Using ‘Advising Contours’ for placement in first-year quantitative courses

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Abstract

Prior to 2004, the University of Connecticut required all students to take mathematics placement tests prior to enrolling in any quantitative course. Two tests were required: a Q-course Readiness test and a Calculus Readiness test. These tests were offered online as a pseudo-course within a *WebCT* environment and were taken by students prior to attending an orientation/registration session during the summer. Successful completion of these tests at a minimum 60% passing rate was necessary for a student to be able to register for a quantitative and calculus course, respectively.

Based on a statistical analysis of the performance of students in quantitative course work, it was determined that these placement tests could be replaced; i.e., there was little value added in having the mandatory tests taken prior to enrollment when other factors such as a student’s Math SAT and high school class rank information could serve as suitable predictors of performance. A logistic regression analysis was performed whereby “success” in a quantitative course was equated to obtaining a grade of C or higher, with a grade of C- or below being equated with “failure”. Significant model parameters used in the logistic regression included the student’s Math SAT score and high school class rank percentile.

‘Advising Contours’ were developed for each 100-level quantitative course taken by first year students. These contour diagrams were published on a placement web site to aid students and advisors in selecting which quantitative courses to enroll in during the first term. Placement in quantitative course work has therefore shifted from requiring a gatekeeper placement test to being advisory in nature with the ‘Advising Contours’ forming a crucial piece of information for both students and advisors. Placement in first-year calculus makes use of a new Calculus Readiness Survey offered online within the *WebCT* environment in conjunction with the ‘Advising Contours’ for each of the different levels of calculus.

Introduction

As Sperber [14] points out, in recent years the academic preparedness of students entering higher education has shown a shift away from those of the ‘*academic*’ subculture (the undergraduate student subculture of serious academic effort) to that of the ‘*collegiate*’ subculture (a world of football, fraternities and sororities, drinking, and campus fun; indifferent and resistant to serious demands from the faculty for an involvement with ideas and issues.) Similarly, in a paper that is now a couple of years old but still seems relevant, Hansen [6] notes the following: students entering college are in more need of remedial work, are accustomed to spending fewer hours per week studying in high school compared to those of a decade earlier, and, despite this, increasingly overestimate their own abilities, rating themselves as “above-average” in virtually all academic areas. Not surprisingly, a survey from a few years ago [13] of the University of Connecticut's School of Engineering first-year students showed a similar self-evaluation of ability for success in quantitative or mathematics course work:

	Strongly Not Confident	Not Confident	Neutral	Confident	Strongly Confident
Algebra	0%	0%	3%	30%	67%
Calculus	6%	11%	26%	46%	11%
Chemistry	3%	4%	25%	59%	9%
Computer	2%	3%	21%	45%	29%
Physics	1%	4%	17%	62%	16%
Trigonometry	0%	3%	13%	47%	36%

Clearly, this shows that expectations for success are high; i.e., students feel they are more than capable in subject areas important for success in Engineering. Unfortunately, this high level of expectation does not equate to actual performance in course work taken in the first term.

While the lack of preparation/motivation of students may be debatable, it can be surmised that today’s students may be different from those of earlier generations, or at least may have more demands placed on them, which requires a different approach to helping them succeed. In particular, placement of students into appropriate quantitative and mathematics courses in their first term has become a more critical issue for advisors in recent years.

Using tests for placement in Quantitative and Mathematics courses

Prior to implementing the changes which arose out of this effort, evaluation of entering University of Connecticut students for quantitative (Q) course readiness involved a placement test for “quantitative proficiency”. Students who had not previously earned college credits in mathematics or statistics were *required* to take the Q-course Readiness test *before registering for quantitative or mathematics courses*. The Q-course Readiness test was obtained from the Mathematical Association of America (MAA) in 1981. The exam consisted of 25 multiple-choice questions that evaluate a student’s algebraic manipulative skills. A passing score was achieved by successfully answering at least 60% of the questions.

Sample questions for this Q-course Readiness test may be found in *Appendix A*. Students were expected to pass the placement test or successfully complete a remedial mathematics course (which carried no credit toward graduation) prior to enrolling in any Q-courses.

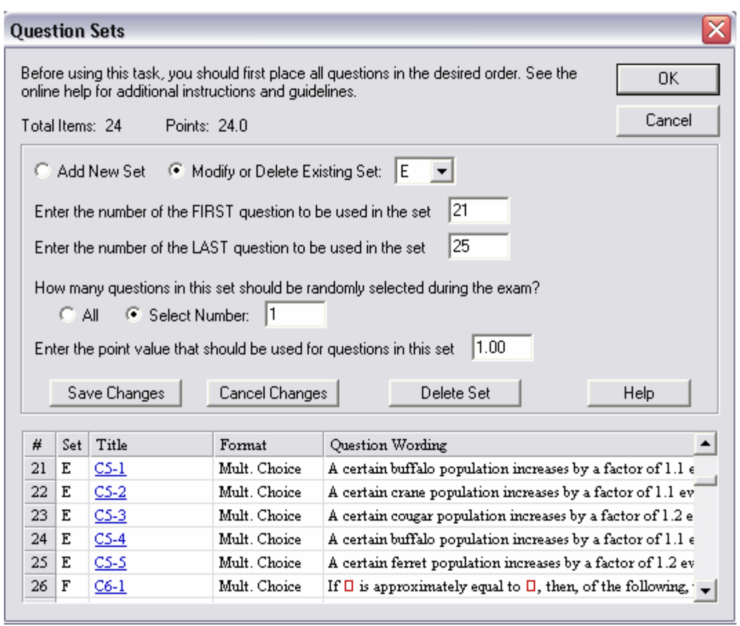
In addition to the Q-course Readiness test, a second placement test assessing preparedness for first-year calculus was also administered for those students enrolled in majors requiring this level of mathematics. Sample questions from the Calculus Readiness Survey may be found in

Appendix B. Students were *required* to take the Calculus Readiness Survey *before registering for calculus*. The exam consisted of 24 questions dealing with algebra and trigonometry. Similar to the Q-course Readiness test, students who successfully completed 60% of the questions were eligible to enroll in MATH 115Q: *Calculus I* (the first of a two-course sequence, MATH 115Q-116Q, covering first-year calculus.) Students who scored below a 14 on the test were eligible to enroll in MATH 112Q: *Introductory Calculus 1* (the first of a three-course sequence, MATH 112Q-113Q-114Q, covering first-year calculus.) Students who are well-prepared will generally register for the two-term sequence, while students with weaker backgrounds are advised to enroll in the alternate extended-course, which includes college algebra and trigonometry.

