2. Project Findings

2.1. Comparison of scaled-up FC course with smaller Modeling ASU honors sections

The Force Concept Inventory (FCI) was given as both a pretest and a posttest in the Foundation Coalition (FC) course. The Mechanics Baseline Test (MBT) was given as a posttest only, and results are described in section 2.5. A comparison of the FCI gain for the 2000 FC course (64 students) with the FCI gains for the ASU honors course (< 24 students) for the 1995-1999 academic years is shown in Figure 2.1.

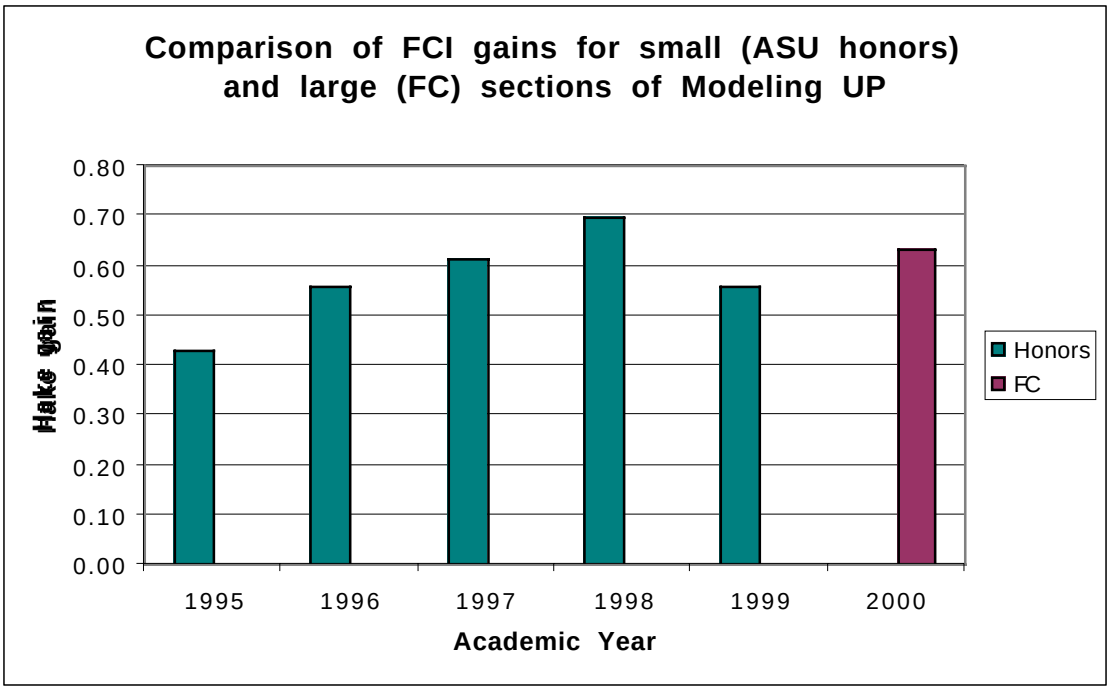

Figure 2.1

The gain for the 2000 FC course was **0.63.** This gain is comparable to the gains achieved by the smaller ASU honors course using Modeling Instruction. We conclude from this result that, with comparably experienced instructors, **scale-up** of the Modeling Instruction method **by a factor of 3** (from a class size of ~20 to a class size of ~60) **resulted in no significant reduction in qualitative mechanics comprehension as measured by the FCI.**

2.2. Comparison of scaled-up FC course with other (control) UP courses at ASU

In the 2000 academic year, the FCI was also administered as a pre- and post-test to a traditional, large, ASU lecture section of UP (116 students) and to the ASU honors UP section (12 students). **We note that in the 2000 academic year, the ASU honors UP section was <u>NOT</u> taught using Modeling Instruction.** Since Politano was teaching the FC section, a different instructor taught the honors section in this year and he taught the class in a traditional lecture/lab/recitation format. We shall hereafter refer to the 2000 ASU honors section as the"ASU traditional honors" section.

