

## AMS Homework Software Survey

The American Mathematical Society undertook an online survey of 1230 U.S. mathematics and statistics departments in spring 2009 to i) assess the experiences of departments using homework software; and ii) understand the concerns of departments that were considering such software. The survey was an outgrowth of work of the AMS Task Force on the First-Year Mathematics Experience. This report summarizes the analysis of the survey responses. This survey project was supported by the National Science Foundation.<sup>1</sup>

Both the First-Year Task Force and AMS President James Glimm felt that such software had the potential to improve student learning in elementary mathematics courses, with a comparatively modest investment, and lead to higher passing rates in these courses. The Task Force was motivated by the same premise underlying the 1999 AMS report *Towards Excellence: Leading a Doctoral Mathematics Department in the 21<sup>st</sup> Century*: mathematics departments need to provide high quality instruction in order to receive the support from University administrations that these departments need to prosper. High failure rates in elementary mathematics courses are perceived by administrators as a failure of mathematics instruction, and so reducing failure rates is essential. The First-Year Task Force had a number of suggestions, besides using homework software, for improving instruction and passing rates in elementary mathematics courses; see the report of the Task Force (AMS Notices, **56**, p. 754-760).

There were 467 responses from the 1230 departments invited to respond to the survey. About 260 of the responding departments had used such software. The survey had three questions for both departments that were users and prospective users about the perceived benefits and drawbacks as well as in what courses the software was or might be used. The 98 responding departments that identified themselves as 'disinterested' were invited to answer the two questions about perceived benefits and drawbacks. There were seven additional questions to learn about experiences of departments that had used such software. Go to <http://www.ams.org/profession/leaders/webassess.html> to see the survey and a summary of all responses.

### Key Findings

*Overall, users were happy with homework software; almost no department discontinued or reduced its use.*

*Almost half of the 162 doctoral mathematics departments reported they were using homework software. Only 30% of the 190 comprehensive universities. and 13% of the 848 collegiate departments reported using this software.*

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*Current users were more positive about the benefits of homework software than prospective users and much less concerned about drawbacks than prospective users: the primary benefit being better student learning; the primary drawback being students not showing their work.*

*The most widely used software was MyMathLab (110 departments, 230,000 students annually among survey responders), which is available with textbooks from most Pearson-owned publishers. The two other most popular systems were WebAssign (80 users, about 100,000 students annually) and WeBWork (55 users, about 100,000 students annually).*

*The courses that users identified most frequently as employing homework software were College Algebra and below (87%), Calculus for Scientists (81%) and Precalculus (78%). When homework software was used in College Algebra and Precalculus, MyMathLab was the users' choice 50% of the time followed by WebAssign with 25%. General Calculus, Calculus for Scientists and Multivariable Calculus were split fairly evenly among MyMathLab, WebAssign, and WeBWork.*

*In doctoral departments, if homework software was used in a course, typically all sections used it. In M.S. and B.S. departments, there were more instances of just some sections using it.*

*Initial faculty resistance to using homework software occurred in most departments. Students and non-tenure-track faculty were more receptive to the software than tenured/tenure-track faculty. The level of faculty acceptance of certain homework systems varied with type of department-- Ph.D., M.S., or B.S., private or public.*

### ***What this Survey did not do.***

1. This survey did not ask the person in each department answering the survey to poll other members of the department to learn how they would answer the survey questions. Thus, the responses may reflect biases of the individual responders.
2. This survey did not solicit information about studies measuring the effectiveness of homework software. For example, questions about the benefits and drawbacks of homework software are answered solely in terms of faculty's beliefs (for prospective users) and observations (for current users).
3. This survey did not solicit information about computer-based testing.

***Nature of Responding Departments and Response Rate.*** The survey responses were broken down by type of institution (Ph.D., M.S., B.S.) as well as by private or versus public. The following numbers omit statistics departments, which are discussed shortly. The institutional categories were:

1. Top-80 ranked doctoral mathematics departments (using NRC 1995 study) – 57 responses (71%): 14 Private, 43 Public
2. Remaining 82 doctoral mathematics departments – 53 responses (65%): 12 Private, 41 Public
3. 190 comprehensive university (Master's degrees) mathematics departments – 81 responses (45%): 15 Private, 66 Public
4. 848 collegiate (Bachelor's degrees) mathematics departments – 257 responses (30%): 177 Private, 70 Public