Delivery of the placement tests via WebCT

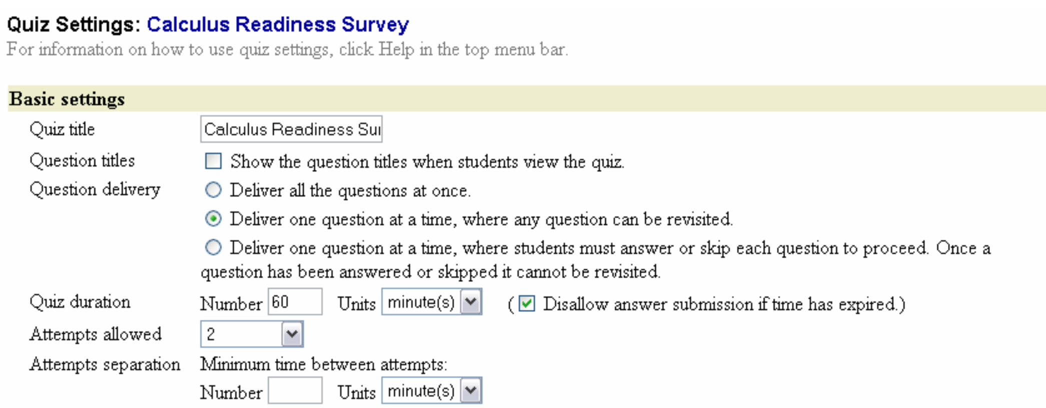
Up until 1999, both placement tests were administered in booklet form to students at sit-down, proctored, sessions during the summer new-student Orientation program. Results of the graded test were provided to advisors who counseled students prior to having them register for first-term courses. In 1999, the booklet version of the exam was converted into an electronic web-based version (originally developed in-house and subsequently migrated) in a *WebCT* environment with no change in content. The change to an online test was prompted by the desire to have students complete their placement tests prior to arriving on campus for Orientation. By doing so, advisors would have ample time to review the results and more time would be available for other orientation activities.

To create the *WebCT*-based placement tests, the *Respondus* (see `http://www.respondus.com`) software tool was used. *Respondus* is a powerful tool for creating and managing exams that can be printed to paper or published directly to *WebCT*, *Blackboard*, and other eLearning systems. *Respondus* provides the ability to create "question sets", which are groupings of questions that are randomly selected during an exam. Below is a shot of the setup screen for one question set.



Here you see that there are five similarly worded questions (items numbered 21-25) and one of these will be selected at random when the quiz questions are delivered to a student. This provides for the ability to create a "random" exam for each student, thereby reducing the potential for cheating on the online tests. In other words, there were five (5) versions of each of the 25 questions used on the test making many different versions available when one of the five was chosen at random in creating a test for a student. This capability of *WebCT* also ensured that any retake of the test typically contained a different (albeit similar) set of questions from the test a student previously completed.

The *WebCT* environment for a quiz is powerful and provides a variety of options for control of the delivery of the placement test. A screen shot showing some of the basic options available is presented below:

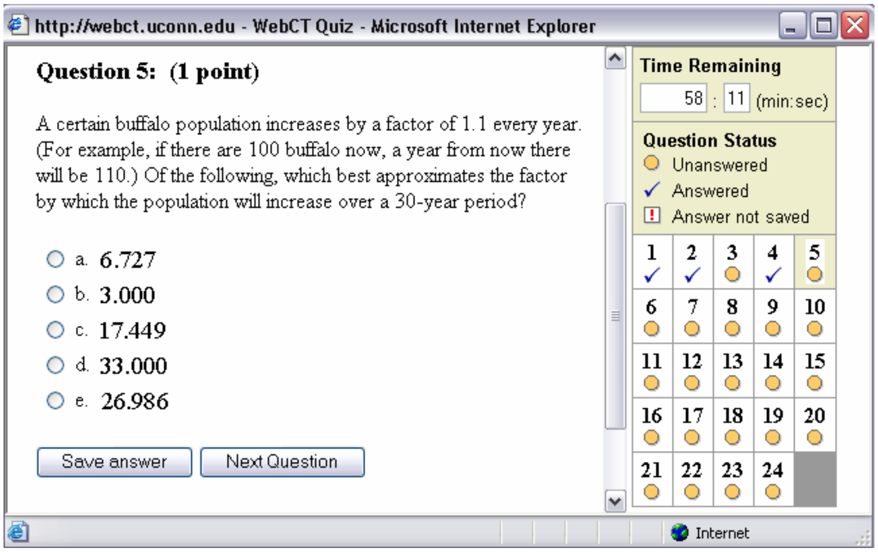


Here we see that the quiz is limited to 60 minutes (the clock starts when a student first accesses the quiz) and that each question is presented to a student one at a time. (The selection of one question being viewable at a time was intended to diminish the potential for cheating.)

Access to *WebCT* (and the placement test) is controlled in that a student needs an account and password to get into the *WebCT* environment. Students were assigned an account upon receipt of their paid fee deposit and sent information from the Orientation office regarding accessing the University placement site `http://placement.uconn.edu`. Students were able to obtain their account information and steps to complete the placement tests via instructions provided on the web site.

The placement test appears to a student as a pseudo-course within the *WebCT* environment, a sample screen shot is below:

Clicking on the link brings a student to information on the placement test and ultimately to the actual test itself. Once in the *WebCT* quiz, questions appear one at a time (based on the setting chosen) within a separate window. An example is shown below:



As can be seen, the *WebCT* quiz environment provides a student with the time remaining as well as the status of which questions have been completed.

All students were *required* to take the Q-course Readiness test online prior to arriving at the Orientation program (and prior to course registration.) The results were used in course prerequisite checking during the registration processing that is part of Orientation. A failure (*grade* < 15) required students to take a remedial mathematics course prior to enrolling in any Q-courses. In a similar manner to the paper-based exam, students were allowed one re-take of the on-line exam if they were not satisfied with the outcome.

