# The Relationship Between Missing Graded Course Work and Student Outcomes in Undergraduate Math Courses


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## 1 Research Question

Which academic factors have a strong relationship with the proportion of graded homework missed and what relationship does missing graded homework have with a failure outcome in an undergraduate math course?

## 2 Background

One of the most important hypotheses of the *theory of student involvement* [1] is that the effectiveness of any educational policy or practice is directly related to the capacity of that policy or practice to increase student involvement thus increasing the amount of student learning and personal development. In addition, students who become intensely involved in their college studies experience considerable satisfaction [1].

In a study of results of the National Survey of Student Engagement between 2000 and 2003 from 18 baccalaureate-granting colleges and universities, Kuh et al. [4] inferred that student engagement in educationally purposeful activities had a small but statistically significant effect on first-year grades. The research herein measures the relationship of student engagement in educationally purposeful work (submitting graded homework) with the student outcome of final exam score.

In a study of 522 pre-algebra and algebra students at the University of Memphis, Glover [3] found seven measures of student effort that were significantly related to course grade. In a study that extends Glover's work [3], Thomas and Higbee [8] looked at 119 university students enrolled in developmental algebra over two academic quarters and concluded that the level of student engagement in educationally purposefully activities measured by number of days absent was consistently related to the achievement variables of homework average, computer test average, test average, final exam score and course grade. The research in this report includes an analysis of both student reported and faculty reported measures of student involvement and achievement in several undergraduate mathematics courses.

In 1981 Cartledge and Sasser [2] infer from their controlled pretest posttest study of 30 volunteer students that there is a tendency for properly assigned and evaluated weekly homework to improve gains on an algebra test after a

freshman algebra course. However, they admit that their research and past research do not provide a clear-cut endorsement for either homework or no-homework groups. It seems reasonable to infer that if there are any gains to be made through homework, they are lost when students do not engage in their homework. The present study hopes to examine differences between students who were engaged with their graded homework and those who were not.

In a study of 108 students of intermediate algebra at a four-year university in western Tennessee [9], it was determined that an experimental class of students in which homework was collected earned a larger number of A's than the class with no homework collection. It was noted that student comments from the control group favoured homework collection. The author also speculates that a possible reason for a larger number of students withdrawing from the experimental class was the higher level of involvement by students. They were more likely to be aware of their course standing and chose to begin again in another semester.

In a synthesis of homework studies Paschal, Weinstein and Walberg (1984) [7] determined that much of the voluminous literature on homework was opinionated and polemical. They analyzed 85 methodologically adequate studies and concluded from these that there is a moderately large average effect of assigned homework, that is commented upon or graded, on course outcomes.

# 3 Research Methodology

Pursuant to the requirements of the Human Ethics Research Board of the Office of Research Services at the University of Victoria, an Ethical Waiver was applied for and approved for this study.

Near the end of March 2008 the *Math and Stats Assistance Questionnaire* survey was distributed to all UVic first year math and second year statistics classes. Anonymous data collected from this survey were used to gather information about student perceptions of academic support services offered by the department and the proportion of graded assignment questions completed. Data from the survey are used in the present study to identify factors that are significantly correlated with missing graded assignment questions for selected UVic courses.

Anonymized course grading sheets were used to analyze the relationship between missing graded homework and course outcomes, i.e. final exam score and overall course score.

One limitation of this study is that the same student may be in more than one math class at a time so it may be difficult to make comparisons between courses. Also, since this is an observational study, we cannot infer *cause and effect* relationships.

For each course in the study, there was an experienced faculty member designated as the course coordinator by the Department of Mathematics and

Statistics at UVic. Relevant course coordinators were interviewed for the qualitative portion of the analysis.

## 3.1 Courses Involved the Study

This study focuses on four significant first year math classes i.e. Math 101, 102, 122 and 151 from the spring term of 2008. The students surveyed and analyzed form a very substantial portion of all students enrolled in these courses during the spring term of 2008. In all four courses, graded homeworks were worth eight to ten percent of the overall course score and the final exam was worth at least 60%. For courses with multiple sections, all sections were taught using a very similar lecture schedule on required topics from the same textbook.

### 3.1.1 Math 101 – Calculus II

Students taking this course have already successfully completed Calculus I. The course is intended for students planning to continue in math, science or engineering. Students in this course were enrolled in one of five sections taught by four different instructors. Each of the five sections analyzed had either three or four graded homeworks and three midterms. A total of 485 students wrote the final exam.

