

# Introduction of Studio Physics Teaching in Panama

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**Abstract.** Physics Studio teaching was recently introduced at an international and multicultural academic program of a U.S. university in Panama. The results of introducing and implementing studio-style teaching on the conceptual understanding of calculus-based introductory physics have been measured by comparing before and during studio implementation. The research was carried on over the last five years in different semesters. The measurement tool was the Force Concept Inventory. The initial learning stage of the incoming diverse students has been found to be at a significantly lower level than generally reported in the U.S. The normalized gain in conceptual understanding was significantly larger than in the former traditional system, and has become consistent in the last semesters. Multicultural aspects that may affect the entry level and performance enhancement are discussed.

**Keywords:** Studio physics, studio teaching, physics education research, force concept inventory, Panama.

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## INTRODUCTION

Most of the research on physics education has focused on the issue of conceptual understanding in introductory calculus-physics courses at universities, colleges, and high schools [1].

Most of this research has resulted in improved instruction and learning space with successful implementations such as Studio Physics [2] which has been extended to large scales with SCALE-UP [3]. One widely used tool to evaluate the effectiveness of such approaches and obtain a measure of conceptual understanding gains in students has been the Force Concept Inventory (FCI) [4]. This work reports the first continued study using the FCI in Panama. FCI and other conceptual understanding evaluation tools have been applied by the author since 1997 at various schools, and since 2005 it has been applied with the physics courses of the international program of Florida State University in Panama (FSU-Panama). FSU-Panama provides the first two years of core studies in most disciplines, and students continue their studies either at the main campus or at other universities. Calculus-based introductory physics courses are taught for engineering and science majors.

The student population at FSU-Panama is diverse. In a typical introductory physics course one finds a majority of Panamanian nationals (>85%), but some come from Colombia (<4%), Venezuela (<7% but increasing), occasionally one student comes from Argentina, Ecuador, Peru or a Central America or Caribbean nation. About 2% are American students that come from FSU's main campus or other U.S. universities.

In a typical first semester course there are up to 25 registered students per physics course. The author is the only physics instructor at the site.

Since 2005 until 2009 the teaching of physics followed the traditional setting of separate lecture, laboratory and recitation sections. Beginning in 2010 studio-style of teaching began, but without the infrastructure generally associated to Studio Physics, such as seating in roundtables for group work and a computer with real-time data acquisition for two to four students. At the end of 2010 the campus moved to a new building where a physics studio room was finally constructed.

The use of FCI began in 2007 to examine the entry state of mechanics conceptual understanding. It was initially administered to help tailor the course to confront the shortcomings and misconceptions of the students. Later Pre- and Post-test evaluations were done in various semesters to obtain a measure of learning gains in the students. Full studio teaching curriculum was finally implemented starting with Spring 2011 using a physics-education research based text [5] and active learning teaching resources.

In this paper I present first the Studio Physics model at FSU Panama and then the results of learning gains from the FCI before and after Studio teaching was implemented to quantify the effects on conceptual gain of the transformation from traditional physics teaching to Studio-style physics teaching, in a multicultural student population. I first describe the environment before and after the transition to studio physics. Then I will discuss briefly the application of the measuring tool (FCI), and present the results of pre- post-test learning gains in various terms, to finally propose some conclusions.

## STUDIO VS TRADITIONAL PHYSICS: THE PANAMA EXPERIENCE

Since the inception of introductory physics at FSU-Panama, its teaching has been done in a traditional format: lecture, laboratory and recitation -when opted-, in separate time schedules and places. Introductory calculus-based physics consists of two parts: the first dedicated to Mechanics and Thermodynamics, and the second to Electricity, Magnetism and Optics. There were three lectures of one-and-half hours and one three-hour lab session per section per week. Often the second half of the third lecture became a recitation session.

When a larger space was available in 1999, the lecture and the laboratory were done in the same space, but at different scheduled times. Laboratory experiments were conducted following prescribed step-by-step instructions in handouts which were modified into a more active learning format. When the author joined FSU-Panama in 2005, the teaching equipment was extremely outdated. There were no computers available, only timers with photo-gates to analyze motion experiments on air tracks. The labs were still conducted in classical large rectangular tables with restricted mobility.

At the end of the spring of 2008 handheld computer data acquisition equipped with real-time sensors replaced the experimental equipment. This change allowed the introduction of some active-learning strategies and practices. However students had not previously used real-time laboratory equipment in high-school, a short-coming that still continues in almost all high schools in Panama and the region.

In 2009 the construction of the new campus began, using a military barrack building in a former U.S. Army complex next to the Panama Canal, which returned to Panama in 2000. The remodeling included a full studio physics classroom with four roundtables and full internet connectivity for up to 25 students. More real-time laboratory equipment was also added. The textbook was changed from legacy traditional textbooks [6,7] to a physics-education research based textbook from Knight [5] to match the optional studio physics teaching implemented in the main campus. Studio teaching is currently done in three two-hour weekly sessions in which lecture, experiments and numerical and conceptual problem solving discussions are interspersed in every session. Normally three to four short experimental activities are done per week, all using real-time data acquisition portable systems with sensors for mechanics, thermodynamics, and most of electromagnetism; for the later an inexpensive and commercially available small form factor interactive circuit design board is also used.