The ranking of doctoral departments used the 1995 NRC study. Most of the findings represented here group all doctoral departments together because of the small numbers in some categories. There are about 150 B.S. departments that were omitted from the survey because the AMS did not have a valid email address for them. Note that the category with by far the largest number of responses was private collegiate departments. However, private colleges tend to have small numbers of students and faculty. On the other hand, doctoral departments had a much higher response rate (68%) than B.S. departments (30%) and doctoral departments are frequently at large universities with much higher enrollments than colleges. This is one reason why this report says little about aggregate responses, but instead focuses on patterns among the different types of departments: Ph.D., M.S., and B.S.; private and public. The other important reason is that prospective users will be most interested in the experiences of users at departments like theirs.

The country's 57 statistics departments were also included; all are doctoral departments. Only 17 responded and these responses were folded in with the responses from mathematics departments (since statistics is taught in many mathematics departments). The responses from statistics departments were quite similar to the responses from doctoral mathematics departments. Including statistics departments, the number of Category 1 responses increased from 57 to 71 responses and Category 2 responses increased from 50 to 53.

A sample of 30 two-year college mathematics departments were also included in the survey. Only 11 responded, 8 being current users. The two-year numbers were too small for any meaningful analysis, although they were generally similar to the responses from collegiate mathematics departments.

***Types of Software.*** All the homework software discussed here can accept algebraic expressions as well as numerical answers. They randomly vary parameters in questions so that each student gets different numbers in their version of an assignment. Students log into a website to see their assignment and enter answers. Typically, when a wrong answer is entered, students can try again and may also be given hints or directed to tutorials on the topic. For the instructor, there is a system to manage and download homework scores. Instructors can typically limit the number of tries, penalize too many ties, allow hints to be displayed, etc. There are often chat rooms and users groups to share experiences. Commercial software has prompt online and phone-in help services. This software can also be used to produce quizzes that are usually given in supervised computer labs.

Homework software can be classified into three categories.

*Publisher-supplied software.* This software has the advantage that it is specifically tailored to the course textbook. It also has the advantage for departments that all costs are born by the students, who pay a fee to get an account at the website where the publisher's software resides. The cost of the software was originally subsidized to help create a market for it, but is now around \$35 a course (or a sequence of courses if the courses use the same

textbook, e.g. a calculus sequence). This software often includes brief tutorials so that this software may accelerate the trend of students not buying course textbooks. With so many students recycling used books, fees for using homework websites may become a major source of income for mathematics textbook publishers.

The huge publisher Pearson that owns Prentice-Hall and Addison-Wesley has the most widely used homework system, called MyMathLab. Almost half the survey respondents using homework software had adopted MyMathLab. Around a dozen respondents mentioned using homework systems from each of Cengage, McGraw-Hill, and Wiley. After this survey was conducted, Cengage dropped its own homework software and affiliated with WebAssign. WebAssign was developed independently of publishers but is now affiliated with Cengage/Brooks-Cole while also supporting texts of other publishers.

*Homework software created by faculty.* If successful, such software may be managed by a for-profit company. The first widely used computer grading system was CAPA (Computer-Assisted Personalized Assignments). It was developed in 1992 by the Michigan State physics faculty. It only handled numerical answers, and its use by mathematics departments seems to have been minimal (just one respondent to the AMS survey was using the current version of CAPA). Starting about a decade ago, several homework software efforts were started in mathematics departments. The most successful has been WeBWorK, developed by Rochester mathematics faculty, and designed originally for calculus. Information about WeBWorK, including a Rutgers study of its effectiveness, was featured in the AMS First Year Task Force report (AMS Notices, **56**, p. 754-760). WeBWorK needs to be maintained on a local server for large courses, although courses of <100 students can use the MAA WeBWorK server. MapleTA is an outgrowth of eGrade, created by Nebraska Mathematics faculty. MapleTA can be hosted locally or on a MapleSoft server.

The other major faculty-designed homework software is WebAssign, developed by science faculty at North Carolina State University and spun off into a company to develop, market and support the software. It is the one homework system that is extensively used in both mathematics and other disciplines. WebAssign can include tutorials and virtual labs. As noted above, WebAssign has recently developed an association with Cengage/Brooks-Cole to provide homework sets for Brooks-Cole texts, including Stewart's *Calculus*.

