that differed in their emphasis on mathematics/quantitative skills, differences among the four disciplinary groups were also explored.

[1] Writing, oral communication, computer applications, group work, mathematical/quantitative work, critical thinking, and creative/artistic/design endeavor.

Results

Student Motivation

Three of the questions on the IDEA form elicited information related to student motivation.

I had a strong desire to take this course.
I really wanted to take a course from this instructor.
I really wanted to take this course regardless of who taught it.

A fourth item was indirectly related:

I worked harder on this course than on most courses I have taken.

For these four questions, a 5-point response scale was used with anchors of "Definitely false" (scored 1) and "Definitely true" (scored 5).

Summary of Results: Student Motivation

Students in classes where math/quantitative skills were emphasized were less motivated *but* worked harder *than did students in classes that placed no emphasis on these skills.*

In three of the four disciplinary groups, student motivation *was similar to that for "all classes." However, in Physical Science classes, students not only were significantly less* motivated *than those in the other three disciplinary groups, but also reported working harder.*

Details supporting these conclusions are given below.

Quantitative Emphasis Subgroup Comparisons. On the three motivation items, statistically significant differences were found among classes differing in their emphasis on math/quantitative skills; averages for "Much" emphasis classes were lower than for "No" emphasis classes while those for the "Some" emphasis classes were between these extremes. Differences between "Much" and "None" groups were large enough to be considered "practically significant" (see Appendix Table 1).

On the *effort* item *(I worked harder on this course than on most courses I have taken)*, the difference between the "Much" group and the "None" group was even greater, and the "Some" group again averaged between these extremes. Additionally, in classes that require "Much math/quantitative work," students generally *worked harder* despite being less motivated than those in classes with "No math/quantitative emphasis" (see Appendix Table 1).

Comparisons of Disciplinary Groups With All Other Classes. On an overall basis, average ratings on the three *motivation* items were similar to those in the "all classes" database for three of the four disciplinary groups. However, for the Physical Science subgroup, average *motivation* ratings on these items were well below those for the entire database (see Appendix Tables 2, 3, and 4).

The Physical Science group also had the highest average rating of *effort*. The other three disciplinary groups had *effort* ratings about the same as that for "all classes" (see Appendix Table 5). Thus, in this study, students in the Physical Science classes were poorly *motivated* but put forth an above average *effort* to learn. Those in the other three disciplinary groups displayed typical levels of both academic *motivation* and *effort*.

Physical science classes were also distinctive when within-discipline comparisons were made of "Much," "Some," and "No" emphasis groups. For this disciplinary group, *motivation* ratings, while well below the "all classes" average, did not differ among the three emphasis groups. For the other three disciplinary groups, *motivation* ratings progressed from low to high as the math/quantitative requirement decreased (see Appendix Tables 2, 3, and 4). On the *effort* item, however, there were no disciplinary differences in trends; the "Much" emphasis group averaged significantly higher levels of *effort* than did the "No" emphasis group for all four disciplines (see Appendix Table 5).

Course Characteristics

The IDEA form asked students to describe the course in terms of:

- *Amount of reading,*
- *Amount of work in other (non-reading) assignments, and*
- *Difficulty of the subject matter.*

Again a 5-point rating scale was used, anchored by "1=Much less than most courses" and "5=Much more than most courses." Average ratings on these items were very different among the four disciplinary groups and among the three groups defined by their math/quantitative requirements.

Summary of Results: Course Characteristics

In classes with a high emphasis on math/quantitative skills, ratings of both difficulty *and* amount of other (non-reading) work *were much higher than for "No emphasis" classes.* Amount of reading*, however, did not differ among "emphasis" groups except for Social/Behavioral Sciences where the "None" group averaged well above the "Much" group.*

There were large disciplinary differences on all three items. Relative to all classes in the database, Applied Math classes were distinguished by low ratings on amount of reading *and high ratings on* amount of other work*. Similar, but less extreme results were found for Physical Science classes which were most differentiated by a very high* difficulty *rating. Business classes were rated slightly above average on all three characteristics, while Social/Behavioral Sciences had very high ratings on* amount of reading *and very low ratings on* amount of other work*.*

Details are given below.