Hence, the Q-course Readiness test provided a pass/fail gate-keeping mechanism which prohibited students who "failed" from registering in a quantitative (Q) course and instead mandated remedial curricular requirements. This nature of the placement process was perceived to be a hurdle which students would seek to avoid despite any diagnostic benefit arising from the placement exam. (A perception among some faculty was that students would cheat to avoid failure and the corresponding mandated remedial course work.)

After the electronic version of the Q-course Readiness test came on-line, the percentage of students failing the exam dropped from 30% to 15%. Directly comparing the pre-1999 sit-down environment, where it was thought that students arrived unprepared and where few students requested re-takes, with the post-1999 online environment is difficult. Nevertheless, the improved rate of passing of the Q-course Readiness test was not consistent with more students having a positive experience in their first Q-course. Coupled with anecdotal evidence, despite a perceived improvement in the quality of incoming students (as suggested by class rank and SAT scores), it seemed that *students were more unprepared then ever to manage successfully in many 100-level Q-courses*. While the ability to more easily re-take the online exam, and perhaps do so with the aid of others, may be responsible for the higher pass rate, it was clear that the value of this placement procedure was questionable.

Rethinking the placement process

In the Fall of 2002, the University Senate formed an *ad hoc* "Committee on Q" amid concerns over the efficacy of the existing Q-course Readiness test in regard to course placement and registration procedures, potential widespread student misrepresentation on the test (and on the Calculus Readiness Survey), inadequate quantitative skills of students entering calculus classes evidenced by poor scores on first-day-of-class quizzes in one of the first-year introductory calculus courses (see *Appendix C*), high attrition (failure/drop/withdrawal) in entry-level Q-courses, and questions regarding the effectiveness of remedial mathematics course work as preparation for entry into Q-courses. The Committee was charged with (i) evaluating the substance, reliability, and validity of the tests for curricular placement purposes; (ii) comparing the tests with others that also measure quantitative skill competency (e.g., the SAT) ; and, (iii) devising a plan for the future administration of the tests with particular attention to security issues.

The Committee began its deliberations regarding the evaluation part of the problem with the questions, "To test or not to test?" Almost immediately the question was divided as follows: Do we need a mathematics placement procedure? Do we need University of Connecticut-administered quantitative-readiness tests?

The Q-course Readiness test evaluates a certain level of proficiency in algebraic skills *only*. From discussions with faculty involved in its inception, it was never intended to do otherwise, and certainly it was never meant to evaluate students regarding their preparation for entry into Q-courses other than Mathematics (e.g., CHEM 127Q), which require more broadly-based abilities in quantitative reasoning. Several Committee members with years of experience in teaching Freshman courses lamented the inability of many current students to manipulate even simple algebraic expressions, such as Ohm's Law ($V = IR$), or the Ideal Gas Law ($PV = nRT$), and related how this lack of ability has hindered teaching the conceptual ideas represented by these equations.

The question became one of whether the University should make an effort to write a "new and improved" Q-course Readiness test with questions aimed at evaluating students' abilities in quantitative reasoning. The Committee immediately realized this process would be fraught with difficulties. What would be the areas of coverage of the new exam? How would the test be constructed and delivered? How would it be graded, and by what standard would it be calibrated? How would its validity as a predictor of success be evaluated? Etc.

The Committee felt that a study of the mathematics evaluation and placement procedures used by other institutions of higher education should be undertaken. A review of the procedures used at 32 other institutions of higher education – including our peer institutions – resulted in the following: *Virtually all universities have some form of Mathematics placement procedure for incoming students.* The procedure begins prior to enrollment with an evaluation of the student's quantitative abilities and ultimately results in a recommendation to the student for placement at a particular level of mathematics which either must be followed (i.e., is mandatory) or is advisory. At every institution surveyed, students are evaluated and placed in courses based on some combination of the following:

- High school record (GPA, class rank, courses taken, etc.)
- Performance on college entrance exams (e.g., SATI, SATII, ACT, etc.)
- Performance on an in-house-administered exam:
    - Either locally-written exam or acquired from a testing service. Commercial tests reviewed included: *Accuplacer* (an un-timed, adaptive, electronically administered, proctored, semi-secure exam); The *Mathematics Diagnostic Testing Project (MDTP)* exam (a timed, non-adaptive exam, sold in booklet form, but parts of which are electronic, non-secure, not originally used for placement, but is being used by the University of California, Cal State and Community College systems as one pillar in their placement procedure for several different levels of mathematics); The *Entry Level Mathematics (ELM)* exam (a highly-controlled, secure exam, regulated by the Educational Testing Service (ETS), but not designed for placement into higher level mathematics, e.g., calculus; used solely by the California State system who commissioned it and owns the copyright to whom royalties would be paid if adopted). A summary of tests available is given by Sattler[10].
    - In some cases given un-proctored, on-line. In other cases administered as a proctored, sit-down, in-person, test during summer orientation or later during enrollment.
    - Mandatory for all students or in other cases mandatory for a subset of students (e.g., whose curriculum will involve Math beyond algebra, or only for those scoring low on the SAT, ACT or other exams.)
    - Given as different tests assessing different levels of Math proficiency.
    - Given also in areas outside Math (e.g., Chemistry).

Suffice it to say, a wide variety of "evaluative procedures" exist among the institutions surveyed.

The survey showed that based on the evaluation, students receive advice and recommendations for placement in courses which fall into different categories:

- Enforced restrictions on enrollment in mathematics courses only.
- Enforced restrictions on enrollment in mathematics *and* quantitative courses (e.g., chemistry, physics, statistics)
- Stated restrictions on enrollment in courses, but not actually enforced.
- Recommendations for placement are solely advisory, i.e., restrictions for enrollment are neither explicitly stated nor enforced, but students may be strongly cautioned.

From the above summary of survey information, it is clear that there exist many different types of evaluation/placement procedures. The Committee reviewed evaluation materials and exams used by many of these other institutions and for many reasons ruled out adopting a commercial test or embarking on the creation of a new in-house placement test for assessing the preparedness of students for enrolling in Q-courses. Instead, the Committee focused on a test that was taken by all entering students, namely the SAT1, since studies have shown its effectiveness in predicting success (see Burton [3].)