There are several universities where mathematics faculty, sometimes in cooperation with faculty from other departments, have developed a homework software system for their campus. In some cases, Ph.D. alumni and friends at a few other institutions use it. Some of these systems have a limited pool of problems. Responses to this survey and personal knowledge of the project advisory committee identified such local homework systems at Temple, Kansas State, University of Kentucky, University of Nebraska, and University of Texas. In some cases, these systems are being used by their state's education departments to give high school students an online assessment of their readiness for college mathematics.

*Learning systems* Learning systems deliver all or almost all the instruction a student needs to learn the material in the course. A key feature of many learning systems is artificial

intelligence software that adapts the instruction and questions as it learns about the strengths and weaknesses of a student. Homework and testing are secondary aspects of these systems. Online instruction uses such software. Forty-three mathematics departments indicated that they used such systems. About half a dozen institutions mentioned using each of ALEKS and Hawkes Learning Systems. These learning systems are mainly used for high school mathematics and remedial college mathematics. Learning systems are widely used for vocational, online learning. Learning systems can be used to create courses where students proceed at their own pace. Such systems are used to teach prerequisite knowledge needed for the lowest level mathematics course that an institution offers; e.g., University of Illinois uses this strategy.

The best-known locally developed mathematics learning system is Virginia Tech's Mathematics Emporium, which is the name given to a converted department store where students access many of the online resources (see [www.emporium.vt.edu](http://www.emporium.vt.edu)). However, unlike commercial learning systems, there is extensive personal supporting, such as one-to-one tutoring. Another example, like the Mathematics Emporium, uncovered by this survey is Colorado State Mathematics Department's PACe, Paced Algebra to Calculus electronically, which consists of five mini-courses involving college algebra and precalculus. Combinations of these mini-courses prepare students for different versions of calculus.

For its possible interest to other mathematics departments, we mention that the Macalester College Mathematics Department has developed software called AcroScore to expedite the online submission and grading of written-out homework solutions.

## ***Survey Analysis***

As noted above, responses were broken down by type of institution: research university (Ph.D.), comprehensive university (M.S.), and college (B.S.), as well as private or public. Doctoral departments were further divided, in the spirit of other AMS surveys, into top-80 doctoral departments (rankings to the 1995 NRC rankings) and other doctoral departments. Generally, both categories of doctoral departments had similar responses, but the responses of the top-80 departments had special significance because of the high 74% response rate from these departments. Responses from Ph.D. and M.S. departments tended to have similar distributions, while responses from collegiate departments in some cases were markedly different. Occasionally, there were significant differences between the responses of departments at private versus public institutions. Responses were also broken down by the homework system, although the system tended to make little difference for most questions.

***CAVEAT-- Subjective Nature of Responses.*** As noted above, several survey questions required subjective judgments that called for an assessment of the whole department's experiences or general views of faculty. The views of the individual completing the survey may have biased some of these subjective responses.

**Question 1. Benefits.** This question listed four benefits and asked if the benefit were: i) a major issue, ii) a minor issue, or iii) not an issue, in motivating the use of homework software, or its prospective use.

- A. Can Now Grade Homework that previously was ungraded
- B. Frees Instructors/TAs from grading duties
- C. Better Learning (e.g., immediate feedback, can try again)
- D. Reduces Student Copying

*Note that this question is not asking current users whether there is better learning or reduced copying, only what their motivation was in adopting homework software.*

The first three benefits were rated a major issue by a majority of respondents and rated a major or minor issue by almost all respondents, users or prospective users and across all types of departments. However benefit C, Better Learning, received a significantly higher overall rating than A or B; it was a major issue for 76% of respondents, averaged over current and prospective users,

Benefits A and C were more likely to be rated as major issues by users than prospective users, while benefit B received about the same ratings from prospective users and users. The one exception to these trends was collegiate mathematics departments where, among both users and prospective users: a) there was the same high rating for benefit C, and b) a significant minority (about 25%) saw no value to freeing instructors from grading duties. Finally, all types of responders gave a low weight to benefit D. Reduces Copying—only about 25% of each type rated it a major issue.

The comments accompanying Question 1 generally reinforced responses about the four benefits. A number of comments praised the greater effort and persistence they see by students with homework software. Others commented on its attractiveness to students; “individualized questions are more personal,” and “today’s students like technology”. Several praised the supplementary tutorials that many systems have. Many praised its appropriateness for drilling basic skills. Finally, several commented that such software enforced some consistency in homework assignments in multi-section courses.