Quantitative Emphasis Subgroup Comparisons. When disciplines were combined, classes placing "Much" emphasis on math/quantitative skills required less *reading,* much more *other work*, and were regarded as much more *difficult* than classes with "No" quantitative emphasis. In each instance, the average rating for "Some" emphasis classes was between the two extremes (see Appendix Table 6).

Comparison of Disciplinary Groups With All Classes. For Business classes, ratings on all three course characteristic items were slightly above the "all classes" average. Applied Math classes required much less *reading* and much more *other work* than did "all classes." Physical Science classes were like those in Applied Math except that the differences from the "all classes" averages were smaller; this disciplinary group was most distinctive because its average on *difficulty of subject matter* was especially high. Classes in Social/Behavioral Sciences made high reading demands when compared to classes, but fewer demands in the amount of *other (non-reading) work* (see Appendix Tables 7, 8, and 9).

Previous IDEA Center studies have shown that *difficulty* is correlated principally with both *amount of reading* and *amount of other work* (correlations of .41 and .47). Results for the Social/Behavioral Sciences, Applied Math, and Business groups were consistent with these findings. But the extremely high *difficulty* rating for Physical Science courses cannot be explained by its combination of below average *reading* requirements and above average *amount of other work* requirements. It appears that, while the types of required assignments typically affect the difficulty of a course, *difficulty* in the Physical Sciences may also be a function of the high level of intellectual challenge posed by the discipline.

Global Outcome Measures

The IDEA system provides four global ratings of teaching effectiveness. The most important of these is "Progress on Relevant Objectives." This measure is obtained by averaging student ratings of progress on objectives the instructor identified as "Important" or "Essential" after double-weighting the latter[2]. As a comprehensive measure of student learning, it represents a potent proxy for teaching effectiveness.

The other three global measures are student ratings on single items:

- *As a result of taking this course, I have more positive feelings toward this field of study.*
- *Overall, I rate this instructor an excellent teacher.*
- *Overall, I rate this course as excellent.*

Standard 5-point rating scales are employed for these three items, anchored by "1=Definitely false" and "5=Definitely true."

[2]To compensate for differences among objectives, averages are converted to standard T Scores (mean=50, standard deviation=10) before being weighted and combined. Because progress ratings for "Essential" objectives are typically higher than those for "Important" objectives, the average PRO for all classes is about 52, a little higher than the 50 average for progress ratings on individual learning objectives.

Summary of Results: Global Outcome Measures

The more emphasis placed on math/quantitative skills, the lower the overall ratings of teaching effectiveness. This was more apparent on measures related to attitude toward the discipline *and* quality of the course *than on* quality of the teacher *or* amount learned*. Classes in Social/Behavioral Sciences were distinctive because the lowest ratings of effectiveness were obtained in classes where "Some" emphasis was placed on math/quantitative skills.*

Most global measures of teaching effectiveness for these disciplinary groups were not significantly different from those for "all classes" in the database except for the Physical Sciences; for this disciplinary group, ratings of overall teaching effectiveness were consistently below the "all classes" average.

Details are given below.

Quantitative Emphasis Subgroup Comparisons. Global outcome ratings were consistently higher for classes where "No" emphasis was placed on math/quantitative skills than on those with "Much" emphasis; "Some" emphasis classes always averaged in between. Differences were sharper on *increased positive attitude* and *excellent course* measures (see Appendix Table 10). Low to high trends for "Much," "Some," and "No" emphasis groups, respectively, were found on all four global ratings for three of the disciplinary groups, except for Social/Behavioral Science classes, where, although the "No" emphasis group had the highest average, the lowest average was consistently obtained by the "Some" group (see Tables 11, 12, 13, and 14). Further study is needed to determine if this anomaly reflects either inconsistencies among the individual disciplines included in this broad category (economics, sociology, psychology, etc.) or some peculiarities of this sample.

