

# Knowledge Surveys: Applications and Results

This document is based on a poster presented at the GSA meeting, fall 2005

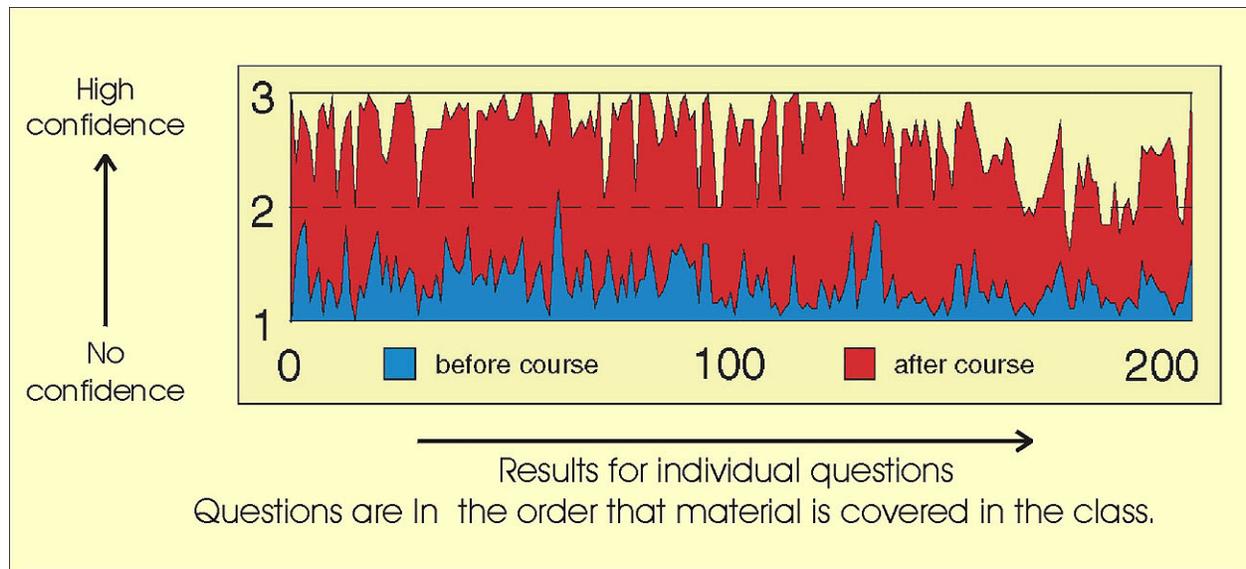
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## What are Knowledge Surveys?

Knowledge Surveys consist of a series of questions that cover the full content of a course (Fig. 1). The surveys evaluate student learning and content mastery at all levels: from basic knowledge and comprehension through higher levels of thinking (Fig. 2). Knowledge surveys can serve as both formative and summative assessment tools. They help students learn, help faculty improve their classrooms, and aid departments and programs as they explore new curricula or pedagogies.

A typical survey may include as many as 200 questions. The key feature of Knowledge Surveys is that students do NOT answer the questions. Instead, they say whether they COULD answer the question and with what degree of confidence (y-axis in Fig. 1). So, students complete the surveys relatively quickly; 200 questions many take 20-30 minutes.

Several recent studies have concluded that knowledge surveys provide a more robust and reliable measure of student learning than any other kind of assessment, including traditional exams.



**Figure 1** Knowledge Surveys involve many questions. Students don't answer the questions, instead they indicate Whether they could answer the questions by rating their confidence on a 3-point scale. Students complete surveys quickly, and the surveys may contain many questions. The questions may be ones that would require long complicated answers if they were given on an exam.