**Question 2. Drawbacks.** This question listed six drawbacks and asked if they were major or minor issues or not an issue with the use of homework software.

- A. Students Do Not Show Work
- B. Restricts Types of Questions
- C. Students Get Frustrated with format
- D. Students Get Lazy on first try
- E. Loss of Funds for student graders
- F. Easy for Students to Get Electronic Help

Drawback D. refers to the fact that with many chances to solve an online problem, students’ first attempt at an answer may not be carefully thought out. This tendency can lead to poor performances on in-class tests where students get only one chance at an answer. The first three drawbacks were typically an issue, major or minor, at 80%+ departments in all

categories, users and prospective users. Only Drawback A was a major issue for a majority of all responders. A reviewer of this report noted that some Internet sites now provide multi-step solutions to mathematics problems, so that even when students are required to show their work it may not really be their work.

Generally, prospective users rated these drawbacks major issues more frequently than current users. There were large differences between users and prospective users for all degree types with respect to whether the first two drawbacks were major issues, although for the first drawback it was private departments that drove the difference:

Is this a major drawback	Students not show work	Restricts type of questions
User	42% (Private only)	32% (All)
Prospective User	71% (Private only)	70% (all)

For drawback C, Student Frustration, there were large gaps between users and prospective users at Ph.D. departments and also surprisingly between private and public users at M.S. departments (a major issue at 53% of private M.S. users versus 24% public M.S. users). Drawback D, Students Get Lazy on first try, was much more likely to be viewed as a major issue for prospective users than users at private Ph.D. and M.S. departments and all B.S. departments. The last two drawbacks were modest concerns with all categories of prospective users and barely a concern among users.

The comments for question 2 came overwhelmingly from users of this software. The comments were of three categories. Some re-emphasized one of the listed drawbacks, some discussed other drawbacks not listed, and a few gave explanations of how they worked around the drawbacks. An example of the last type was that in-class quizzes mitigated problems with getting Internet help with homework. The other complaints included: available homework questions did not cover a topic in the textbook being used; it was very tedious to create needed additional questions (beyond those supplied with the system); and students 'game' the system by entering lots of nonsense answers so that some systems will give them enough hints to make the answer obvious.

**Question 3. Status.** This question asked if the respondent were: a current user, a prospective user, or not interested in becoming a user. The answer to this question was used to categorize responses to questions 1 and 2, as discussed above. The following table summarizes the responses to this question by type of mathematics department (the 17 responding statistics departments are not included in these numbers). In the following table, percentages are with respect to row totals.

	User	Prospective User	Not Interested	Row Totals
Top-80 Ph.D. depts.	38 (67%)	9 (16%)	10 (17%)	57
Private	6 (38%)	5 (31%)	5 (31%)	16
Public	32 (78%)	4 (10%)	5 (12%)	41
Other Ph.D. depts	33 (63%)	14 (26%)	6 (11%)	53
Private	6 (50%)	5 (40%)	1 (10%)	12
Public	27 (66%)	9 (22%)	5 (12%)	41

Master's depts.	57 (70%)	17 (21%)	7 (9%)	81
Private	11 (73%)	4 (27%)	0 (0%)	15
Public	46 (70%)	13 (20%)	7 (10%)	66
Collegiate depts.	107 (43%)	71 (29%)	69 (28%)	247
Private	63 (36%)	53 (30%)	61 (34%)	177
Public	44 (63%)	18 (26%)	8 (11%)	70
Column Totals	235 (54%)	111 (25%)	92 (22%)	438
Private	86 (39%)	67 (30%)	67 (31%)	220
Public	149 (68%)	44 (20%)	25 (12%)	218

First the absolute numbers show that by far the largest number of responses came from collegiate departments. Second, for all degree types, responding departments were much more likely to be users at public institutions than at private institutions. Also, one third of responding private departments in the top-80 Ph.D. and B.S. categories are not interested at all in homework software.