Comparisons of Disciplinary Groups with All Classes. Results for the Physical Sciences were relatively distinctive. Whereas most of the global ratings for other three disciplines were not significantly different from those for "all classes," Physical Science classes averages were lower (see Tables 11, 12, 13, and 14)[3].

[3]Outcomes are affected by a number of "extraneous circumstances"--factors not under the control of the instructor. Chief among these is student motivation. When such factors were controlled statistically, outcomes for these disciplinary groups were more positive, regardless of the degree to which math/quantitative skills were emphasized. However, even after adjustments, outcomes for the Physical Sciences group were significantly below those for all classes and for other disciplinary groups. Whether this reflects the distinctiveness of the disciple or of its teaching processes cannot be inferred from these results.

Discussion

Those teaching classes which require math/quantitative skills encounter a relatively unique learning environment. This study provided evidence that students in such classes are, on the whole, less motivated than those in other classes. Since motivation is a major determinant of the amount of student learning, teachers face a serious challenge of dealing with student attitudes and fears so that they will not seriously inhibit subject matter mastery.

We can only speculate on the reasons motivation ratings were so low. It seems likely that these findings reflect the lack of confidence that students commonly express in their mathematics background. Fear may stimulate effort, but it is not an effective facilitator of learning.

The general findings of this study were consistent with this observation. Students in quantitatively-oriented classes worked harder than those in other classes. Nonetheless, student ratings of outcomes were generally less favorable in classes emphasizing math/quantitative skills. Students who are fearful that their skills may be inadequate to meet the demands of the class are likely to be handicapped in learning beyond what would be expected purely on the basis of their academic qualifications. As expected, they rated these classes as having a very high difficulty level.

Although, when all classes are considered, difficulty is most closely related to *amount of reading* and *amount of other (non-reading) work*. The high difficulty rating of math-oriented courses cannot be explained by these relationships. It seems likely that the high difficulty ratings of math/quantitatively oriented classes reflects both "math anxiety" and the fact that classes requiring such a background pose especially challenging intellectual demands. If these findings are confirmed in subsequent studies, it may be necessary to take them into account in routine IDEA reports to participating faculty.

Since there were many differences among the four disciplinary groups included in this study, it is apparent that many of its implications must be discipline-specific. Additional studies are needed to confirm these findings through replication, to expand both the number of disciplinary groups and the number of objectives, and to study individual disciplines. Such studies should also determine if the effectiveness of specific teaching methods varies with the amount of emphasis given to math/quantitative skills.

Appendix

Table 1: Student Motivation
Quantitative Emphasis Subgroup Comparison: Average Rating (Number of Classes)

Student Motivation Item	Level of Quantitative Emphasis		
	Much	Some	None
I had a strong desire to take this course.	3.41 (487)	3.53 (527)	3.73 (1236)
I really wanted to take a course from this instructor.	3.14 (488)	3.20 (527)	3.32 (1236)
I really wanted to take this course regardless of who taught it.	3.33 (488)	3.35 (527)	3.44 (1236)
I worked harder on this course than on most courses I have taken.	3.73 (488)	3.61 (527)	3.46 (1236)

Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between 4=More true than false 5=Definitely true

Table 2: I had a strong desire to take this course.
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.60	3.85	3.84	S,N>M	287	3.77
2. Business	3.46	3.71	3.69	S,N>M	669	3.63
3. Physical Sciences	3.29	3.23	3.22	NS	300	3.25
4. Social/Behavioral Sciences	3.23	3.27	3.76	N>M,S	994	3.67
Significant Differences	1,2>3,4	1>2,3,4	1>2,3 2,4>3			
All Classes					8649	3.66

Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between 4=More true than false 5=Definitely true