**Survey Questions by Subject Area and Bloom Level**

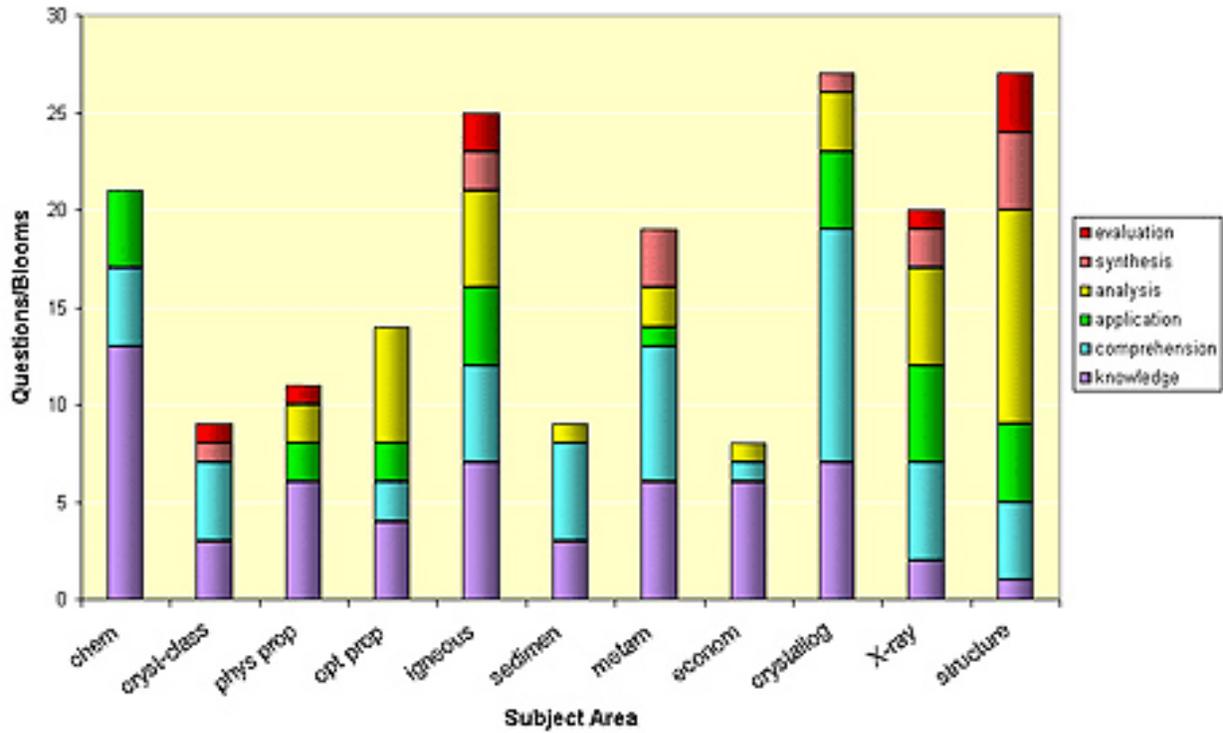
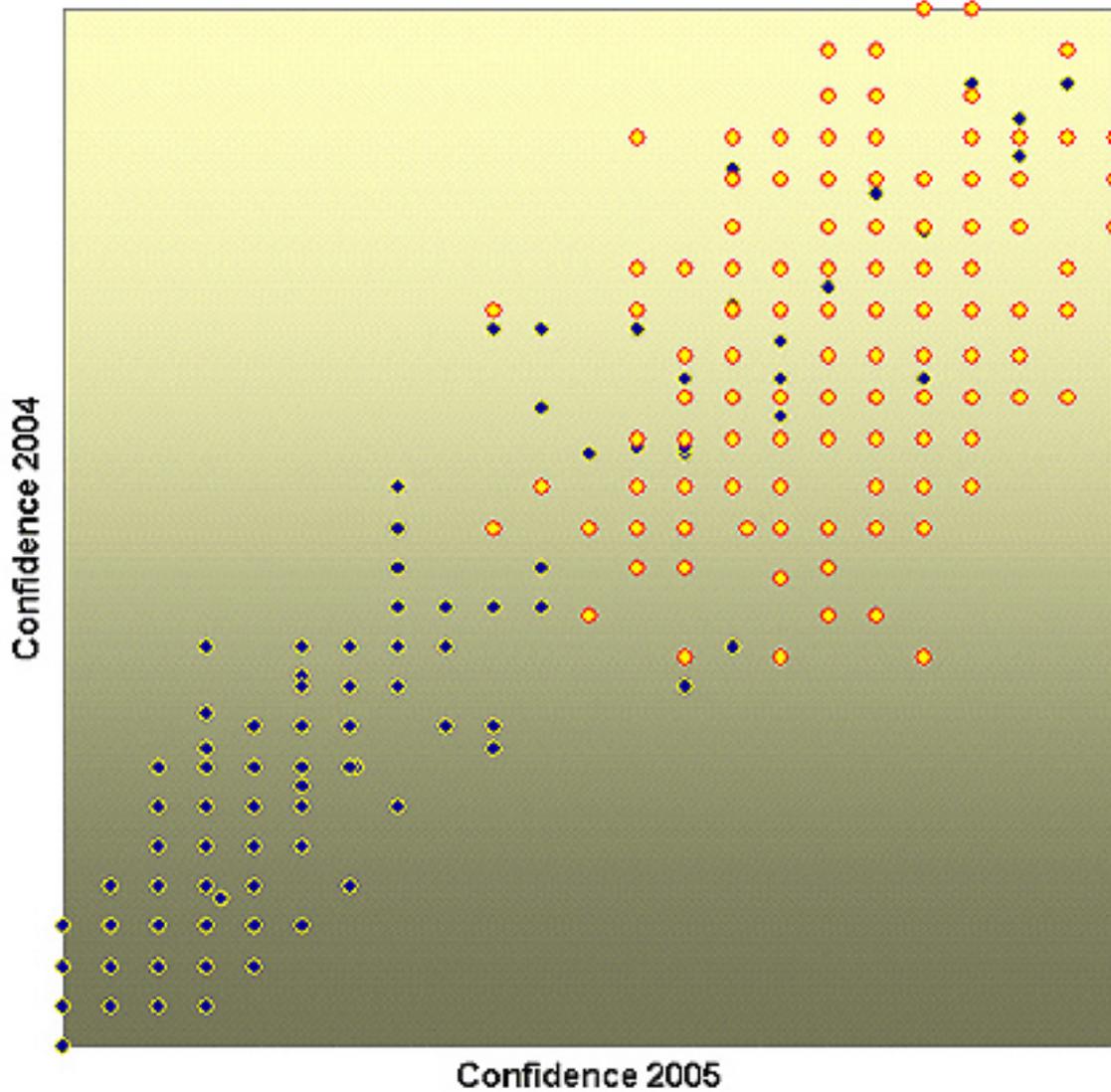
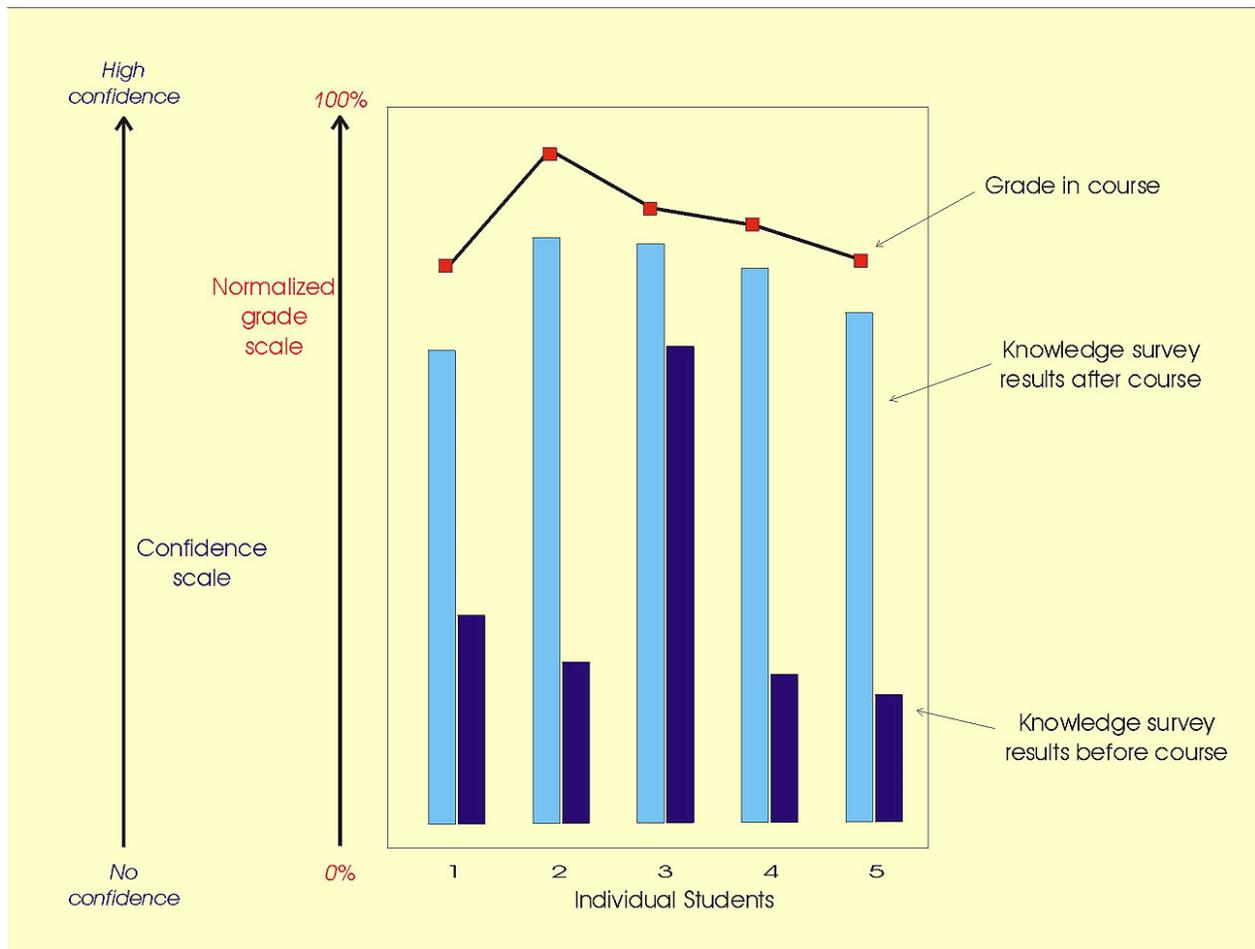


Figure 2. When creating a Knowledge Survey, an instructor takes care to cover all the important information in a course, and to make sure questions cover all kinds of thinking. Here we see an example from a Mineralogy course. Questions are sorted by topic and by Blooms Level (nature of the thinking required to answer the question).

## Comparing Confidence: Postcourse Surveys 2004 & 2005



**Figure 3** This figure shows results for two years of Mineralogy at UND. The black symbols show student confidence on the first day of the semester. The yellow/red symbols are student confidence just prior to the final exam. The distribution of “pre” responses shown here indicates that many of the questions covered things that students knew prior to taking the course. The distribution of “post” responses indicates that students did not completely master all of the knowledge.



**Figure 4** One way we analyze survey results is by looking at the average responses that a class gives for each question, as in Figure 1. Alternatively, it is often useful to look at average survey scores for individual students, as in Figure 4. Note that students #3 came in with much more background knowledge than the others. On a diagram such as this one, we can compare the grade that an individual gets on an exam, or in an entire course (shown here by the black line) with survey results.

### Why use Knowledge Surveys?

Knowledge surveys are indispensable tools for instructors and for students, and may aid departments with curriculum design.

For instructors, the benefits are of several types. First, developing and using the surveys forces an instructor to make sure that course content, course goals, and course assessments are all aligned. Second, the surveys allow instructors to assess how much students know going into a course, to measure how much learning is occurring, and to evaluate overall success after a course is completed. So, the surveys aid basic course design, facilitate mid-course corrections, and provide information for summative assessment.

For students, the surveys serve as valuable study guides. They provide students with full disclosure of the course objectives and allow students to focus learning in areas of importance. Additionally, by making learning more “visible” they help students develop self-assessment skills, and to better develop the habits of the mind that lead to successful life long learning.

Knowledge surveys also provide fundamental information that can guide curriculum development/modification, and that can be used to evaluate the effectiveness of alternative pedagogies.