We know that at least 44% of all doctoral departments use such software-- 71 responding users out of 162 doctoral departments. The response rate for M.S. and B.S. departments was too low to give any meaningful low bounds, for reasons explained shortly. Doctoral departments probably have higher usage rates because they have incentives and advantages for the use of homework software. The incentive is very large introductory courses for which there are inadequate resources for hand grading. The advantages include departmental technical support for getting started with the software. With their lighter teaching loads, selected doctoral faculty have the opportunity, if they choose, to take some time away from research and become deeply involved in learning how to use such software, constructing new homework sets for this software, and instructing other faculty in its use.

There are subjective factors to consider when looking at this seemingly clear-cut data. We suspect that if a department were not using homework software, a survey of individual faculty would frequently find that some faculty were receptive to considering the use of homework software and some were not. Since faculty typically have considerable autonomy in how they run their classes, most faculty in a department might not be interested in homework software even though it is being used by one or a few faculty. Note that question 9 asking for the number of students using homework software provides good data about the extent of software usage in a department.

Clearly, departments using homework software or seriously interested in using it have a high likelihood of responding to this survey. This is particularly evident with the 30 community colleges contacted, where 8 of the 11 responders were users. On the other hand, it is not reasonable to assume that almost all homework software users responded to this survey. One of the methods used in surveys like this to estimate the fraction of non-responders interested in the topic of the survey is to look at the straggler responses—the very last responses that came in a month or more after most responses. Typically these late responses tend to be representative of the non-responders. In this survey, the late



responses had the same percentage of users as the early responses. So, it is reasonable that there are a number of users who did not respond to this survey.

**Question 4. Which Courses--** *for prospective users only.* This question asked prospective users, for which courses might their department be interested in using homework software and whether they anticipated using it for all grading or part of the grading. Responders could also indicate that they did not offer the course. The courses listed were College Algebra and below, Precalculus, Business Calculus, General Calculus/Calculus for Biologists, Calculus for Scientists, Multivariable Calculus, Differential Equations, and Statistics.

As might be expected, few prospective users planned to use homework software for *all* grading in any of the listed courses. Typically, at least 75% of Ph.D. and M.S. responders were considering such software for grading some of the homework in Precalculus, Business Calculus, General Calculus, and Calculus for Scientists. For Multivariable Calculus, Differential Equations, and Statistics, the percentages dropped to 60%-70% for these responders. Collegiate responders typically had percentages that were a little lower for using homework software (for partial grading) in all of these courses. In general, there was little difference between the plans of prospective users at private versus public institutions, although in general prospective users at public institutions were a little more likely than those at private institutions to plan to use such software for all grading. There was one outlier: the majority of prospective public collegiate departments did not plan to use homework software in multivariable calculus or differential equations.

***The remaining questions were designed exclusively for current users.***

**Question 5. Which Courses.** This question asked in which courses it was used, and if used, was it for all homework or part of the homework in the courses. Again the courses listed were College Algebra and below, Precalculus, Business Calculus, General Calculus/Calculus for Biologists, Calculus for Scientists, Multivariable Calculus, Differential Equations, and Statistics. NOTE: this question turned out to be ambiguous. Some respondents interpreted 'used for part of the homework' to mean 'used in some (but not all) of the sections' of a course; follow-up emails clarified the situation.

The highest percentage use of homework software was (excluding schools that do not offer these courses) in College Algebra and below (87%), Calculus for Scientists (81%) and Precalculus (78%). Business Calculus, General Calculus, Multivariable Calculus, and Introductory Statistics had usage rates between 55% and 65%. Differential Equations' usage rate was only 30%. When usage rates are broken down by degree awarded, the percentages were about a third higher at Ph.D. departments than M.S. and B.S. departments. These percentages follow from the fact that the average doctoral department used homework software in 3.8 courses while for M.S. and B.S. departments the average was 2.7 courses. There were no significant differences between responses from public and private institutions.

At doctoral departments, users were substantially more likely than prospective users to use software for grading *all* homework in all the listed courses except Differential

Equations. A similar but smaller trend existed at M.S. departments for all courses and at B.S. departments for College Algebra. An example of the doctoral pattern is Calculus for Sciences: 35% of doctoral users employed software to grade all homework in this course, while only 8% of prospective doctoral users contemplated all software grading. There are two explanations that come to mind for this doctoral pattern. First, these users may lack the resources for hand grading. Second, they may have started with using software for part of the homework and then developed a comfort level with the software that led to heavier use, possibly to free resources for more extensive hand grading in other courses.