The SAT1 is widely advertised by the College Board, and the ETS that oversees it as being effective at measuring innate aptitude in verbal and quantitative skills. Indeed, it has been used for decades as a key tool for admission to colleges and universities in the United States. Thus, the Committee considered whether the SAT1, which is an authenticated exam and required of all entering students, might be used in conjunction with other indicators, e.g., class rank, as a predictor of success in entry-level Q-courses. A positive aspect is that the SAT1 score would be available at no cost to the institution.

The important question is whether the SAT1 score has statistically significant predictive validity that would justify its use for evaluating readiness for mathematics and/or Q-courses. The Committee thought that at the very least, the SAT1 could be used to narrow the population of students who need a Q-course Readiness test, thereby facilitating its administration. The Committee imagined, for example, that students could be exempted from the placement test and allowed to register for Q-courses if they scored above a value on the SAT1 that corresponded to a high probability of success in an entry-level Q-course. The assignment of this value would need to be determined from a detailed statistical study correlating SAT1 scores with students' grades in their first Q-course. The Committee undertook such a statistical study. A brief summary of the results follows.

Statistical analysis – Logistic Regression

Logistic regression was the choice for analysis since we were interested in looking at whether students were "successful" in their first Q-course. We defined a grade of C or above to represent "success" and anything below a grade of C to represent a "failure". By doing so, the grade achieved by a student in the course is represented by a dichotomous variable: it can be either a 1 or a 0, corresponding to "success" or "failure":

1 = if a student achieves a grade ≥ C in the Q-course
0 = if a student achieves a grade < C in the Q-course

This feature precludes the use of normal linear regression since the response variables are not continuous but instead are categorical. (See Menard [8] or Pampel [9] for an explanation of why the logistic regression is needed.)

The logistic model predicts the probability of a "success". For the response probability to be modeled, $P = \Pr(Y = 1 \mid \underline{x})$, and a given vector of explanatory variables, $\underline{x}$, the linear logistic model has the form

$$logit[P] = \ln\left(\frac{P}{1-P}\right) = \beta_0 + \underline{\beta}'\underline{x}$$

where β_0 is the intercept and $\underline{\beta}$ is the vector of parameters.

Data from seven years (1995-2001) consisting of SAT1 Math score only, high school class rank, placement test scores, and course grades in nine entry-level Q-courses were examined. Data from all students with a given entry year were analyzed for each of the nine courses, and the fits from the logistic regression were reported. A sample of the *SAS* logistic regression output is given in *Appendix D*.

It was determined that *the coefficients of SAT1 Math score and class rank are significant in each case*, and the model shows adequate fit. A model with SAT1 Math score alone as predictor also gives a good fit. However, the inclusion of class rank also as a predictor appears to provide a better fit in most cases, in terms of correctly predicting the proportion of true successes.

The Q-course Readiness test score, Calculus Readiness Survey test score, and SAT1 verbal score were also included as predictors in logistic regression models, singly and in combinations with other variables. It was found that *the Q-course Readiness test score was not a significant predictor of success in Q-courses*. Too few students take the Calculus Readiness Survey for a useful conclusion on its significance as a predictor of success. The SAT1 Math score in combination with the Q-course Readiness test and Calculus Readiness Survey test scores provided a significant predictor of success, but *with little value added* compared to the SAT1 Math score by itself or the SAT1 Math score used in combination with class rank.

Based on this statistical analysis, the following conclusions were reached:

- The evaluation of quantitative reasoning skills of incoming students should include more than just a raw number score and should consist of an advising report that delineates student potential for success in different Q-courses.
- The current Q-course Readiness test should be retired from use as an evaluative tool for Q-course placement; i.e., the results showed it was not a suitable predictor for success.
- The SAT1 Math score combined with high school class rank should be used as primary evaluative tools for Q-course placement.
- The results of the evaluation should be used in an *advisory manner* for Q-course placement; i.e., there would no longer be a "failure" mandate of remedial course work as a registration hurdle prior to allowing enrollment in Q-courses.

Advising students on placement in quantitative courses using 'Advising Contours'

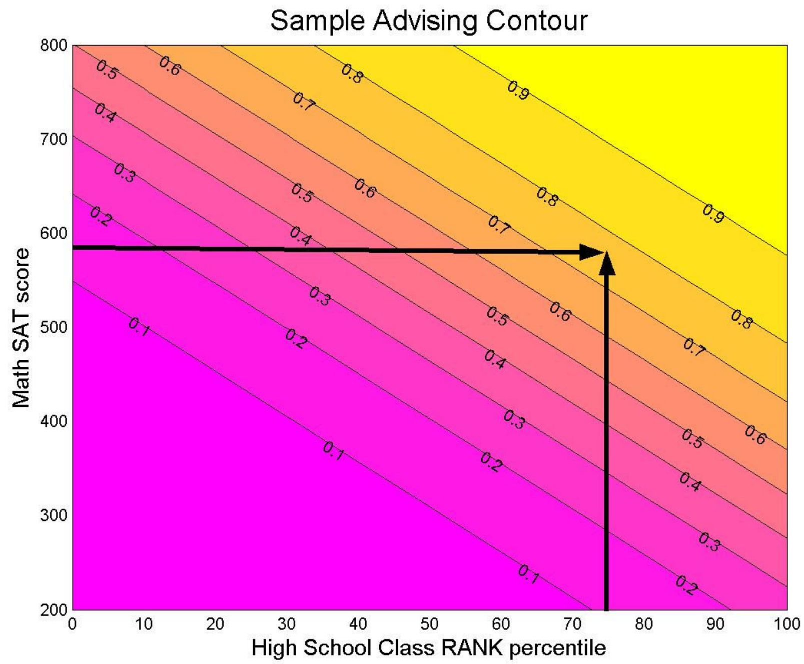
The logistic regression analysis resulted in a final model which includes *SAT1 Math score and high school class rank as the most significant predictors of success in entry-level Q-courses.*

$$\ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 MathSAT + \beta_2 Rank$$