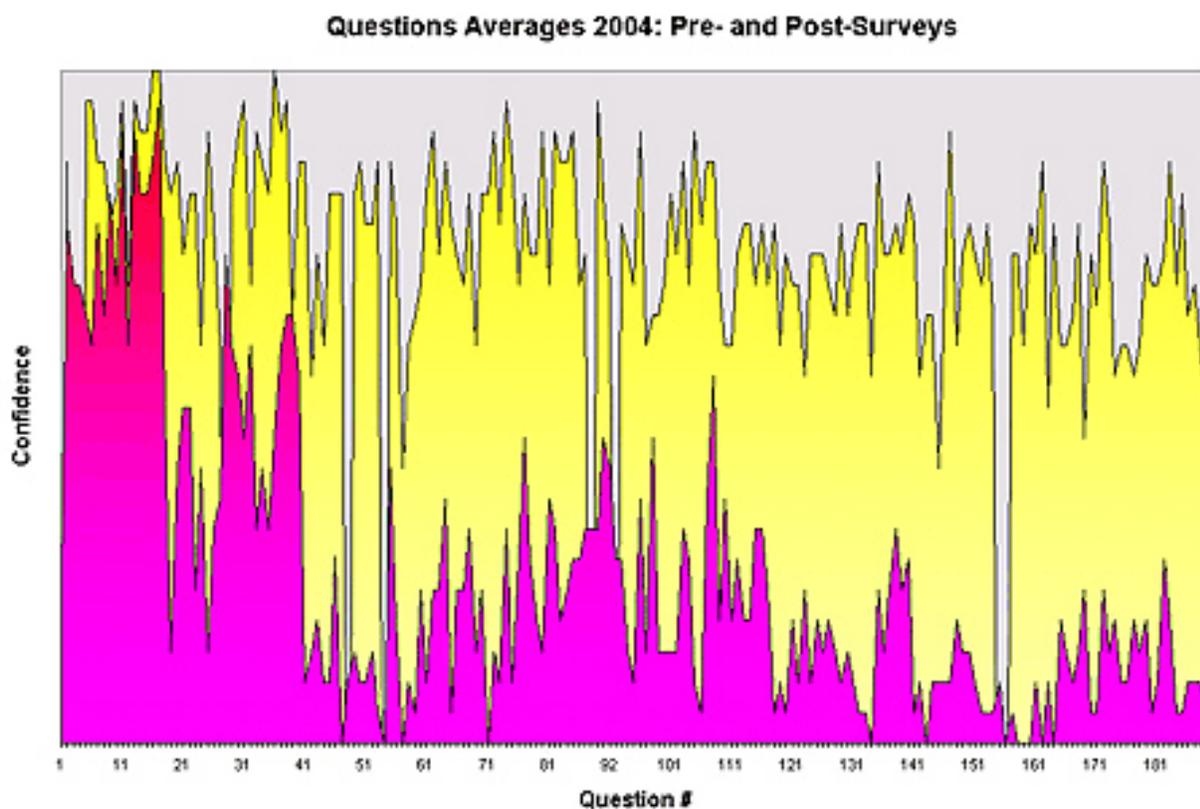
### How to compose a Knowledge Survey

To create a Knowledge Survey, most instructors start by combining questions from old exams, perhaps

going back several years, and then eliminating redundant questions. Questions are sorted by topic to make sure that all parts of the class are covered adequately. To ensure that the survey covers all levels of thinking, the instructor scores the questions, classifying them by level of thinking using Bloom's scale. Generally, instructors find that they have too many low-level questions, and so must develop new ones to adequately cover all levels of thinking.

### Examples of Results

Figures 5 and 6 show Survey results for two different semesters of Mineralogy at UND. Two key features stand out in these results. First, the material covered at the beginning of the course (questions 1-40) was largely remedial. This suggests that the instructor was not making optimal use of class time. Second, there is a general decrease in content mastery from the beginning to the end of the semester. This could be because the class is rushed at the end of the semester (not true in this case) or because the topics covered later in the course are more difficult (true for UND Mineralogy, see Fig. 2).



**Figure 5** Survey results of the UND Mineralogy class in 2004

Questions Averages 2005: Pre- and Post-Surveys

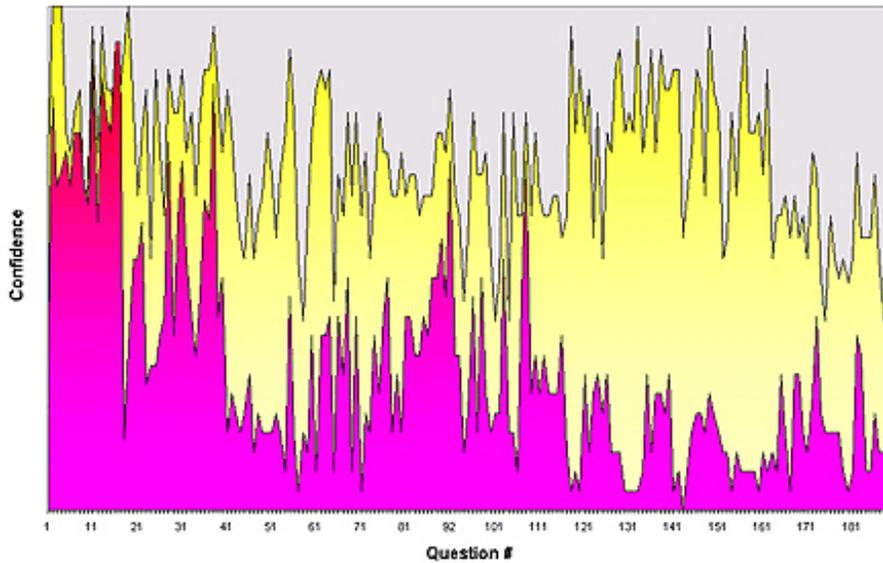
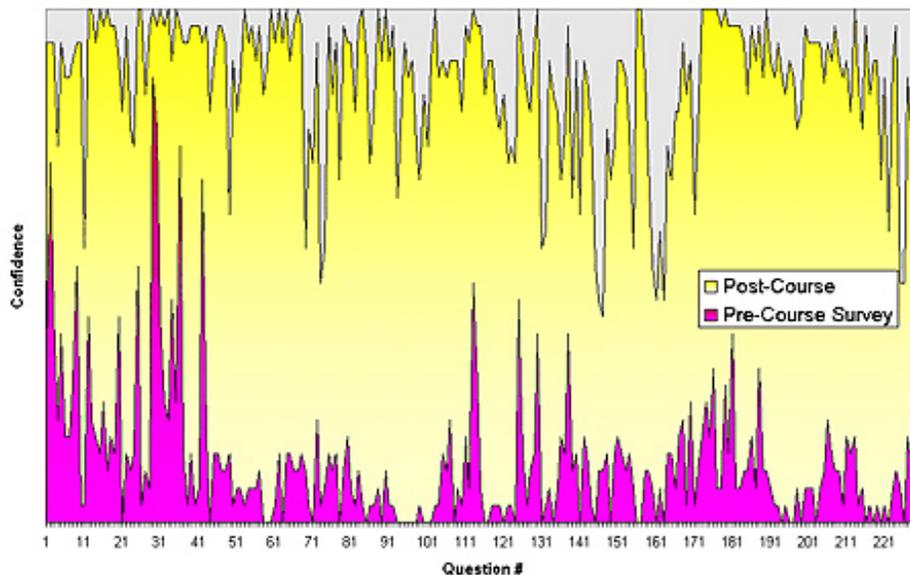


Figure 6 Survey results for UND Mineralogy in 2005

Figure 7 (below) does not show the same gradual decrease in confidence from beginning to end of the course (as in the previous two figures). However, results for one part of the course (questions 131-171) are somewhat depressed compared to the rest of the course. There are a number of possible explanations, but the most likely is that the material was taught in an ineffective way, suggesting that the instructor should make improvements. (In this case, however, the real explanation is that the students were given no exam covering the material and so did not put in the required effort to learn it.)

Dynamic Earth Course



### **How to use Knowledge Surveys**

In the simplest application of knowledge surveys, students complete a survey during the first few days of a class, providing baseline information. They then take an identical survey just prior to the final exam. Before taking the final exam, both students and instructors see the results and compare them with results at the beginning of the semester. The students see how much they have learned and, also, see the areas where they need to focus studying. The instructor sees which parts of the class have been most successful and which have not (Figs. 8 and 9).

Some instructors may choose to use mini-surveys to help students prepare for tests. In this case, the select a subset of questions for a survey that focuses on one or a few topics. Although this use of knowledge surveys has value to the students, it does not particularly help the instructor.

Knowledge surveys may also be used in many other ways. For example, they allow comparison of the effectiveness of different pedagogies (Fig. 18). They also may be used to evaluate an entire curriculum or to compare different courses within a curriculum (Fig. 19). We have also used them to measure long-term knowledge retention by students (Fig. 20)

Some instructors may use surveys in the “scholarship of teaching and learning” – as part of classroom research focused on learning. For example, results of knowledge surveys may be used to evaluate student learning goals, barriers to learning, or knowledge retention. Surveys can be used to separate “good” questions from “bad.” That is, instructors may identify questions that do not reliably reflect student learning. Surveys also permit evaluation of the efficacy of different pedagogies and of curricula.