In Figure 2.2, we show the FCI gains for the 2000 academic year for the ASU traditional large lecture section, the ASU traditional honors section and the scaled-up FC section.

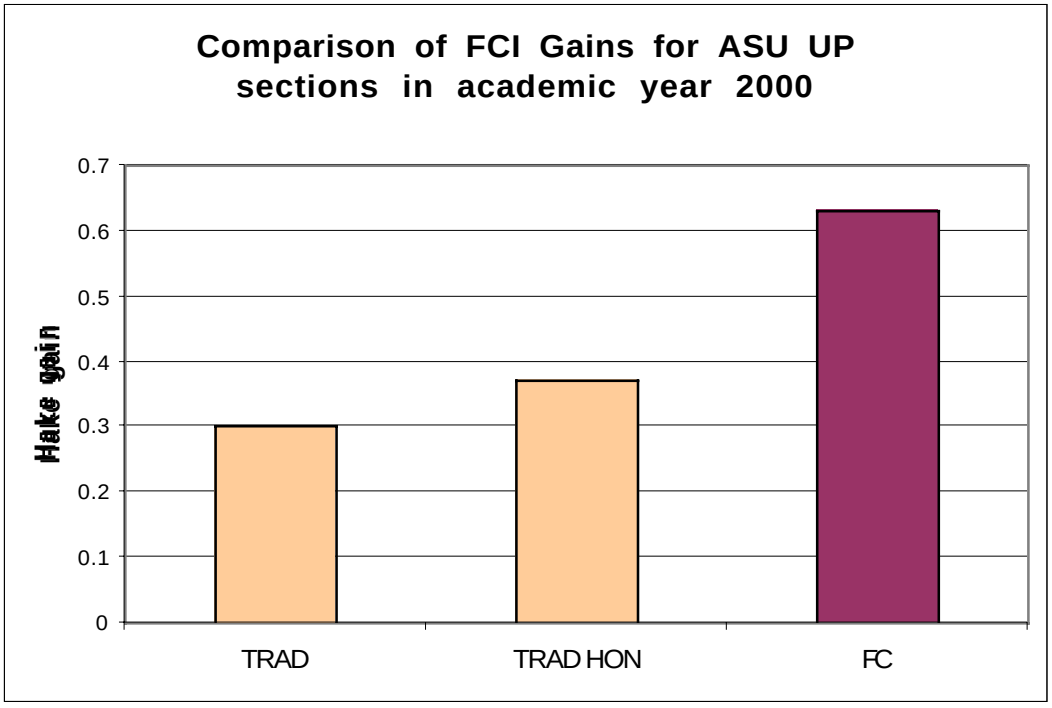

Figure 2.2

The gain of 0.30 for the traditional large lecture course is typical of the gains reported by Hake for traditionally-taught physics courses (see Figure 1.1 in Project Activities). The gain of 0.37 for the traditional ASU honors course is a bit higher than typical gains for traditionally-taught courses. However, this is understandable given the following additional information. In 2000, the ASU honors section *started* with 24 students, but only *12* students *finished* the course (and took the FCI posttest). The mean FCI *pre-test* score for those 12 students who completed the course was 81%. The mean FCI pre-test score for those students who *dropped* the course was 54%.

The comparative data in Figure 2.2 for the scaled-up FC course show the same trend as the data in Figure 1.1 (in Project Activities), which compares the FCI gains for the smaller ASU Modeling honors section with traditionally taught physics courses:

Students in a UP section taught with Modeling Instruction, whether small (~20 students) or large (~60 students), have gains in physics comprehension, as measured by the FCI, that are 100% (a factor of 2) greater than students who are taught with traditional instruction.