NS=No significant differences

Table 3: I really wanted to take a course from this instructor.
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.28	3.49	3.46	S,N>M	287	3.42
2. Business	3.15	3.33	3.31	S,N>M	669	3.27
3. Physical Sciences	3.09	3.00	2.99	NS	300	3.04
4. Social/Behavioral Sciences	2.97	2.98	3.32	N>S,M	994	3.26
Significant Differences	1>2,3,4 2>4	1>2,3,4 2>3,4	1>2,3,4 2,4>3			
All Classes					8650	3.44

Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between
4=More true than false 5=Definitely true

NS=No significant differences

Table 4: I really wanted to take this course regardless of who taught it.
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.32	3.42	3.42	NS	287	3.39
2. Business	3.37	3.39	3.40	NS	669	3.39
3. Physical Sciences	3.25	3.31	3.36	NS	301	3.29
4. Social/Behavioral Sciences	3.42	3.26	3.47	N>S,M	994	3.44
Significant Differences	NS	NS	4,2>3			
All Classes					8650	3.31

Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between
4=More true than false 5=Definitely true

NS=No significant differences

Table 5: I worked harder on this course than on most courses I have taken.
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.66	3.52	3.44	M>N,S	287	3.54
2. Business	3.72	3.69	3.43	M,S>N	669	3.59
3. Physical Sciences	3.77	3.66	3.49	M>N	301	3.68
4. Social/Behavioral Sciences	3.75	3.51	3.47	M>S,N	994	3.56
Significant Differences	NS	2,3>1,4	NS			
All Classes					8650	3.56

Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between
4=More true than false 5=Definitely true

NS=No significant differences

Table 6: Course Characteristics
Quantitative Emphasis Subgroup Comparison: Average Rating (Number of Classes)

Student Motivation Item	Level of Quantitative Emphasis		
	Much	Some	None
Amount of reading	3.12 (489)	3.17 (529)	3.43 (1236)
Amount of work in other (non-reading) assignments	3.67 (487)	3.55 (527)	3.21 (1236)
Difficulty of subject matter	3.92 (487)	3.66 (527)	3.33 (1236)

Students rated the items on a 5-point scale: 1=Much less than most courses 2=Less than most courses 3=About average 4=More than most courses 5=Much more than most courses

Table 7: Amount of reading
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	2.93	2.79	2.87	NS	287	2.86
2. Business	3.23	3.30	3.32	NS	669	3.29
3. Physical Sciences	3.08	3.13	3.18	NS	302	3.11
4. Social/Behavioral Sciences	3.14	3.31	3.54	N>S>M	994	3.49
Significant Differences	2,3,4>1 2>3	2,3,4>1 2,4>3	2,3,4>1 4>2,3			
All Classes					8651	3.20

Students rated the items on a 5-point scale: 1=Much less than most courses 2=Less than most courses 3=About average 4=More than most courses 5=Much more than most courses

NS=No significant differences

Table 8: Amount of work in other (non-reading) assignments
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.76	3.65	3.55	M>N	287	3.65
2. Business	3.66	3.71	3.35	M,S>N	669	3.54
3. Physical Sciences	3.73	3.56	3.42	M>S,N	300	3.62
4. Social/Behavioral Sciences	3.48	3.21	3.11	M>S,N	994	3.15
Significant Differences	1,2,3>4	1,2,3>4	1,2,3>4 1>2			
All Classes					8649	3.42

Students rated the items on a 5-point scale: 1=Much less than most courses 2=Less than most courses 3=About average 4=More than most courses 5=Much more than most courses

NS=No significant differences

Table 9: Difficulty of the subject matter
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.70	3.38	3.19	M>S>N	287	3.42
2. Business	3.88	3.60	3.25	M>S>N	669	3.53
3. Physical Sciences	4.11	3.93	3.60	M>S>N	300	3.97
4. Social/Behavioral Sciences	3.94	3.70	3.36	M>S>N	994	3.44
Significant Differences	NS	NS	3>1,2,4 2,4>1			
All Classes					8649	3.42