Knowledge surveys produce a tremendous amount of data. Instructors may administer them in many ways but, due to the amount of data, manual scoring is not recommended. Standard hard copies of exams can be handed out, with students asked to complete scantron (bubble) sheets. Most computer scoring packages can return results in a format easily imported into a spread sheet for analysis. Alternatively, surveys may be administered using courseware such as Moodle or specific survey packages developed for knowledge surveys.

Data may be sorted and analyzed in any of a number of ways. Perhaps an instructor wants to measure learning for different subject areas of their class. Perhaps they want to know how learning at the low end of Bloom's scale compares with learning at the high end. Or, perhaps they just want to compare students, or to compare one class to another. Analysis is best aided by graphical means, shown by examples in this poster.

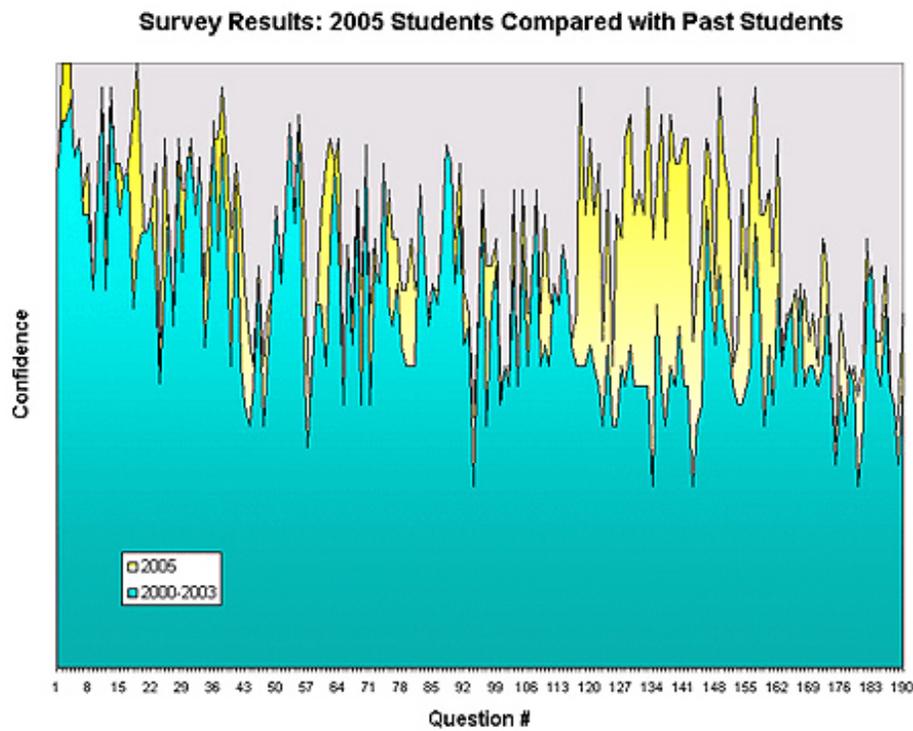


Figure 8

Figures 8 and 9. Surveys can provide instructors with much valuable information. In 2004, a new emphasis was put on teaching crystallography and X-ray mineralogy in UND Mineralogy. Additional changes were made the following year. The instructor designed new exercises and group projects because students were not learning as well as the instructor wanted. Survey questions that deal with crystallography and X-ray are indicated in Figure 9. The survey results show clearly that the changes produced real learning gains.

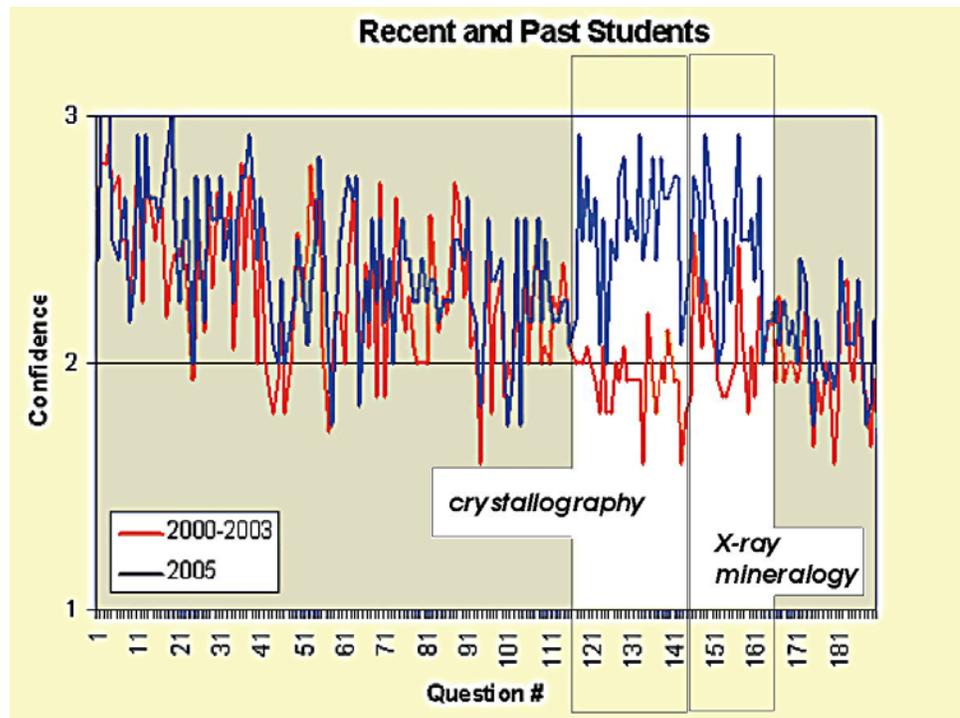
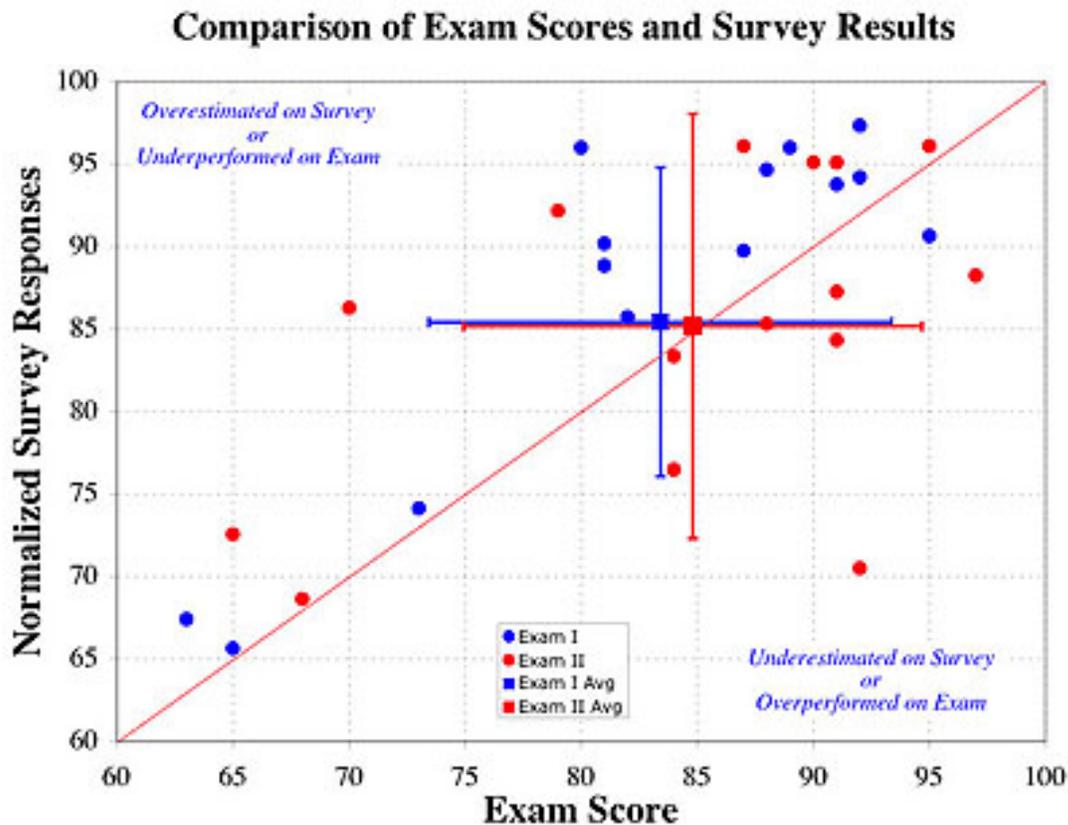
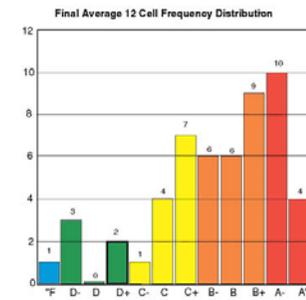
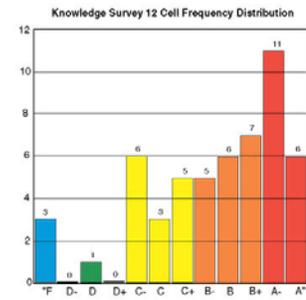
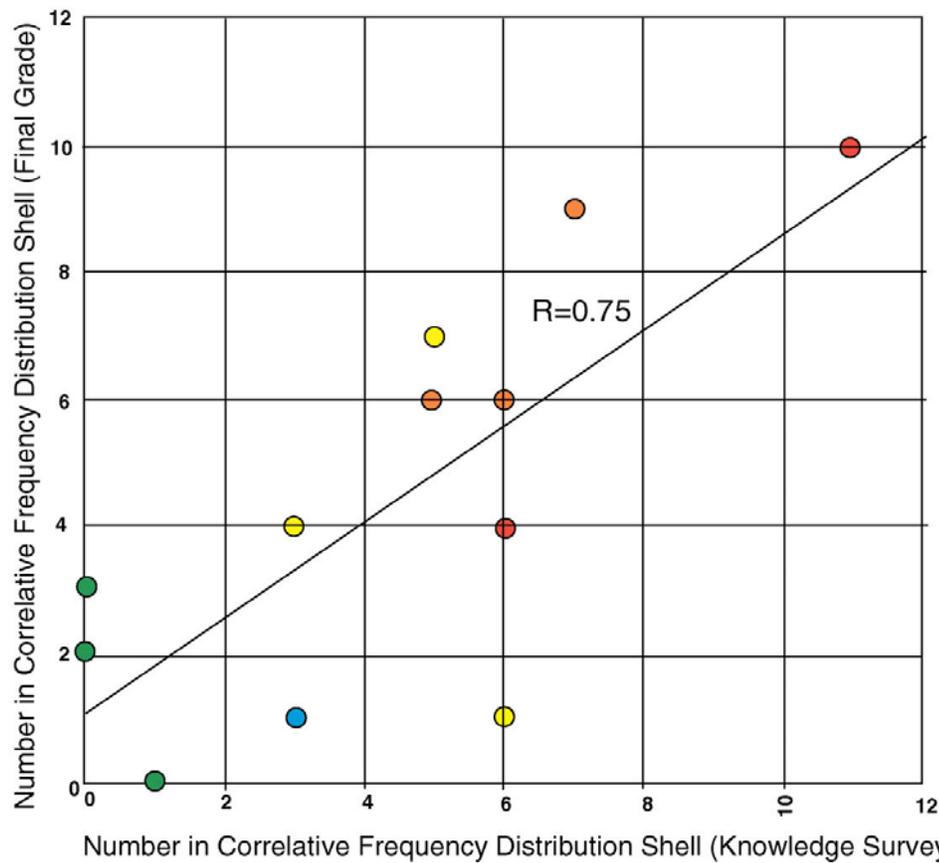