This course includes the following topics: volumes; arc length and surface

area; techniques of integration with applications; polar coordinates and area; l'Hospital's rule; Taylor's formula; improper integrals; series and tests for convergence; power series and Taylor series; complex numbers. The course coordinator reported that each graded homework assignment consisted of three questions and were assigned in such a way that there was an assignment or test approximately biweekly. The goal of these assignments was to help the student develop the ability to clearly explain concepts and so they required detailed, careful and thorough explanations. Graded homework questions were typically more difficult than those on the final exam. This term was the first time graded homeworks were assigned for this course, and that long answer questions were asked on the final exam in more than ten years.

### 3.1.2 Math 102 – Calculus for Students in the Social and Biological Sciences

Students taking this course must have successfully completed Principles of Math 12 or equivalent, or the UVic course Math 120. This course is intended to be the only calculus required by programs in the social and biological sciences. The students that were studied from this course were enrolled in one of two sections taught by two different instructors with very similar lecture schedules on required topics from the same textbook. Each of these two sections had thirteen or fourteen graded homeworks, two or three in-class

tests and a final exam. A total of 121 students from these two sections wrote the final exam for this course. A further two sections of this course were not included in this study since no graded homeworks were assigned.

This course focuses on calculus of one variable with applications to the social and biological sciences. The following topics are included: limits; continuity; differentiation; applications of the derivative; exponential and logarithmic growth and integration. The course coordinator reported that weekly graded homeworks consisted of five or six questions that required some thought and background knowledge. Typical assignment questions were a little more difficult than those on the final exam. During this term the course coordinator noted that it was possible some students were doing only the graded homeworks and not the suggested exercises – thus in subsequent terms the graded homeworks were easier if the student had completed the suggested exercises. During the first five weeks of the course some of the assignments due were reviews of algebra.

### 3.1.3 Math 122 – Logic and Foundations

Students taking this course must have successfully completed Math 100, 102 or 151. Students in this course were enrolled in one of two sections taught by two different instructors. Each of the two sections analyzed had six graded homeworks, two midterms and a final exam. A total of 126 students wrote

the final exam for this course.

This course includes the following topics: basic set theory; counting; solution to recurrence relations; logic and quantifiers; properties of integers; mathematical induction; asymptotic notation; introduction to graphs and trees. The course coordinator reported that the majority of graded homework questions were significantly more difficult than the questions on the final exam but similar in difficulty to the suggested problems. The primary focus of the graded homework assignments was on proof techniques. It was necessary to have a thorough understanding of the concepts in the course to do the graded homework.

### 3.1.4 Math 151 – Finite Mathematics

Students taking this course must have successfully completed Principles of Math 11 or equivalent. Students in this course were enrolled in one of six sections taught by six different instructors. Five sections had two midterms and one section had four midterms. All six sections analyzed had four graded homeworks and a final exam. A total of 431 students wrote the final exam for this course.

This course includes the following topics: geometric approach to linear programming; linear systems; Gauss-Jordan elimination; matrices; compound interest and annuities; permutations and combinations; basic laws of

probability; conditional probability; independence; urn problems; tree diagrams and Bayes formula; random variables and their probability distributions; Bernoulli trials and the binomial distribution; hypergeometric distribution; expectation; applications of discrete probability and Markov chains. The course coordinator reported that all graded homework for this course was calculation based and involved applying the more challenging concepts learned in the course. The graded homework questions were approximately the same difficulty level as the more challenging questions on the final exam. It was also reported that the majority of students indicate on their course evaluation forms that they take this course because it is a requirement of their degree program.

# 4 Analysis

## 4.1 Results of the Analysis of Course Grading Data

The data from the course grade sheets submitted by these instructors to the department were analyzed through calculation of relative risk, analysis of variance and regression techniques to determine the relationship between missing graded work and course outcomes. Students who did not write the final exam during the regularly scheduled exam period were not included in the analysis.

For each course, grading spreadsheets were analyzed and summarized in tables 1, 2 and 3. Since data collected and results were somewhat different for each course the data is stratified by course.