In looking for an association between software systems and courses, the survey showed that when software was used in College Algebra and Precalculus, MyMathLab (the Pearson textbook software) was used 50% of the time followed by WebAssign with 25%. General Calculus, Calculus for Scientists and Multivariable Calculus were split fairly evenly among MyMathLab, WebAssign, and WeBWorK (recall that WeBWorK was originally designed for calculus courses). Statistics usage was dominated by MyMathLab and statistics-specific software.

**Question 6. Course Enrollments.** This question asked for the estimated annual enrollments in each course where homework software was used. Again the courses listed were College Algebra and below, Precalculus, Business Calculus, General Calculus/Calculus for Biologists, Calculus for Scientists, Multivariable Calculus, Differential Equations, and Statistics.

This question yielded data that were in many ways independent of the issue of homework software. The mathematics departments using homework software reported course enrollments that were typical of departments at their type of institute. For example, the enrollment numbers for doctoral departments were large because most doctoral mathematics departments are in very large public universities, e.g., the median enrollment for doctoral departments in Business Calculus was 1000 and in Multivariable Calculus was 400. The median enrollment numbers for lower-level courses in Master's departments were about half the doctoral numbers and for higher-level course about one quarter the doctoral numbers. The median enrollment at Bachelor's departments was about half the Master's numbers.

**Question 7. Changing Level of Usage.** This question asked for the courses in which it is/was used, is the percentage of sections using software growing, flat, or declining? Again the courses listed were College Algebra and below, Precalculus, Business Calculus, General Calculus/Calculus for Biologists, Calculus for Scientists, Multivariable Calculus, Differential Equations, and Statistics.

This question provided unequivocal endorsement for the use of homework software by departments that have tried it. There was negligible decline ( $\leq 5\%$ ) in the percentage of sections using homework software in any course. Further, 35% to 50% of respondents reported increasing the number of sections using homework software, depending on the course. The course where there was the largest increase in the percentage of sections using

homework software was College Algebra and below. This increase may reflect the attractiveness of homework software for providing extensive practice with basic skills.

Comments indicated that the few declines typically involved one professor who used the software in just his/her section of a course, and either stopped teaching the course or found it hard to be the only one using the software. A few comments revealed instances where faculty were unhappy with a particular software system. Their response was to switch to another system rather than discontinue the use of any homework software.

**Question 8. Which Software.** This question asked which homework systems are/were used. The survey named five such systems—Cengage (now discontinued) and MyMathLab, both publisher software; Maple TA, WebAssign, and WeBWorK-- with the option to write in another system. The most popular systems were MyMathLab (from Pearson), cited 110 times, then WebAssign, cited 80 times (this number will grow with WebAssign's new association with Cengage/Brooks-Cole), and WeBWorK, cited 55 times. MapleTA was cited only 15 times.

About 70 respondents listed other systems. Publisher software systems from Wiley and McGrawHill were each mentioned about a dozen times. Two statistics-oriented systems were each mentioned half a dozen times. A variety of different learning systems were mentioned by three dozen respondents, with the most frequent ones being Hawkes Learning Systems, 10 times; Web CT (associated with Blackboard), 6 times; and ALEKS, 4 times. Finally a dozen institutions mentioned locally developed software.

About 60% of the 240 homework software users were using just one system. The other users were typically using three or more software systems. Given their larger instructional loads and better technical support, it is not surprising that doctoral departments were more likely (almost 50%) than M.S. and B.S. departments to use multiple systems. Follow-up inquiries to several of the departments using many different systems revealed that the diversity of systems reflected the individual choices of faculty for their courses. Also, textbooks were the most common determinant in the choice of software, because the textbook publisher's software was often used. Thus in departments that were heavily committed to homework software, textbooks from different publishers led to the use of the different publishers' homework software. A few institutions noted that different sections within their main freshman calculus course used different homework software, based on the professors' choices.

The popularity of the different homework systems varied little among the different types of departments with the exception that the top-80 doctoral departments are twice as likely to use WeBWorK (almost 40%) as M.S. or B.S. institutions. This pattern may be explained by the fact that WeBWorK needs local technical support to be mounted and maintained (although small-size usage can be hosted by a WeBWorK server at the Mathematical Association of America) and that WeBWorK was developed by mathematicians at a top-80 doctoral department.