Figure 9

## How Well Do Surveys Predict Performance?

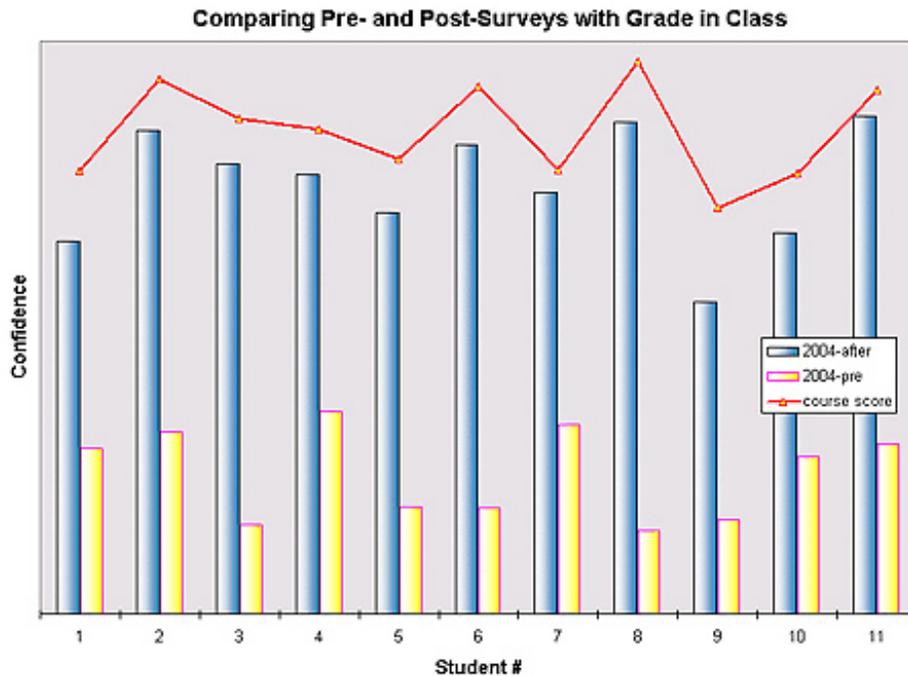


**Figure 10** Results from Mineralogy at Macalester College. This shows comparison of Exam scores and survey results just prior to taking the exam. Class averages correlate exceptionally well, but results for individual students are somewhat scattered. Surveys, in general, are better for class assessment than they are for individual student evaluation. This diagram compares results from a survey containing many question to an exam that only contained a few. If the common questions, only, are considered, the correlation between survey results and exam score improves significantly.

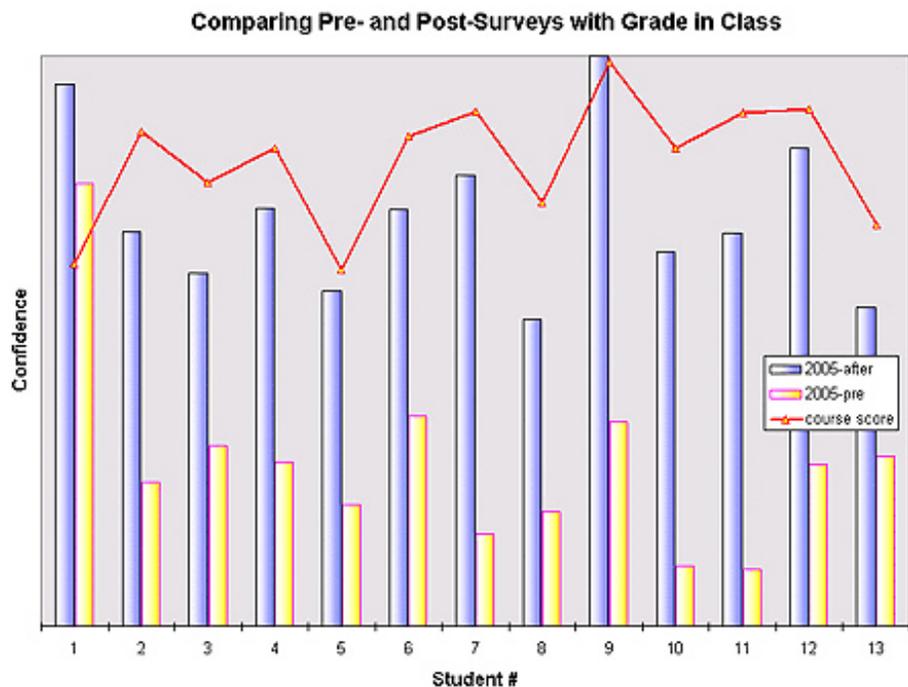


**Figure 11** This diagram shows final grade in the class versus the final grade predicted by the knowledge surveys. The axis values are the number of students at each grade level, shown in the histograms on the right. The high degree of correlation suggests that knowledge surveys are good indicators of overall student knowledge.