Table 1: Assigned vs. Submitted Homework

| **Mean Number of** | 102 | 101 | 151 | 122 |
|---|---|---|---|---|
| **Assigned Homeworks** | 13.51 | 4 | 4 | 5.46 |
| **Submitted Homeworks** | 9.96 | 3.51 | 3.36 | 4.1 |
| **Mean Pct Submitted** | 73.72 | 87.75 | 84.00 | 75.09 |

Table 1 lists the mean number of graded homeworks assigned per student and the mean number submitted per student. The last row shows the mean percentage of assigned homeworks that were submitted per student. Students in different sections of Math 101 and 102 had different numbers of assigned homeworks.

Table 2: Summary of Performance by Course

| **Mean Score** | 102 | 101 | 151 | 122 |
|---|---|---|---|---|
| **Final Exam** | 54.03 | 50.66 | 66.44 | 55.97 |
| **Course** | 53.59 | 52.44 | 63.82 | 54.79 |
| **Term Tests** | 52.37 | 50.62 | 59.07 | 53.37 |
| **All Term Work** | 52.67 | 54.91 | 59.75 | 52.70 |
| **Homework** | 53.57 | 67.78 | 61.81 | 50.48 |

Table 2 lists mean score per student on various portions of the course work. *Course* score includes all graded homework and term tests plus the final exam weighted as in the course outlines. *All Term Work* includes all graded homeworks and term tests. Weights for graded homeworks and midterms tests are as reported to students in their course outlines. Reported scores are out of 100.

Table 3: Proportion of Students Who...

| | 102 | 101 | 151 | 122 |
|---|---|---|---|---|
| **Missed 1st Homework** | 0.12 | 0.06 | 0.06 | 0.10 |
| **Had a Downward Trend in Homework** | 0.17 | 0.34 | 0.22 | 0.36 |
| **Scored at Least 50 in Course** | 0.58 | 0.51 | 0.82 | 0.63 |
| **Scored at Least 50 on Final** | 0.57 | 0.48 | 0.85 | 0.65 |

Table 3 lists the proportion of students who were identified in the categories listed.

### 4.1.1 Relative Risk

Table 4 lists a number of risk factors in an attempt to identify ones that have a significant effect on final exam score.

The first risk factor listed in Table 4 is *missed more than one homework*. A student belongs in this category if they missed submitting more than one graded homework. The second risk factor is *missed first homework*. A student

belongs in this category if they did not submit the first graded homework assignment. The third risk factor in table 4 *downward trend on first two homeworks*. A student is counted in this category if their score on the second graded homework assignment is less than 75% of their score on the first.

For the population of students involved in this study, the relative risk of earning less than 50% on the final exam (course outcome) for the risk factor of missing more than one graded homework (risk factor) was substantially different across the four courses. Since these risk ratios are substantially different the data is stratified by course to avoid mistakes in computing correlation between student engagement/involvement levels and course outcomes [5]. The remaining results are separated out for each course.

Table 4: Relative Risk of Earning Less than 50% on the Final Exam

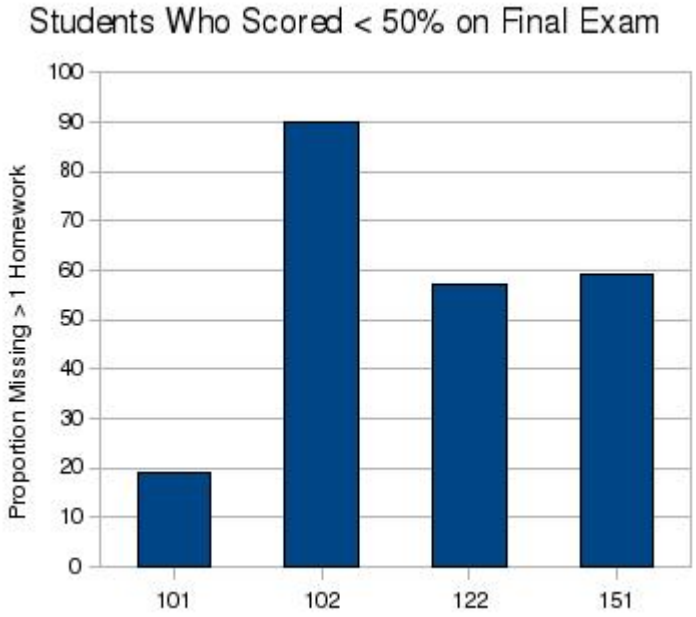
| **Risk Factor** | 101 | 102 | 151 | 122 |
|---|---|---|---|---|
| **Missed More Than One Homework** | 1.92 | 4.14 | 6.75 | 2.73 |
| **Missed First Homework** | 1.88 | ** | 4.57 | 1.93 |
| **Downward Trend on First Two Homeworks** | 1.42 | ** | 2.27 | ** |