To express the probabilities rather than the *logit* as a function of the independent variables, we can manipulate using exponentials to yield the probability of success as

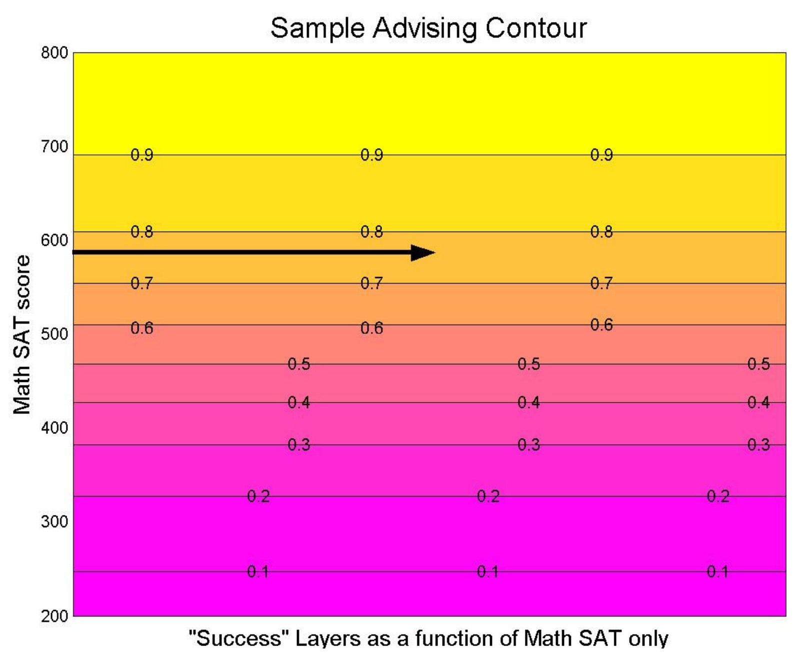
$$P = \frac{\exp\{\beta_0 + \beta_1 MathSAT + \beta_2 Rank\}}{1 + \exp\{\beta_0 + \beta_1 MathSAT + \beta_2 Rank\}}$$

Based on the fitted model for each Q-course for every year, we then solved for the combination of SAT1 Math score and class rank values that would predict (100 x **p**)% probability of success, for **p** = 0.1 to 0.9 in steps of 0.1. These data are shown in "*advising contour diagrams*." These diagrams were obtained from a model (with no interaction) with SAT1 Math score and class rank as predictors, resulting in straight line plots for each of the probability levels. Using the contour graphics ability of the numerical software *Matlab*, contour plots are easily obtained. Below is an example of a ‘advising contour’ using both SAT1 Math and high school class rank information:



As can be seen, the "advising contour" is a family of line plots showing the "estimated probability of success, **p**" in a Q-course as a function of SAT1 Math and High School Class Rank percentile information for **p** = 0.1 to 0.9 in steps of 0.1. By locating the spot on the "advising contour" where a student's SAT1 Math and high school class rank values intersect, the estimated probability of achieving success (defined as a grade of C or better) in the Q-course based on historical data on student performance in that course may be determined.

Similarly, an ‘advising contour’ based solely on SAT1 Math scores can be generated.



The example shown considers a student having an SAT1 Math score of 580 and a high school class rank of 76. Here we see that the student falls in a spot on the "advising contour" plot in an area between the lines corresponding to **p**=0.7 to **p**=0.8 which means that the likelihood of achieving success (as measured by a grade of C or above) is expected to be between 70% and 80%. Based on this it would seem likely that the student would enroll in the course if needed rather than consider strengthening his/her quantitative skills prior to enrolling in the Q-course.

The advising contour diagrams should be used by advisors in the following way: Suppose that a student is to be advised on whether to take a particular Q-course. Based on the student's SAT1 Math score and class rank, the advisor can immediately determine from the diagram specific to that course what the student's predicted probability of success in that course is. If the value is less than desirable, the advisor would counsel the student appropriately.

Making the Advising Contours available to advisors and students

The 'advising contours' for each 100-level quantitative course are provided on the University's placement web site `http://placement.uconn.edu` along with information on how to use the contours to gain advice on the likelihood of being successful in a first-term Q-course. A section of the web site information is shown below:

Q-course placement using "advising contours"

A statistical analysis of historical data on student performance in Q-courses has revealed that a student's SAT1 Math score and high school class rank are the most significant predictors of student performance in entry-level quantitative (Q) courses. Based on this analysis, a family of line plots showing the "estimated probability of success, **p**" in a Q-course as a function of SAT1 Math and High School Class Rank percentile information for **p** = 0.1 to 0.9 in steps of 0.1 were determined. These data are shown in *"advising contour"* diagrams which may be used by students and advisors to determine the likelihood of success (defined as a grade of C or better) in certain quantitative (Q) courses.

The "advising contour" diagrams should be used in the following way: Suppose that a student is to be advised on whether to take a particular Q-course. Based on the student's SAT1 Math score and high school class rank, the advisor can immediately determine from the diagram specific to that course what the student's predicted probability of success in that course is.

If the value determined from the "advising contour" is acceptable, the student should choose Q-courses compatible with his/her interests and intended area of study. If the value is less than desirable, the advisor may counsel the student:

- To enroll in MATH 101 in an attempt to gain better quantitative skills
- To postpone enrolling in the first Q-course until after at least one semester has elapsed.
- To enroll in extended-sequence versions of entry-level Q-courses; e.g., CHEM 124Q-125Q-126Q vs. CHEM 127Q-128Q, or MATH 112Q-113Q-114Q vs. MATH 115Q-116Q.

More information on the Q-course "advising contours" along with additional information to help students in determining placement in first-year Q-courses may be found by clicking on the link below.

Go to **Q-course Advising Contours**. (Clicking on this link will open a new window.)