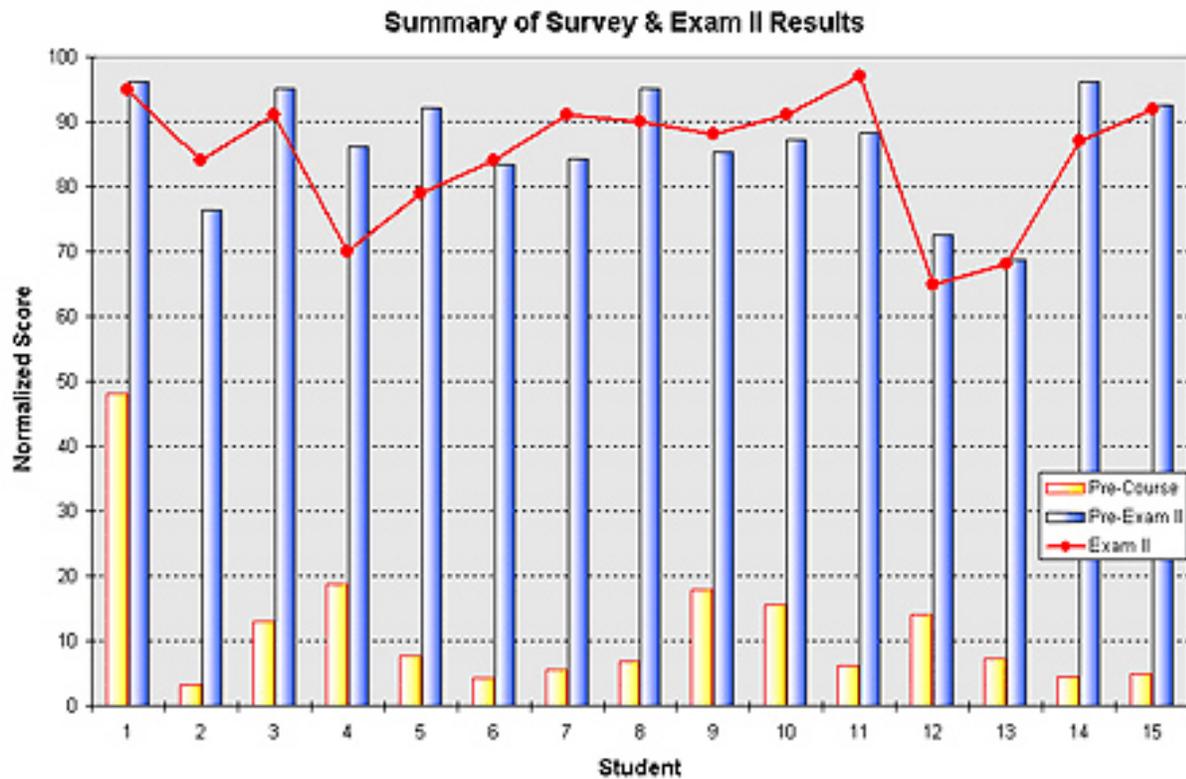
Figures 12 and 13 (below) show results from two semesters of Mineralogy at the University of North Dakota. The course grades (red line) have been normalized and correlate exceptionally well with the final knowledge survey (blue). Course grades are higher than the student confidence would predict because students received credit for other things besides knowledge retention. Results for 2005 (Fig. 13) show one student (#1) significantly overestimated how he would perform in the course. His poor final grade was due mostly to the fact that he did not complete and turn in his laboratory assignments.