We may view the FCI data in a slightly different way that makes the comparison with traditional instruction even more striking. A common saying among educators is that the method of instruction will have only a small effect on students near the top of the class and students near the bottom of the class—the biggest effect will be on students in the middle. In Figure 2.3, we show FCI pretest and posttest scores for the same three ASU sections as in Figure 2.2. The scores for a given section have been grouped into quartiles. The thin, solid lines above and below the gold rectangles show the range of the top 25% and bottom 25% of scores on a given exam (pre or post). The gold rectangles show the range of the *middle 50%* of the scores on a given exam. There is significant overlap between the middle 50% of the scores for the posttest and the middle 50% of the scores for the pretest for the traditional large lecture section and for the traditional honors

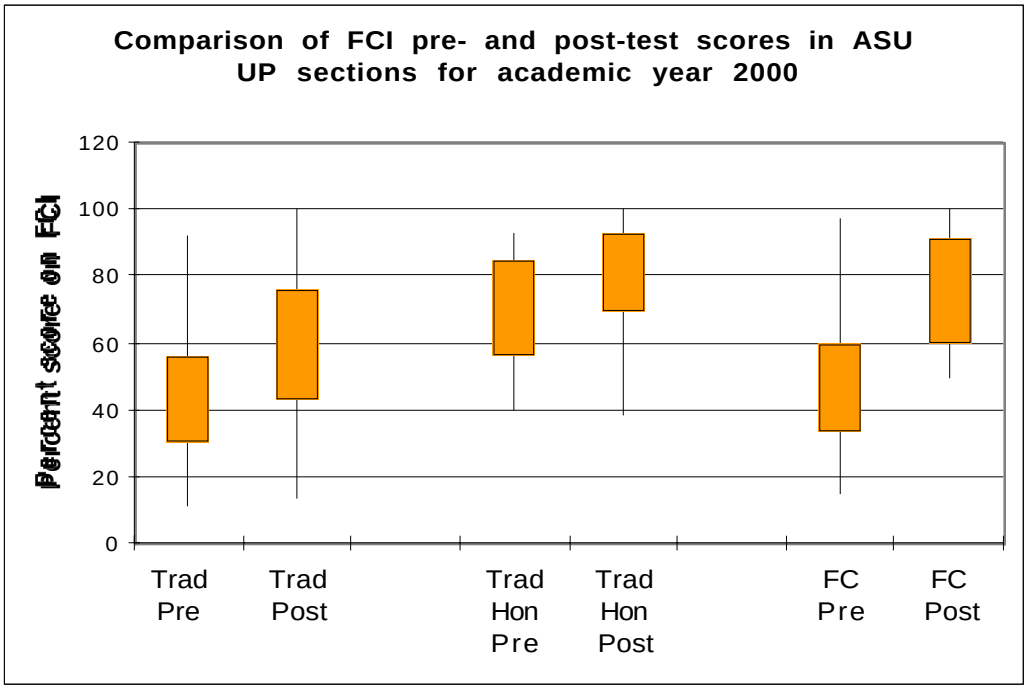

Figure 2.3

section. There is *no* overlap among the middle 50% for the FC section, indicating a substantial increase in physics comprehension for this middle population. (We also note that there is no overlap among the bottom 25% of the scores for the FC section as well.)

2.3. Comparison of scaled-up Modeling FC course with prior FC courses

As we have noted, the FC had been experiencing serious problems in trying to reform their UP course. One of the aims that we stated in our proposal was to "save the day" for the FC course by importing our scaled-up version of Modeling Instruction. Figure 2.4 shows the FCI gains for the FC course for the 1994-2000 academic years. From 1994-1998, the course was taught in a fairly traditional manner. In 1999, we experimented with a preliminary attempt to import a scaled-up version of Modeling Instruction to the FC course. Two of Hestenes' graduate students team-taught the FC course with the FC physics instructor from 1998. In 2000, full scale-up was implemented with Politano replacing the previous FC instructor.