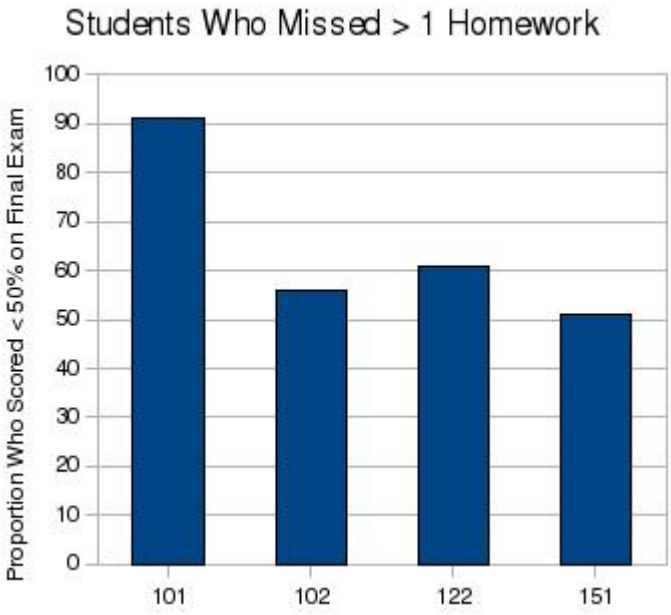
(** indicates that there was little or no evidence that the risk factor and course outcome are dependent variables).

Thus a student in Math 151 who missed more than one graded homework was almost seven times more likely to score less than 50% on the final exam than a student who missed at most one homework. All relative risks quoted in

the table above have p-values for independence tests with the course outcome of less than 0.10 for each course.

The following two histograms explore the relationship between missing more than one graded homework and earning less than 50% on the final exam a little further. The first histogram focuses on students who scored less than 50% on the final exam and for each course it lists the proportion of these students who missed more than one graded homework. The second histogram focuses on students who missed more than one graded homework and reports the proportions of these students who earned less than 50% on the final exam.






### 4.1.2 Analysis of Variance

Table 5 lists mean final exam scores (out of 100) for students categorized by the number of graded homeworks that were not submitted by the student. Data is stratified by course.

Table 5: ANOVA Analysis of Final Exam Percentages

| **Student Missed** | 101 | 102 | 151 | 122 |
|---|---|---|---|---|
| **No Homeworks** | 55.57 | 74.12 | 73.05 | 63.04 |
| **One Homework** | 44.32 | 64.71 | 61.65 | 60.60 |
| **More Than One Homework** | 31.9 | 47.09 | 46.66 | 42.55 |

### 4.1.3 Proportion of Variation $R^2$

A value of the Pearson-R coefficient $R$ that is less than 0.40 (i.e. $R^2 < 0.16$) may indicate a less than significant influence of the independent variable on the dependent variable.

Table 6: Proportion of Variation $R^2$ in Final Exam Score

| | 101 | 102 | 151 | 122 |
|---|---|---|---|---|
| **Proportion of Homework Submitted** | $**$0.14 | 0.35 | 0.31 | 0.25 |
| **Performance on Term Work** | 0.61 | 0.77 | 0.61 | 0.72 |

The first line in Table 6 reports the proportion of variation in final exam score (dependent variable) that can be attributed to variation in the proportion of graded homework submitted by the student. For each course except Math 101, the proportion of homework submitted by the student is significantly correlated with the final exam score.

The second line in Table 6 reports the proportion of variation in final exam score that can be attributed to variation in performance on term work, i.e. the student's mean score on midterms and graded homeworks.

## 4.2 Analysis of Math & Stats Assistance Questionnaire

The Mathematics and Statistics Assistance Centre (at UVic) offers math tutoring to students enrolled in any first year Math, second year Math, or

second year Stats course. It operates as a free, first-come-first-served, drop-in service. An undergrad who requires assistance goes to any one of the locations and puts his or her name and course number on the sign up sheet. The student gets help when the next qualified tutor is available.