After following links with information on the advising contours and presenting a course selection list, a student is brought to the specific advising contour information for the course he/she is interested in taking in the first-term. An example for CHEM 127Q taken by many majors including Engineering is presented below:

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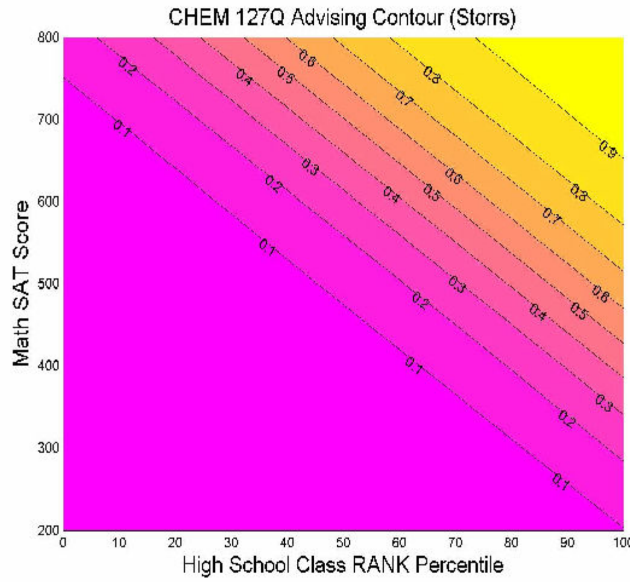
CHEM 127Q Storrs Advising Contour

Provided an "advising contour" exists, you may use the graph shown to get an idea of the likelihood of achieving "success" (a grade of "C" or higher) in this Q-course. If you know your SAT1 Math score and High School Class Rank, you may also use the simple calculator below to determine your probability of success.

Note: Class Rank is actually a percentile, hence the range from 0 to 100. The top person would be in the 99th percentile. In other words, a student who is "ranked" 138 in a "class size" of 415 is the 138th person from the top of the class. This position equates to saying that the student has a High School Class Rank of (415 - 138) / 415 = 66.74699 = 67 (which is short for the 67th percentile.) Hence, the student ranks above 67% of his/her peers or is in the top 33% of his/her class. Such a student would enter 67 in the **RANK** box below.

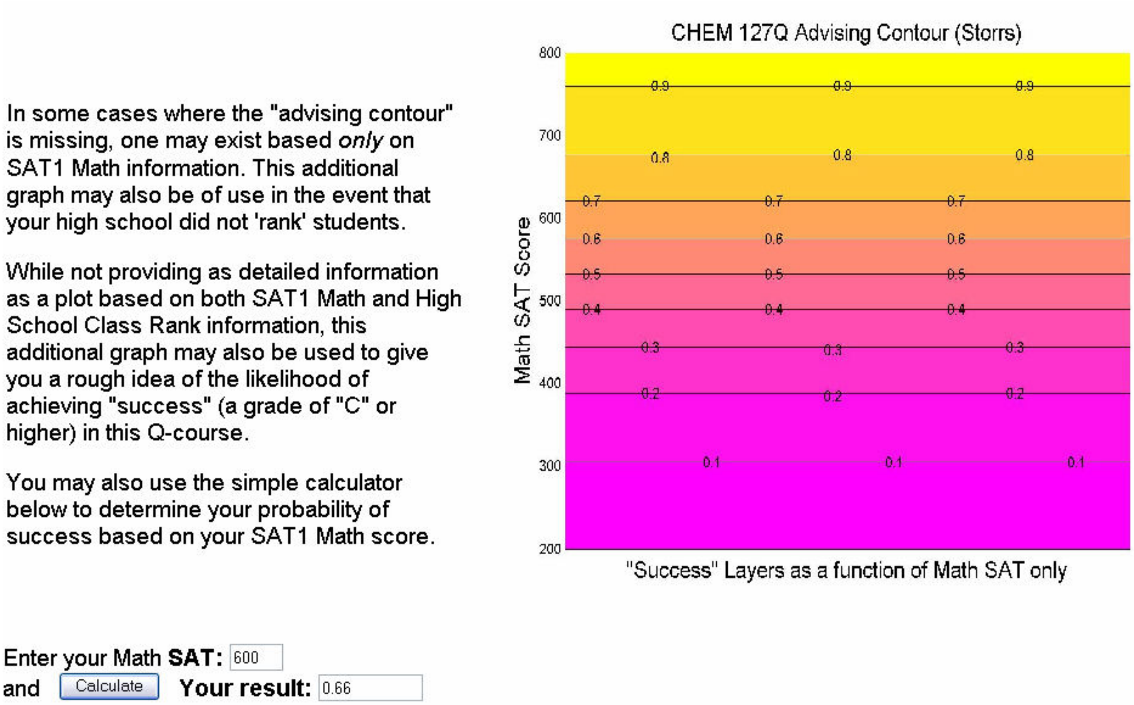


Enter your Math **SAT:** 600
and High School **RANK:** 80
and Calculate **Your result:** 0.65

Students can use the advising contour diagram to locate where their SAT1 Math and class rank values intersect to see which contour level they fall on as a means to get an idea of their likelihood for success in the course. At the same time, as can be seen in the screen shot, a simple *JavaScript* calculator is provided which allows a student to enter his/her SAT1 Math score and class rank information to compute the success probability.

An important aspect of the advising contours is that they convey a message that "success" is not guaranteed. Even students with high school credentials which place them near the top will see that they fall on the advising contour in a region which carries some level of uncertainty in regard to achieving a grade $\geq$ C in a particular quantitative or mathematics course. This helps reinforce a message conveyed by advisors and instructors in First Year Experience orientation courses about the rigor of higher education and the need to adopt study skills for success [13].

Realizing that not all high schools provide their students with class rank information, and knowing that some students may not be certain of this information, advising contours based solely on the SAT1 Math score were also developed. Again, the ability to calculate the probability of success via a simple calculator is provided.



Revised placement of entering students in Mathematics and Q-courses

The question must now be addressed regarding what quantitatively-oriented courses a student should be advised to take based on the evaluation procedure described above. As previously mentioned, students appearing to possess sufficient quantitative skills for success in entry-level Q-courses, and who may or may not have the intent of majoring in quantitatively-oriented fields, should simply be allowed to choose any Q-course that meets their interests and intended area of study. Students possessing average quantitative skills should be counseled according to their interests and using the advising contour diagram for the course in which they wish to enroll. Students appearing *not* to possess adequate quantitative skills and who are seriously at risk for success in entry level Q-courses, and who may or may not have expectations of majoring in quantitatively-oriented fields, provide the most serious challenge to our system because they may require remedial work and/or tutorial assistance.