Students rated the items on a 5-point scale: 1=Much less than most courses 2=Less than most courses 3=About average 4=More than most courses 5=Much more than most courses

NS=No significant differences

Table 10: Global Outcome Measures
Quantitative Emphasis Subgroup Comparison: Average Rating (Number of Classes)

Student Motivation Item	Level of Quantitative Emphasis		
	Much	Some	None
Progress on relevant objectives.[1]	49.95 (492)	50.53 (527)	53.20 (1236)
As a result of taking this course, I have more positive feelings toward this field of study.[2]	3.53 (487)	3.66 (527)	3.95 (1236)
Overall, I rate this instructor as excellent.[2]	3.95 (487)	3.99 (527)	4.21 (1236)
Overall, I rate this course as excellent.[2]	3.53 (487)	3.66 (527)	3.95 (1236)

[1]Average of student ratings of progress on objectives identified by the instructor as either *important* or *essential*. To compensate for differences among objectives, averages are converted to T Scores, a standardized score with an average of 50 and standard deviation of 10. *Essential* objectives are double weighted.

[2]Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between 4=More true than false 5=Definitely true

Table 11: Progress on Relevant Objectives
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	51.19	51.79	52.29	NS	287	51.77
2. Business	50.13	51.35	52.72	N>M	669	51.59
3. Physical Sciences	47.86	50.15	51.18	S,N>M	305	49.21
4. Social/Behavioral Sciences	52.40	48.62	53.59	M,N>S	994	52.90
Significant Differences	1,2,4>3	2>4	NS			

Average of student ratings of progress on objectives identified by the instructor as either *important* or *essential*. To compensate for differences among objectives, averages are converted to T Scores, a standardized score with an average of 50 and standard deviation of 10. *Essential* objectives are double weighted. Because progress ratings for "Essential" objectives are typically higher than those for "Important" objectives, the average PRO for all classes is about 52, a little higher than the 50 average for progress ratings on individual learning objectives.
NS=No significant differences

Table 12: As a result of taking this course, I have more positive feelings toward this field of study.
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.67	3.86	3.91	S,N>M	287	3.82
2. Business	3.55	3.75	3.91	N>S>M	669	3.76
3. Physical Sciences	3.38	3.48	3.67	N>M	300	3.46
4. Social/Behavioral Sciences	3.63	3.54	3.99	N>S,M	994	3.91
Significant Differences	1,2,4>3	1,2>3,4	1,2,4>3			
All Classes					8649	3.88

Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between 4=More true than false 5=Definitely true

NS=No significant differences

Table 13: Overall, I rate this instructor as excellent.
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.91	4.07	4.16	N>M	287	4.05
2. Business	3.91	3.95	4.10	N>S,M	669	4.00
3. Physical Sciences	3.92	4.02	4.05	NS	300	3.98
4. Social/Behavioral Sciences	4.24	3.96	4.27	M,N>S	994	4.23
Significant Differences	4>1,2,3	NS	4>2,3			
All Classes					8649	4.19

Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between 4=More true than false 5=Definitely true

NS=No significant differences

Table 14: Overall, I rate this course as excellent.
Disciplinary Group Comparison: Average Rating

Disciplinary Group	Level of Quantitative Emphasis			Significant Differences	Number of Classes	Overall Average
	Much	Some	None			
1. Applied Mathematics	3.69	3.86	3.96	S,N>M	287	3.84
2. Business	3.63	3.79	3.91	N>S>M	669	3.80
3. Physical Sciences	3.49	3.58	3.75	N>M	300	3.57
4. Social/Behavioral Sciences	3.74	3.59	4.03	N>S,M	994	3.96
Significant Differences	1,2,4>3	1,2>3,4	4>2,3 1>3			
All Classes					8649	3.92

Students rated the items on a 5-point scale: 1=Definitely false 2=More false than true 3=In between 4=More true than false 5=Definitely true

NS=No significant differences

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