The bubbled response section of the Math & Stats Assistance Questionnaire addressed eight potential factors of student success:

- Q1: Math and Stats support satisfaction,
- Q2: frequency of visits to the Assistance Centre,
- Q3: frequency of visits of office hours,
- Q4: percentage of homework (graded work) attempted,
- Q5: percentage of suggested problems (non-graded work) attempted,
- Q6: frequency of Math and Stats practice outside of class,
- Q7: number of classes missed, and
- Q8: individual performance satisfaction.

Response rates are summarized in Table 7 for the courses included in this study:

### 4.2.1 Multiple Regression Analysis

Using stepwise regression with backward elimination, multiple regression models to explain some of the variation in amount of homework turned

Table 7: Response Rates for Bubble Portion of Math & Stats Assistance Questionnaire

| **Course** | **Enrollment** | **Bubbled Responses** | *PercentCaptured* |
|---|---|---|---|
| **Math 101** | 524 | 244 | 46.6 |
| **Math 102** | 257 | 123 | 47.9 |
| **Math 122** | 135 | 77 | 57.0 |
| **Math 151** | 477 | 234 | 49.1 |

in were developed. A model to explain approximately 24% of the variation in amount of homework completed in Math 101 is $Q4 = -0.134 + 0.121 * Q5 + 0.359 * Q7 + 0.256 * Q8$. A model to explain approximately 17% of the variation in amount of homework completed in Math 102 is $Q4 = 0.733 + 0.606 * Q7 + 0.201 * Q8$. A model to explain approximately 19% of the variation in amount of homework completed in Math 122 is $Q4 = 0.236 + 0.129 * Q5 + 0.299 * Q7 + 0.205 * Q8$. A model to explain approximately 12% of the variation in amount of homework completed in Math 151 is $Q4 = 0.165 + 0.159 * Q1 + 0.102 * Q2 + 0.125 * Q7 + 0.190 * Q8$. The utility of each model is given in table 8.

A value of $R^2$ that is below 0.16 indicates that the model is not considered to be significantly correlated with the dependent variable.

Table 8: Revised Regression Model Tests with $\alpha_1 = 0.01$, $\alpha_2 = 0.025$

| $Course$ | $Dependent$ | $Independent$ | $v_1$ | $v_2$ | $F - Stat$ | $F_{v1,v2_{\alpha 1}}$ | $F_{v1,v2_{\alpha 2}}$ | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| 101 | $Q4$ | $5, 7, 8$ | 3 | 240 | 25.25629284 | 3.78 | 3.12 | 0.24 |
| 102 | $Q4$ | $7, 8$ | 2 | 120 | 12.71389687 | 4.82 | 3.83 | 0.17 |
| 122 | $Q4$ | $5, 7, 8$ | 3 | 73 | 5.757738311 | 4.05 | 3.30 | 0.19 |
| $**151$ | $Q4$ | $1, 2, 7, 8$ | 4 | 229 | 7.973401681 | 3.32 | 2.79 | 0.12 |

## 4.3 Qualitative Analysis

The course coordinators for courses included in the study were interviewed for their responses to the following questions (and future research questions and the nature of homework in their course). A summary of their feedback is offered.

The course coordinators found it surprising that the results varied by course, responses for individual items on the survey were relatively independent and that student involvement could have such an effect on student outcomes. They also wondered whether poor outcomes can be attributed to lack of basic study skills, academic background or other factors.

When asked for feedback on the low achievement of students who missed more than one homework, course coordinators commented that mathematics is extremely developmental and it is very difficult to move on with future material until past material is understood, and wondered what some of the

reasons are that students are not turning in their homework.

Course coordinators planned to encourage student involvement in homework and in class discourse, and through grading strategies. They plan to encourage students to start assignments early and work steadily.

Course coordinators recommended that as an institution we should have a consistent practice of assigning homework, use technology to assist in homework, enforce debarrment rules and establish a math skills centre to help students fill gaps in their background.

# 5 Discussion and Conclusions

## 5.1 Math 101

A linear combination of quantity of suggested problems completed, number of classes missed and individual performance satisfaction proved to be a statistically significant predictor of the amount of graded homework completed. Class attendance, individual performance satisfaction and completing suggested problems also had a positive correlation with homework completion (i.e. the more suggested problems attempted, the more graded homework attempted).

Students in this course who missed more than one homework had a probability of 91% of earning less than 50% on the final exam and had an average

score of 31.9% on the final exam vs. 55.57% for those who missed no homework. Students in this course turned in the highest proportion of graded homeworks compared to other courses and had the greatest discrepancy between mean final exam score and mean homework score. It was noted by the course coordinator that scores in Math 101 were reduced from previous terms possibly due to the introduction of graded homeworks and long answer questions on the final exam.