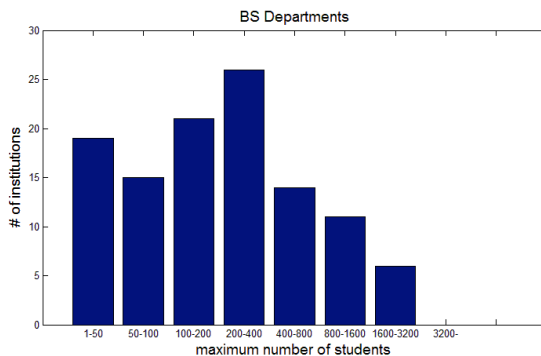
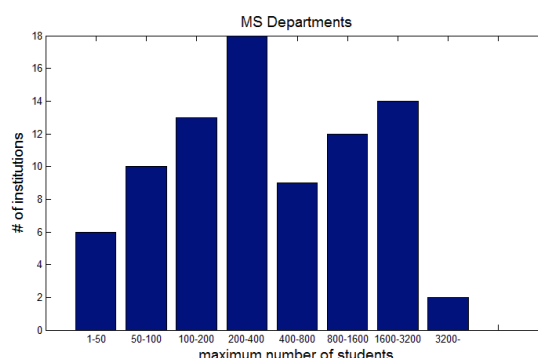
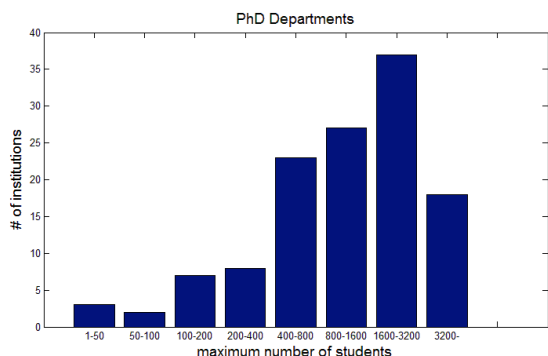
**Question 9: Software Enrollments.** This question requested an estimate of the maximum number of students who used different homework software in any year (current or past). This question had the same software choices as Question 8: Cengage, MyMathLab, Maple TA, WebAssign, WeBWorK, and Other.

In terms of total number of students using different systems at all responding institutions, MyMathLab, used at 110 departments, was first with 230,000 students; WeBWorK, used at 55 departments, was second with a little over 100,000 students; and WebAssign, used at 80 departments, was third with a little under 100,000 students. The number of departments and student users was much smaller for other software; breakdowns by department type were only analyzed for the top three systems.

Median number of students users	MyMathLab	WeBWorK	WebAssign
Doctoral departments	2000	1400	950
M.S. departments	850	325	200
Collegiate departments	325	180	190

Unfortunately, there are three independent variables affecting these numbers: size of institution, enrollment in courses using software, and number of sections using software.

What is more interesting is to ignore the type of software used and just look at the distribution of the total number of students using homework software at different types (Ph.D., M.S., B.S.) of departments.



These histograms give a partial answer to the question of what fraction of the sections in a course use homework software. From the histograms, one can infer that (i) few Ph.D. departments used homework software in just a few sections of a course; rather the

software was usually used course-wide; (ii) M.S. departments had more partial-course adoptions; and (iii) B.S. departments had many instances where just few sections of a course were using homework software (although another interpretation is that only one or two small-enrollment courses used homework software). The histograms were similar for private and public institutions for each type of department.

**Question 10. Obstacles to Adopting Software.** This question listed seven obstacles in the conversion to using homework software and asked if the items were: a) major factors, b) minor factors; and c) not a factor.

- A. Difficulties in Installing Software on local server
- B. Inadequate Technical Support for Start-up period
- C. Inadequate Financial Support for Acquiring Software/Hardware
- D. Inadequate Long-term Technical Support
- E. Inadequate Long-term Financial Support for Software/Hardware
- F. Faculty Had Trouble Learning to use the system and deal with its limitations
- G. A Number of Faculty Resisted using new software

While the first five obstacles listed here were issues for most departments to contend with in adopting homework software, they were mostly rated as minor factors. This assessment held for all software systems except WeBWorK and locally created systems. With these two exceptions, there are no departmental costs (students pay them) or local support requirements, since the software suppliers provide the servers and maintain the software. However, there still is the potential for start-up and long-term problems in using the software. Generally the technical support seemed all right with two exceptions. Over 75% of top-80 Ph.D. departments and of M.S. departments had technical start-up problems, major or minor, with all software systems. Also, 60% of these departments had problems with long-term technical support for WebAssign. However, the percentage of technical support problems for WebAssign at other Ph.D. departments and B.S. departments were comparable to other software, around 40%. There were only a modest number of technical support problems reported by departments using more extensive learning systems like ALEKS or Hawkes Learning System.