Placement has shifted from a mandatory "test" which had to be "passed" to allow a student to register in quantitative courses, to that of an *advisory* system providing quality information on the likelihood for success. The SAT1 Math score and class rank data used in the advising contour diagrams is used by advisors in thoughtful advising session with each student taking into account the quantitative evaluators and the student's interests. The key is that the 'advising contours' provide information to the student on the likelihood of success which conveys more about the rigor of higher education than the older, discontinued, Q-course Readiness test which allowed a student with a 60% passing score to enroll into a quantitative course with the impression that he/she was adequately prepared for success when often this may not have been the case.

In regard to placement in first-year calculus, it was decided to maintain the Calculus Readiness Survey as an *advisory* diagnostic tool to provide students with additional guidance beyond the advising contours. The issue of the value of the Calculus Readiness Survey for placement into calculus sequences is complex. Students who score poorly on this test are advised to enroll in MATH 112Q: *Introductory Calculus 1* (the first of a three-course sequence covering first-year calculus.) Students who are well-prepared will generally register for MATH 115Q-116Q: *Calculus I-II* (a traditional two-term sequence) in their Freshman year, but many students who score well on this exam opt for the more conservative three-course sequence, which includes college algebra and trigonometry. Because "failure" on the Calculus Readiness Survey does not carry the same stigma as "failure" on the Q-course Readiness test, and because both calculus sequences carry college credit, there is significantly less incentive for students to misrepresent themselves.

The advising contour diagrams for MATH 112Q and MATH 115Q have reliable predictive validity and can be used instead of the Calculus Readiness Survey for calculus course placement. However, it was felt by the Mathematics department that the Calculus Readiness Survey should be continued for placement in calculus courses as a supplementary evaluative tool. The rationale for doing so was, in part, due to the faculty observations of results of a first-day background quiz administered in one of the first-term calculus courses (see *Appendix C*) which showed a questionable preparation of some students; prompting the idea that the supplemental information may help in the advising process.

Conclusions

Given that today's students in college seem to be different from those of earlier generations, the ability to place students in appropriate quantitative and mathematical courses in the first-term has become more and more important. Since the ability to be successful in the first quantitative and mathematics courses taken is crucial for success in rigorous majors such as Engineering, providing information to students on the likelihood for success in course work based on his/her high school preparation forms the foundation of quality advising.

Based on perceptions of inadequate preparation of students enrolled in quantitative and mathematics course work, an analysis of the efficacy of previously used placement tests was performed which showed that the old mandatory quantitative (Q) course readiness placement test formerly taken by all entering students was of little value. The logistic regression analysis showed that this placement exam could be discontinued and instead information on a student's ability as measured by SAT1 Math and high school class rank scores could be used in a predictive model to provide advisors/students with information on the likelihood for success in each Q-course.

Development of a comprehensive placement web site allowed dissemination of 'advising contour' information in a convenient means for students and advisors. Advising contour information helps convey the notion that higher education is different from secondary school and seems to have helped students enter their first-year course work with an informed expectation of the rigor involved.

The *WebCT* course delivery environment provides a good means to delivery diagnostic placement tests in an online manner and has proven to be suitable for a supplemental placement evaluation tool such as the Calculus Readiness Survey which is used to supplement 'advising contour' information to help guide students in enrolling in first-year calculus.

Future work is planned to look at the suitability of the Calculus Readiness Survey as a supplemental diagnostic tool. Currently, recommended placement in mathematics is based on the 'advising contours' as well as the score obtained on this diagnostic test. With the formation of a Quantitative (Q) Center on campus aimed at providing tutorial support for those students whose 'advising contour' shows them to be at risk of not being successful, there will be a need to look at course sequencing within a curriculum. In addition, there may be a need to look at 'advising contour' information pertaining to specific demographic information; i.e., incorporating gender, ethnicity, etc. into the predictive model may be pursued.

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Appendix A: Sample problems for the Q-course Readiness placement test

The Q-course Readiness test dealt primarily with algebraic manipulations as given in the sample problems below.

Sample problems for the Q-Course Readiness placement test

(1) Add: $\frac{1}{a} - \frac{2}{b}$

(2) Add: $\frac{2}{x^2-1} + \frac{3}{x^2-2x+1}$

(3) Solve for x: $\frac{1}{x} = \frac{2}{3} + \frac{2}{x}$

(4) Solve for x: $x^2 - 4x - 10 = 11$

(5) $3x - 2y = 6$ crosses the x axis at what value of x?

(6) Find the common solution to

$$x + 2y = 1$$
$$2x - 4y = 2$$

(7) Simplify $3x + 4(x - 2y) + 3y$

(8) Simplify $\frac{2}{3-\frac{1}{5}}$

(9) Simplify $(2x^2y^3)(-3x^3y)$

(10) Simplify $\sqrt{8u^9v^4}$

(11) Simplify $\frac{3b^2-6b}{3b}$

(12) Simplify $\frac{2x^2-4x+2}{x^2-1}$

(13) Simplify $\left[\frac{x^2}{2y}\right]^{-3}$

(14) Simplify $\left(x^2y^{-3}\right)^{-\frac{1}{2}}$

Appendix B: Sample problems for the Calculus Readiness Survey placement test

The Calculus Readiness Survey dealt with algebraic and trigonometric manipulations as given in the sample problems below.

Sample problems for the Calculus Readiness Survey

(1) Solve for x: $x^2 + 2x = 2$

(2) Factor $2a^2 + 3ab + 6a + 9b$

(3) Factor $27r^6 + 8s^6$

(4) Simplify $\left[\frac{x^3}{y^{-6}}\right]^{\frac{-4}{3}}$

(5) If $f(x) = x^2 - 1$ and $g(x) = \frac{x+1}{x-1}$ find $f(g(2))$

(6) Simplify $\frac{\frac{x+1}{x} - \frac{x^2-2}{x^2-x}}{2-\frac{x}{x-1}}$

(7) Simplify $\frac{1}{\sqrt{x}-\sqrt{x+1}}$

(8) Solve for x: $\frac{1}{x} + \frac{2}{x^2-1} = \frac{1}{x^2-x}$

(9) Solve for x: $2^{x^2} = \frac{8^x}{4}$

(10) If $\cos(A) = x$ find $\cos(2A)$

(11) One angle of a triangle is 60^o. The two adjacent sides are 1 and 3, respectively. Find the length of the opposite side.