**Figure 12** Knowledge survey results and overall course scores for individual students in UND Mineralogy 2004

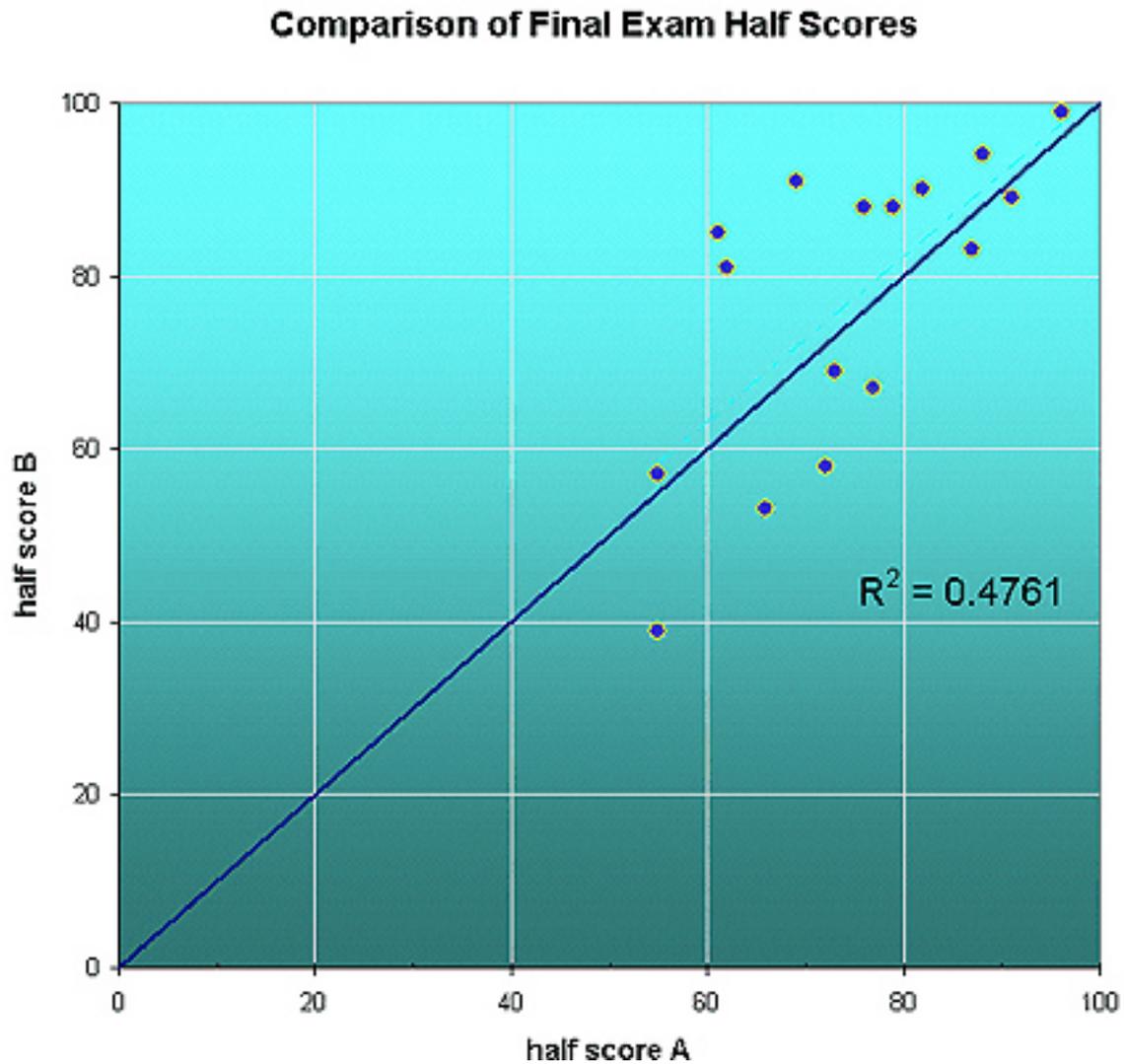


**Figure 13** Knowledge survey results and overall course scores for individual students in UND Mineralogy 2005

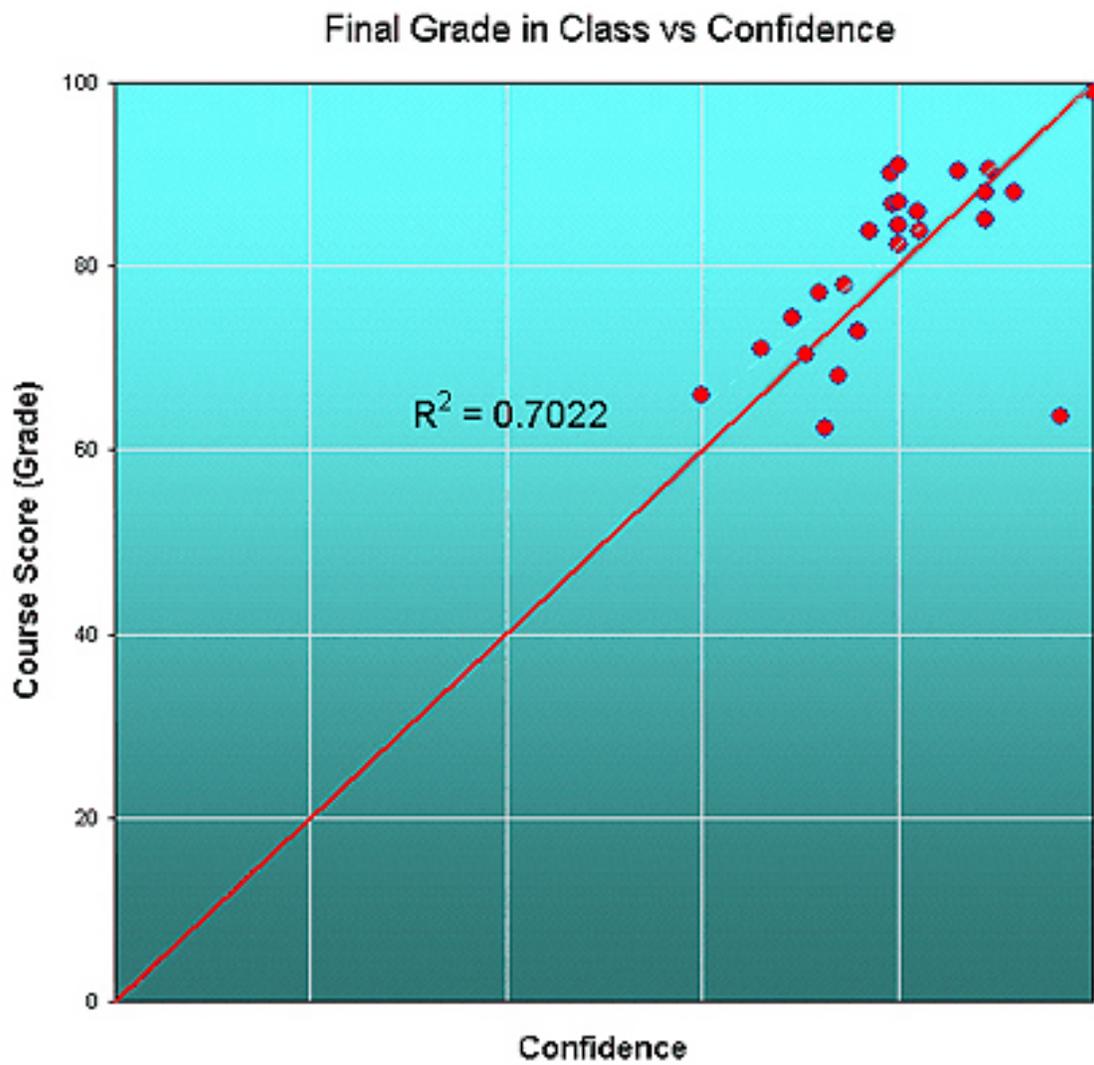


**Figure 14** Results from Exam #2 in the 2004 Dynamic Earth class at Macalester. Here we see pre-course survey results (yellow), survey results obtained just before Exam #2, and the (normalized) grade students received on the exam. There is excellent correlation between student confidence and grade. Note that two students, #12 and #13, predicted they would do poorly, and they did. Student #1, who came into the class with the most knowledge, obtained the highest grade.

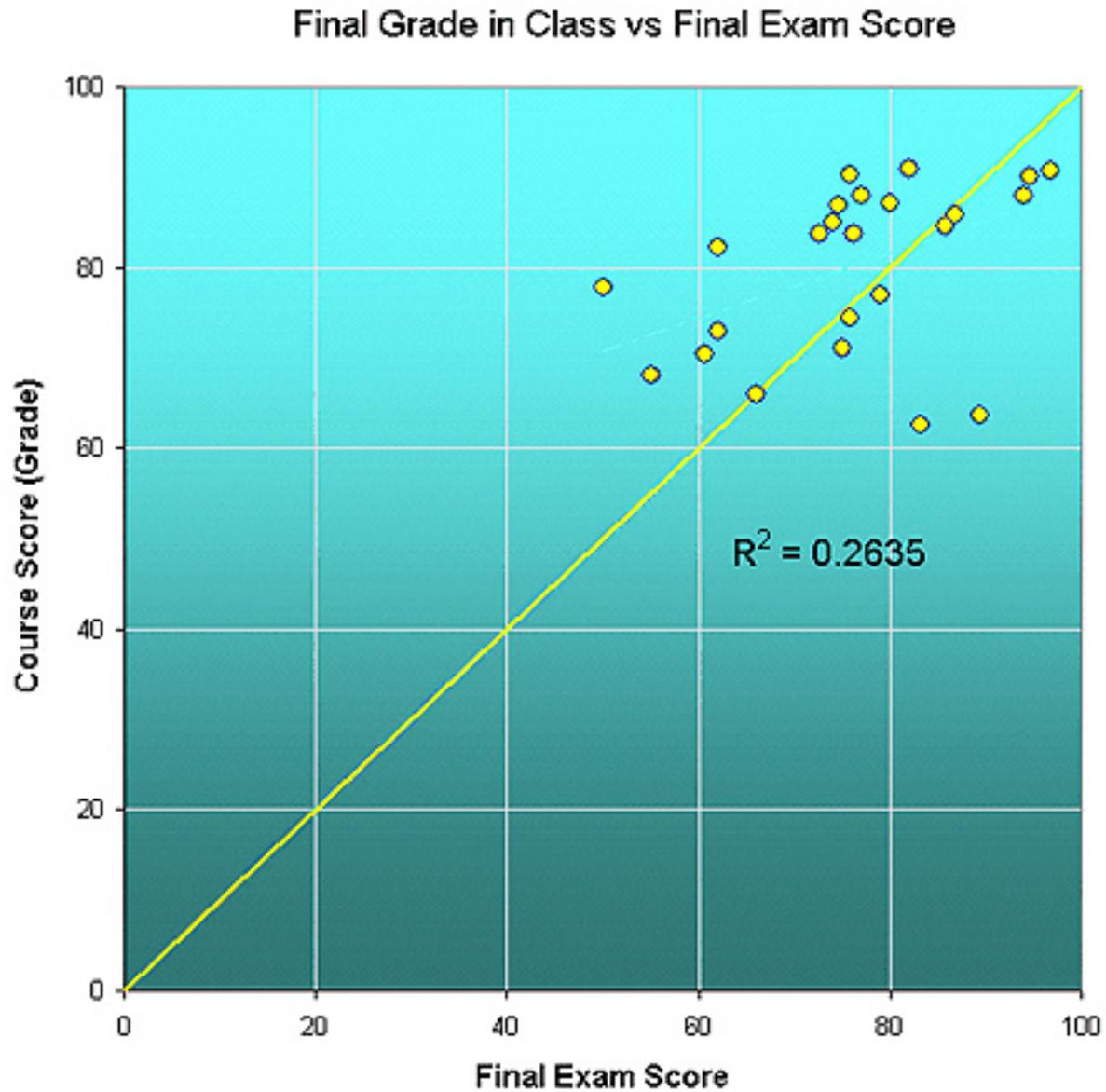
## Do Surveys (or Exams) Measure Learning?



**Figure 15** How reliable are exams for measuring student learning? One way to estimate reliability is to grade exams and quizzes question-by-question and then randomly divide the questions to give two scores. If the exams, and all the items on the exams, are good measures of learning, there should be a high correlation between the two scores. This example shows results from one semester of Mineralogy. 84 questions were considered (from quizzes and exams). Correlation between the two half-scores is poor (0.47).



**Figure 16** In comparison with Figure 15, here we see a high degree of correlation. This figure shows final course scores compared with final knowledge surveys (completed just before the final exam) for one section of Mineralogy. (The one anomalous student was omitted for calculating the correlation coefficient.)



**Figure 17** How well do class grades compare with final exam scores? Not very well, as this figure shows. If final class grades are being assigned appropriately (if they really do reflect degree of student learning) then these last three figures show clearly that knowledge surveys measure learning better than exams. The better reliability of knowledge surveys can be traced to several factors. First, the surveys include many more items than can be included on an exam. Second, when taking a survey, students do not suffer any test anxiety. Third, even if some of the questions are poor or misleading, they do not affect overall survey score to a significant degree. In contrast, a few bogus question on an exam can have major effects.