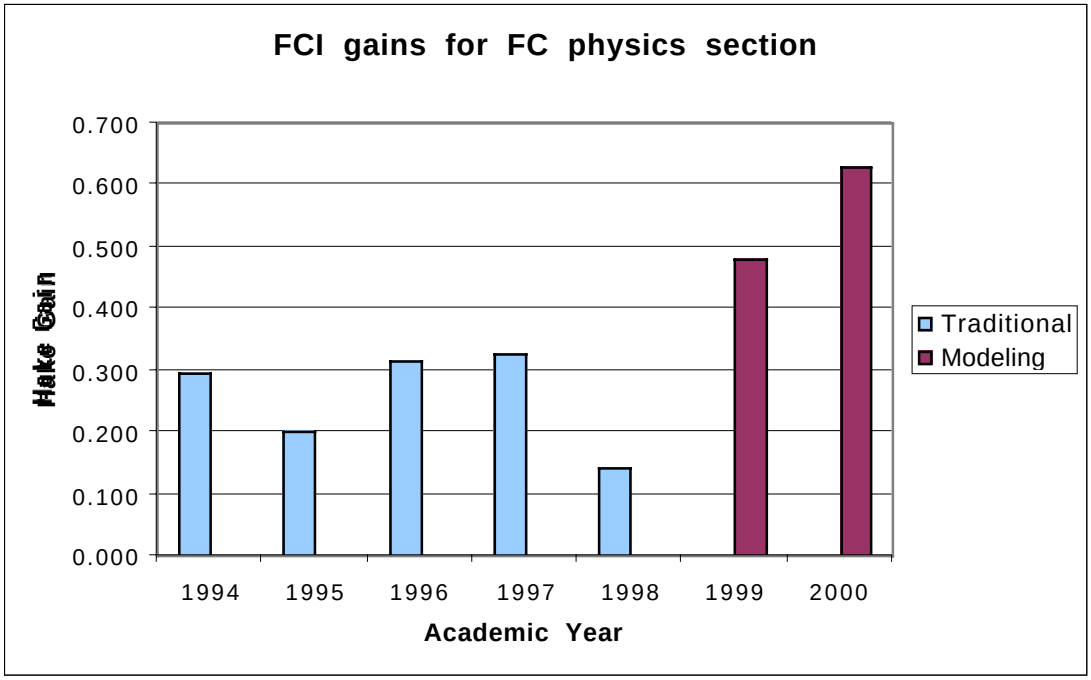

Figure 2.4

The FCI gains for the traditional FC courses are, once again, typical of gains reported by Hake for courses taught with traditional lecture/lab/recitation methods. The FC gain for 2000 is a factor of two better than the best gain achieved by the traditional

FC courses (0.33 in 1997). In addition, student satisfaction with the FC physics course, as measured by students' comments on the course evaluations, has improved dramatically over the past two years. We therefore believe that we have achieved our aim of "saving the day" for the FC physics course and have helped the FC to achieve its aim of improving undergraduate engineering courses.

2.4. Comparison with "scale-up" efforts by other physics education research groups

The issue of scale-up is an important one and is being addressed by other physics education groups around the country. We believe it is fair to say that most of these groups' efforts are in their early stages, as is ours. Strong comparisons, therefore, would be premature at this time. Nonetheless, early comparisons can be made. At last summer's AAPT meeting in Guelph, Ontario, several groups with scale-up programs presented their initial results. The largest gain on the FCI reported by these groups was 0.50. In comparison, the gain we achieved in the scaled-up FC course in 2000 was 0.63.

The task at hand, improving performance in introductory college physics courses, is a national problem, and thus warrants a national effort. Therefore, we are collaborating with several of the other physics education groups to share and compare ideas in order to develop optimal strategies for addressing the issue of scale-up.

2.5. Mechanics Baseline Test (MBT) Results

The MBT was given as a posttest only in the FC physics course. Experience with the MBT has shown that the students' initial knowledge state is so poor that giving the exam as a pretest reveals little. The mean score on the MBT achieved by the FC physics course in 2000 was 67%. We did not receive permission to administer the MBT in other ASU UP sections in 2000, as we did with the FCI. However, other groups for comparison exist.