## 5.2 Math 102

A linear combination of individual performance satisfaction and number of classes missed proved to be a statistically significant predictor of the amount of graded homework completed. Class attendance and individual performance satisfaction had a positive correlation with homework completion.

Students in this course who missed more than one homework were more than four times as likely to earn less than 50% on the final exam, accounted for 90% of the students who scored less than 50% on the final exam and had an average score of 47.09% on the final exam vs. 74.12% for those who missed no homework.

There was a significant positive correlation between performance on the algebra review assignments and performance on the final exam for these students.

## 5.3 Math 151

A linear combination of math and stats support satisfaction, frequency of visits to the assistance centre, number of classes missed and individual performance satisfaction proved to be a statistically significant predictor of the amount of graded homework completed. Class attendance and individual performance satisfaction had a positive correlation with homework completion. Visiting the *Math Assistance Centre* had a negative correlation with homework completion (i.e. the more often a student visited the Math Assistance Centre, the less likely they were to complete a higher amount of graded homework).

Students in this course who missed more than one homework were almost seven times as likely to earn less than 50% on the final exam and had an average score of 46.66% on the final exam vs. 73.05% for those who missed no homework.

## 5.4 Math 122

A linear combination of quantity of suggested problems completed, number of classes missed and individual performance satisfaction proved to be a statistically significant predictor of the amount of graded homework completed. Class attendance, individual performance satisfaction and completing suggested problems had a positive correlation with homework completion.

Students in this course who missed more than one homework were almost three times as likely to earn less than 50% on the final exam and had an average score of 42.55% on the final exam vs. 63.04% for those who missed no homework.

## 5.5 Common Results

The mean final exam score for students who missed more than one homework was significantly less than for those who missed at most one as shown in table 5. For the courses in this study, the risk factors in table 4 which describe student engagement / involvement posed a significant amount of relative risk which was more than the relative risk of a downward trend on the performance in the first two homework assignments (second assignment score less than 75% that of the first). The students studied who missed more than one graded homework were between approximately 2 and 7 times more likely to achieve less than fifty percent on the final exam (a failure outcome) than those who missed at most one graded homework. Although it is apparent from table 6 that not as much of the variation in performance on final exam scores can be explained by a measure of student engagement/involvement such as completing graded homework as by performance on term work, the analysis of course grading sheets shows that student engagement / involvement in the course in the form of submitting graded homework does play a

significant role in student achievement.

There seemed to be some similarity between results for students in Math 151 and Math 102. These students are not required to have as much math experience as the other two courses. Could that be a reason for similarity?

Class attendance had a positive correlation with homework completion (i.e. the more classes a student attended, the more likely it is that he or she would complete all his or her homework). Individual performance satisfaction also had a positive correlation with homework completion (i.e. the happier a student was with his or her performance, the more likely it was that he or she would complete all her homework).

## 5.6 Conclusions

It is reasonable to infer that an improvement in academic support services related to class attendance, individual performance satisfaction, number of suggested problems completed, satisfaction with math and stats support and frequency of visits to the assistance centre may have a positive impact on student success rates.

It should be noted however that since this is an observational study no *cause and effect* relationships can be inferred.

Missing a graded homework assignment is an early warning signal that a student is at a significantly higher risk of failing a first year math course

than his or her classmates. Many of these students currently face the likely future penalty of failing the course.

# 6 Further Research Questions

The authors would like to thank the course coordinators for contributing some of the questions for possible future research.

What are common reasons for a student not submitting graded homeworks? Does the use of technology in the classroom (e.g. clickers) in which students are involved in answering questions effect student outcomes? What other academic factors are strong predictors of failure outcomes? Has there been similar research in other disciplines such as social sciences and the arts? What forms of intervention for at-risk students are successful? Does a significant difference in midterm test scores and homework scores indicate a higher risk of failure (possibly indicating a student who is familiar with the material but does not test well)? What factors effecting student involvement can a university significantly influence? Do institutional changes designed to increase student involvement increase performance? If we repeated the analysis in this study for the same courses in another term, how different would the results be? Can you relate lack of involvement in math courses to overall

success in university? Is there a relationship between the year of study in which a student takes a math course and their success in it? What proportion of students who fail their term work also fail the final exam? What do students report as common reasons for not submitting graded homework?

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