The sample size was small, but all 9 Ph.D. departments using MapleTA had start-up and long-term technical support problems (MapleTA can be either maintained locally or at a MapleSoft server; it is not known which option these departments were using).

WeBWorK is locally maintained and so technical and financial support looms larger for WeBWorK. Around 70% of WeBWorK users at all types of departments reported major or minor installation problems. There were also significant start-up technical support problems, except at top 80 Ph.D. departments (which probably have stronger in-department computer support). The majority of other Ph.D. departments and M.S. departments also reported financial problems with hardware acquisition and maintenance for WeBWorK.

The last two adoption obstacles, Faculty Have Trouble Learning and A Number of Faculty Resist, were significant. Faculty had trouble learning to use homework software in 75% to

90% of departments. However, less than a quarter of responses rated this as a major factor for any of the systems. Faculty resistance was pervasive-- in 80% to 100% of respondents-- and was rated as a major factor by upwards of 50% of respondents. WeBWorK caused the least faculty resistance, being a major factor in only one third of departments. Faculty resistance to WebAssign, other publisher software (besides MyMathLab), and Learning Systems were rated a major factor in 50% of the departments. There were minor variations among types of department in the responses to question 10. The only significant place where the private-public division stood out was that faculty resistance was rated a major factor at 73% of private M.S. departments while it was only 35% for public M.S. departments and not more than 45% for any other category of department (public or private, Ph.D. or B.S.).

**Question 11. Attitudes.** This question asked the attitudes towards homework software (very favorable, generally favorable, mixed, generally negative, very negative, don't know) of various groups:

- A. Students
- B. Tenured/Tenure-Track Mathematics Faculty
- C. Lecturers and Other Non-Tenure-Track Mathematics faculty
- D. Mathematics Graduate Teaching assistants
- E. Faculty in Client Departments
- F. Campus Administration

There were very few negative responses to this question. Under 8% of respondents in all types of institutions and for all systems indicated negative attitudes for each of the groups. However, for most systems, at least 50% of the tenured/track-track faculty were judged to have mixed attitudes. Also, for all software, attitudes of students and non-tenured track faculty were judged more favorable than those of tenure-track faculty. At least 60% of the two former groups' attitudes were favorable towards all major systems, while only about 40% of the tenured/tenure-track faculty were favorable, with the exception of WeBWorK that got favorable ratings from 60% of these faculty at Ph.D. and B.S. departments (but only 25% favorable from these faculty at M.S. departments). The extreme case was attitudes towards MyMathLab at public doctoral departments: over 70% of students and non-tenure-track had favorable attitudes but only 23% of tenured/tenure-track faculty had favorable attitudes. Also, WebAssign had particularly low favorable ratings, around 25%, among tenured/tenure-track faculty at M.S. departments. All software except WeBWorK showed little difference between the responses from private and public departments at different types of departments. For WeBWorK, tenured/tenure-track faculty (but no other group) at private institutions had about a 25% higher favorable percentage than those faculty at public institutions; this pattern held for Ph.D., M.S.. and B.S. institutions.

TAs were rated as having the most favorable response to homework software, at least two-thirds favorable for all systems. Sample sizes for postdocs were too small to use. For most software systems and types of institutions, the responses about attitudes of administrators and other departments were evenly split between favorable and Do Not Know.

**General Comments.** There were general comments submitted by 137 respondents but most comments simply reinforced answers to earlier questions. Several department chairs wrote of their desire to see more of their faculty interested in using homework software. All software systems received words of high praise. Some respondents noted that their faculty believed that more students were doing the homework after the switch to homework software. Others noted that homework software was adopted to improve passing rates in college algebra and lower courses; several said there was a noticeable improvement in the passing rate, but one said there was no change. There was one complaint that managing course homework spreadsheets was hard with commercial homework software. One doctoral respondent complained that funds for student graders were cut when homework software was adopted (“no good deed shall go unpunished”).

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