Shown in Figure 2.5 are mean posttest MBT scores from a variety of university physics courses. The first two bars, labeled "ASU HON '98" and "CGCC '98" respectively, show the best mean MBT score for the ASU honors UP sections and the Chandler Gilbert Community College UP sections. Both of these sections had ~20 students and were taught using Modeling Instruction. The mean MBT score for both of these sections was 79%. The third bar, labeled "HARV '95," shows the best mean MBT score for the 16 UP courses that gave the MBT in the Hake survey. The "HARV '95" course was taught by Eric Mazur at Harvard University, using an interactive engagement method of instruction known as "Peer Instruction." The mean MBT score for this course was 76%. The fourth bar, labeled "FC TRAD '98," shows the mean MBT score for the Foundation Coalition UP course in 1998. This was the last year the FC course was taught using *traditional* instruction. The mean MBT score for this section was 38%. The final

bar shows the mean MBT score for the FC physics course taught in 2000 using the scaled-up version of Modeling Instruction.

To the best of our knowledge, the mean posttest MBT score of 79% for the ASU honors and CGCC UP sections is the highest posttest score reported for the MBT. The 2000 FC section scored twelve percentage points lower than the smaller ASU honors '98 and CGCC '98 sections. Nevertheless, the mean MBT score for the 2000 FC section was almost a *factor of two* higher than the mean MBT score for the 1998 FC section, which was taught using traditional instruction. We are currently analyzing the raw MBT data for the 2000 FC section to determine where deficiencies in student understanding exist and how to correct them for next year.

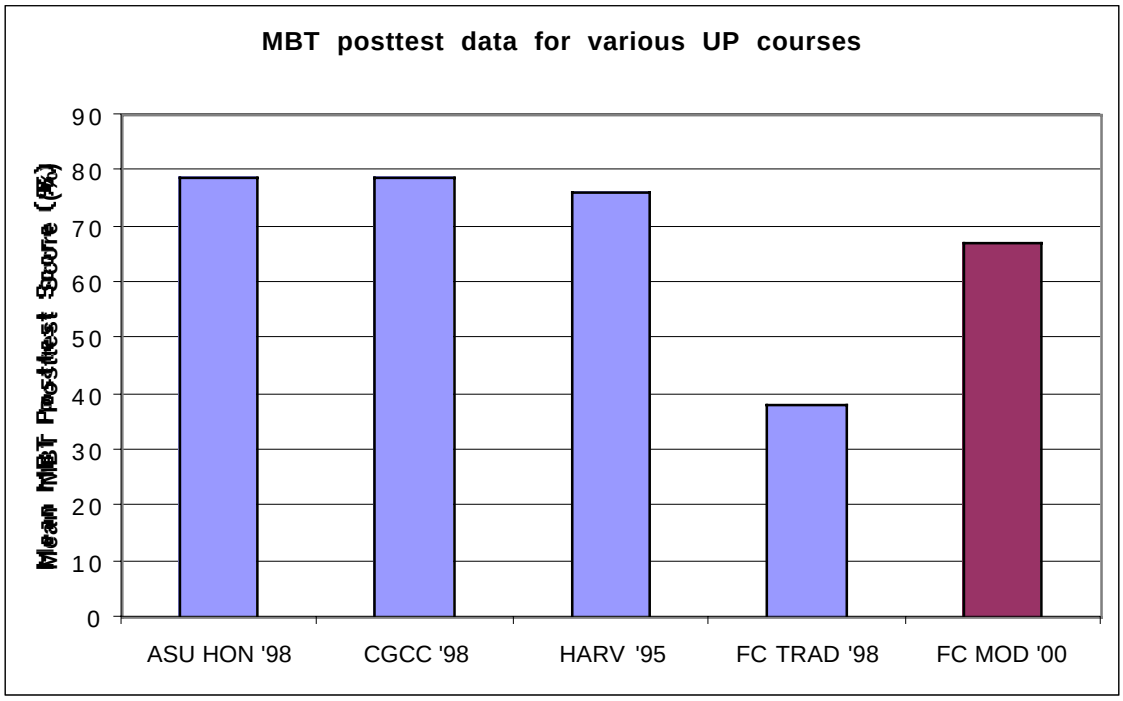

Figure 2.5