(12) Write the equation of the line through the points $(1, 2)$ and $(2, -3)$.

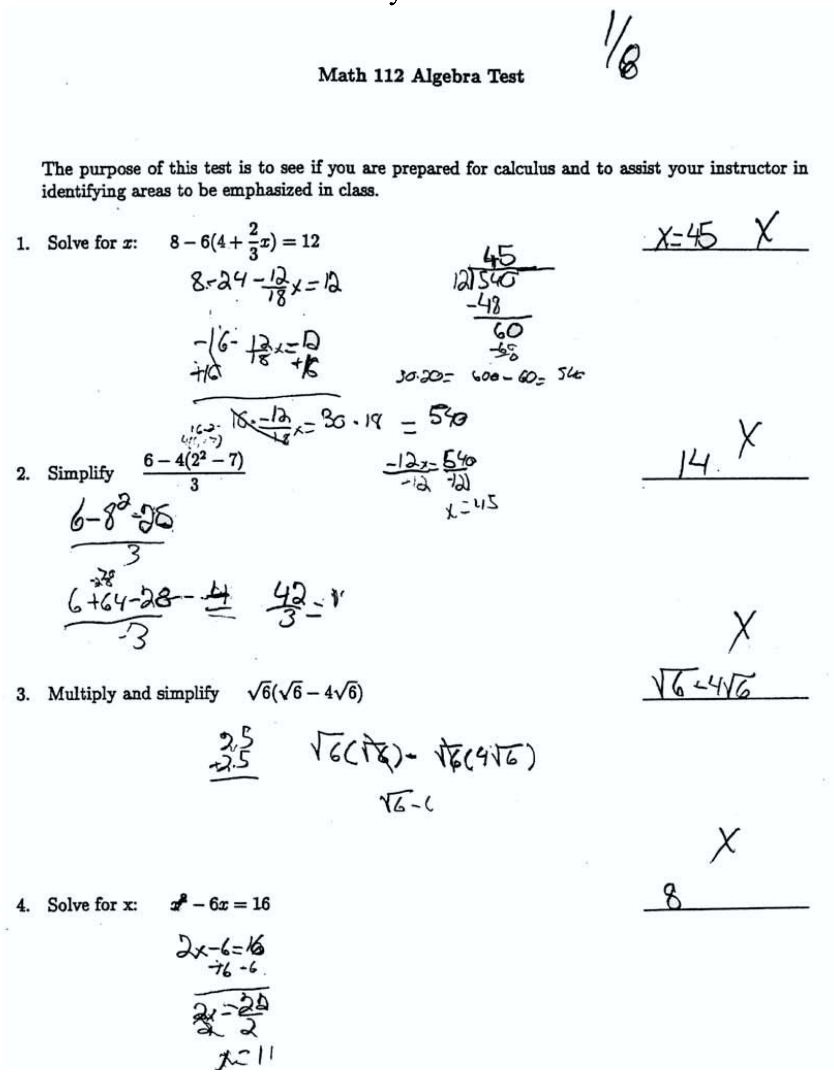
(13) If $\cos(A) = \frac{1}{3}$ and $\sin(A) < 0$ then find $\tan(A)$.

(14) Find all solutions to $2\sin^2 x + 5\sin x + 2 = 0$ in the interval $[-\frac{\pi}{2}, \frac{\pi}{2}]$.

(15) Simplify $\frac{\sin 2x+\cos 2x+2\sin^2 x}{\sin x+\cos x}$

Appendix C: Example of a student's ability upon entering *Introductory Calculus 1*

Example of performance on the first half of an eight-question, first-day-of-class quiz, given to students enrolled in MATH 112Q *Introductory Calculus 1*. These are students who passed the Q-course Readiness test but placed into this introductory calculus course based on their performance on the Calculus Readiness Survey.


1/8

Math 112 Algebra Test

The purpose of this test is to see if you are prepared for calculus and to assist your instructor in identifying areas to be emphasized in class.

1. Solve for x: $8-6(4+\frac{2}{3}x)=12$ — x=45 X

2. Simplify $\frac{6-4(2^2-7)}{3}$ — 14 X

3. Multiply and simplify $\sqrt{6}(\sqrt{6}-4\sqrt{6})$ — $\sqrt{6}-4\sqrt{6}$ X

4. Solve for x: $x^2-6x=16$ — 8 X

	Scores (median = 4)								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of Grades	12	15	25	39	45	45	42	16	11
Percent	5%	6%	10%	15%	17%	16%	16%	6%	4%

Granted, not all students enrolling in this level of calculus were majoring in Engineering. Nevertheless, the results were sobering to say the least and reinforced the perception among Mathematics faculty that the high school preparation of students was weak (despite high SAT scores) and that appropriate placement in mathematics course work is crucial for success.

Appendix D: Sample *SAS* logistic regression output

Consider the following model fit for CHEM 127Q with "success" defined as achieving a grade of C- or greater. The desired "significance level" is obtained when Pr>ChiSq is < 0.05; i.e., when this is the case, we achieve significance at the 5% level.

Response Profile		
Ordered Value	**Chem127Qpass**	**Total Frequency**
1	1	1640
2	0	782

R-Square	0.1541	**Max-rescaled R-Square**	0.2153

Analysis of Maximum Likelihood Estimates						
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**	**Exp(Est)**
Intercept	1	-9.5550	0.5853	266.4880	<.0001	0.000
SAT_Math	1	0.00979	0.000786	155.0927	<.0001	1.010
RANK	1	0.0537	0.00403	177.6072	<.0001	1.055

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
SAT_Math	1.010	1.008	1.011
RANK	1.055	1.047	1.064

Hosmer and Lemeshow Goodness-of-Fit Test		
Chi-Square	**DF**	**Pr > ChiSq**
22.7029	8	0.0038

Appendix E: Advising Contours as a function of Math SAT and High School Rank for chemistry and mathematics courses taken by Engineering students in the first-term