## Broader Applications

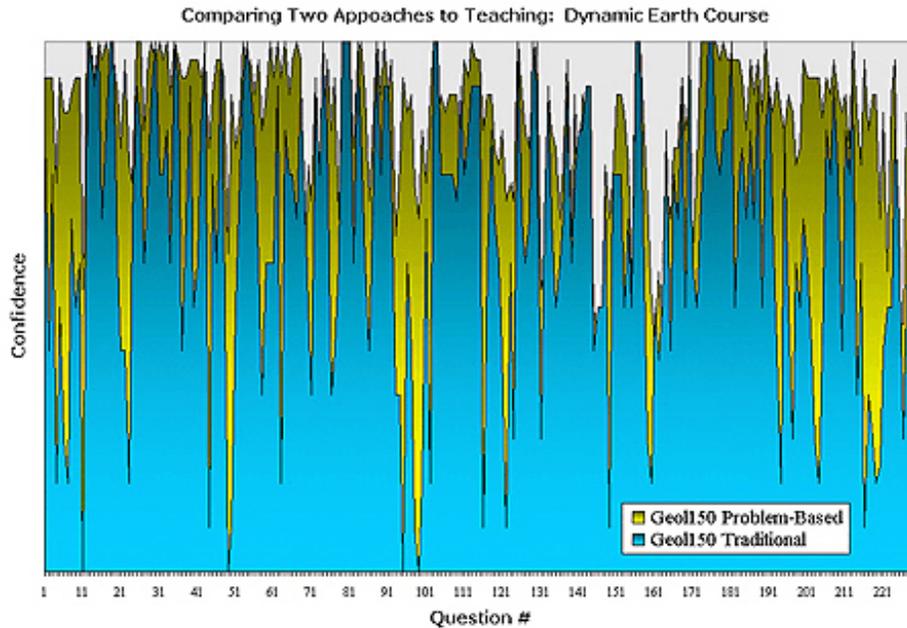


Figure 18 (left) compares survey results for two different sections of a Dynamic Earth class. One was taught using a traditional lecture-lab approach. The other was taught using a project-based approach that emphasized cooperative learning. The survey results suggest improved learning in the project-based course.

Besides evaluating individual classes, knowledge surveys can have broader applications. Figure 19

(below) shows results from four different classes taught at the University of Idaho. One was a freshman class, one a sophomore class, one a junior class, and one a senior class. The four classes all display different attributes. Learning in the freshman class declined steadily as the semester progressed, suggesting that the instructor should make some change in the way the class was taught. Additionally, the class included much remedial information at the beginning that could, perhaps, be omitted. The sophomore class seems to have found a good balance with significant learning occurring throughout the semester. Both the junior and senior level classes display more erratic results. Students apparently struggled to master class content. Perhaps these classes were taught at too high a level or were not taught using the most appropriate pedagogy.

Knowledge surveys can be used in many ways. Figure 20 (below) gives an idea of how well students

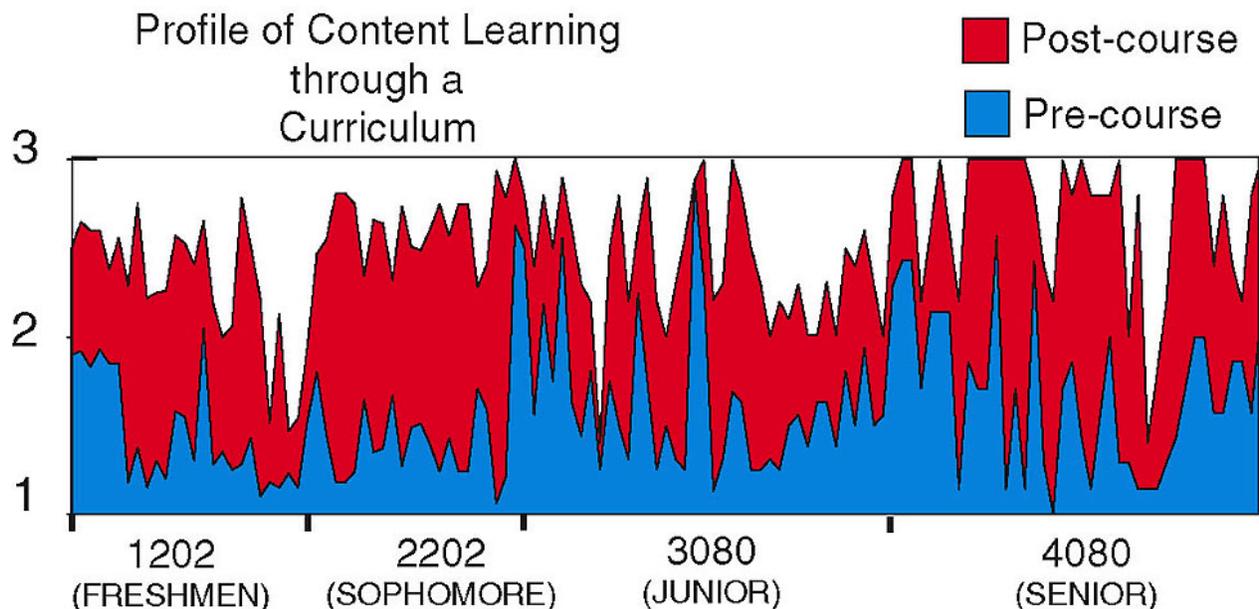
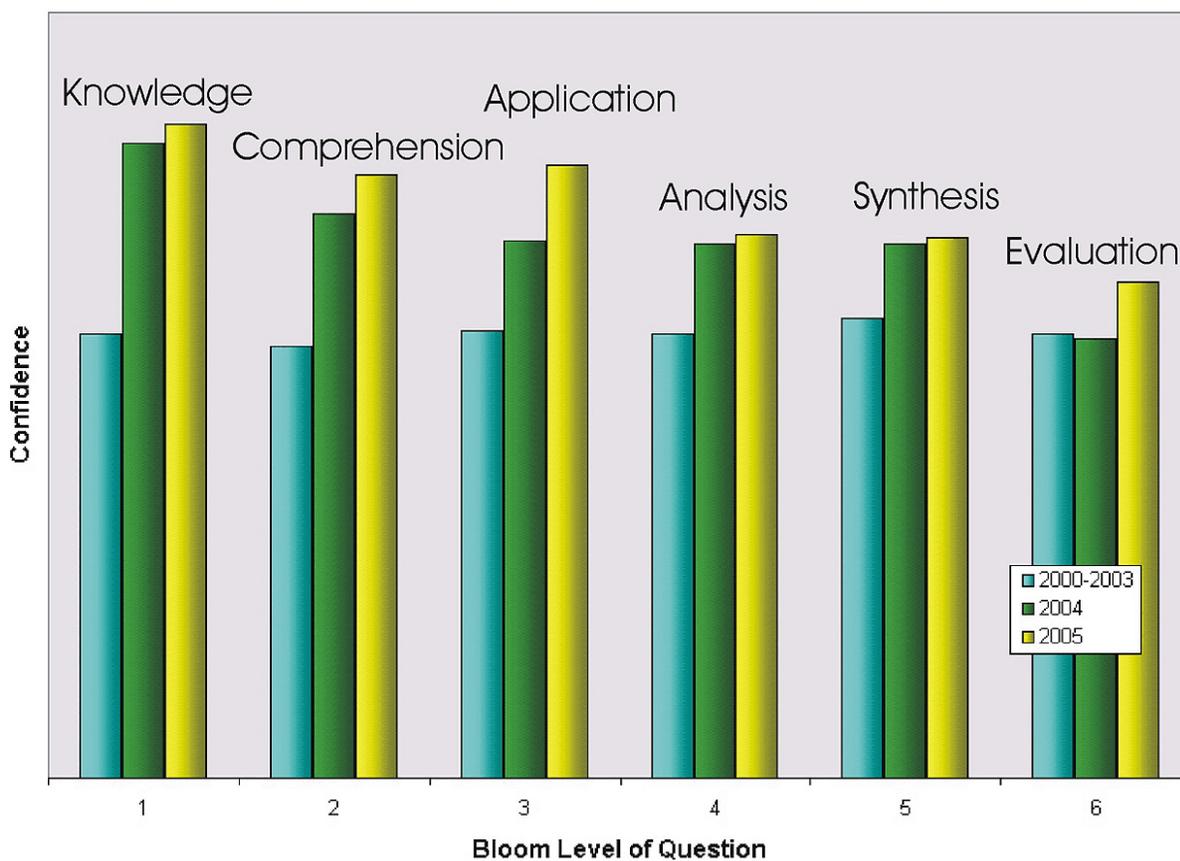


Figure 19

retain what they learn, based on survey results.

We gave the same survey to 74 students who took the UND Mineralogy class between 2000 and 2005. We sorted question by Bloom level and by year of class completion. The trends in the diagram are remarkable for their continuity! These results show clearly that students forget much of the basic knowledge they learned in a very short time. In comparison, they remain confident in being able to answer more complex questions. So, at what level should we be teaching our classes? Should we put even more time into teaching basic knowledge, hoping that they don't forget it, or should we de-emphasize it and focus on higher order learning?

**Confidence by Bloom Level: Comparison of the Past 2 Years to Earlier Years**



**Figure 20** Knowledge Survey results for UND Mineralogy 2000-2005. Confidence is sorted by Bloom level of the questions asked.