## MEASURES OF CONCEPTUAL UNDERSTANDING GAIN

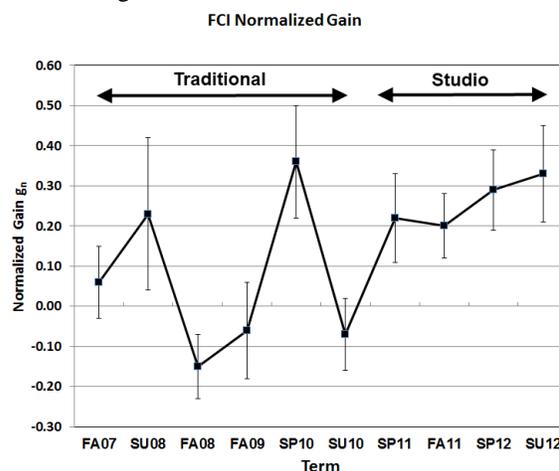
In order to obtain a measure of the gain in conceptual understanding in mechanics, to account for the effects of transforming physics teaching from traditional to Studio format, the FCI test was applied as a Pre-test and Post-test during the following terms: Fall 2007, Summer 2008, Fall 2008, Fall 2009, Spring 2010, Summer 2010, Spring 2011, Fall 2011 and Spring 2012. The normalized gain in conceptual understanding [8] was calculated as follows:

$$g_n = \frac{\%_{Post-test} - \%_{Pre-test}}{100 - \%_{Pre-test}}. \quad (1)$$

From 2007 to the end of 2010, the teaching was considered traditional, with some active-learning elements since 2008, such as the use of real-time data acquisition systems with handheld computers, joined by lecture demonstrations. From Spring 2011 term the courses were done at the new Studio facilities.

## RESULTS

The change in normalized gain through the transformation from traditional to Studio format is shown in Figure 1.



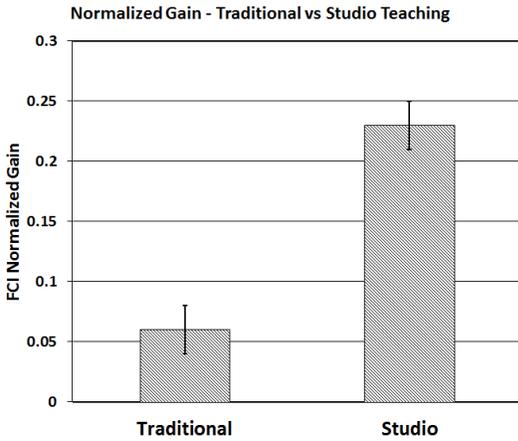
**FIGURE 1.** FCI Normalized Gain, for Traditional teaching (FA07-SU10) and Studio teaching (SP11-SU12).

The corresponding results of the FCI averages and normalized gains per terms on Figure 1 are shown in Table 1. The same students that took the Pre-test also took the Post-test. In the terms not shown, only Pre-tests were done. Pre-Test results on the cases shown were similar to those Pre-test in terms where no Post-test was done.

**TABLE 1.** Results of Force Concept Inventory Pre-Test and Post-Test percent correct averages and Normalized Gain in Conceptual Understanding, with respective standard errors.

Tested Terms	Students Enrolled	Pre-Test Average (%)	Post-Test Average (%)	Normalized Gain $g_n$
<b>Traditional Teaching</b>				
Fall 2007	14	42.6 ± 3.7	46.2 ± 3.8	0.06 ± 0.09
Summer 2008	9	36.7 ± 6.8	51.3 ± 9.2	0.23 ± 0.19
Fall 2008	16	39.3 ± 4.3	30.4 ± 2.5	-0.15 ± 0.08
Fall 2009	11	36.7 ± 6.2	33.0 ± 4.4	-0.06 ± 0.12
Spring 2010	10	31.7 ± 5.6	56.3 ± 6.0	0.36 ± 0.14
Summer 2010	9	25.2 ± 6.2	20.0 ± 2.4	-0.07 ± 0.09
<b>Studio Teaching</b>				
Spring 2011	9	27.4 ± 4.0	43.3 ± 6.4	0.22 ± 0.11
Fall 2011	23	28.3 ± 3.9	42.9 ± 4.0	0.20 ± 0.08
Spring 2012	17	31.0 ± 3.6	50.8 ± 5.2	0.29 ± 0.10
Summer 2012	10	24.6 ± 3.2	49.5 ± 7.7	0.33 ± 0.12

From these results, the FCI normalized gain of all traditional courses was compared to that of all Studio courses; this comparison is shown in Figure 2.

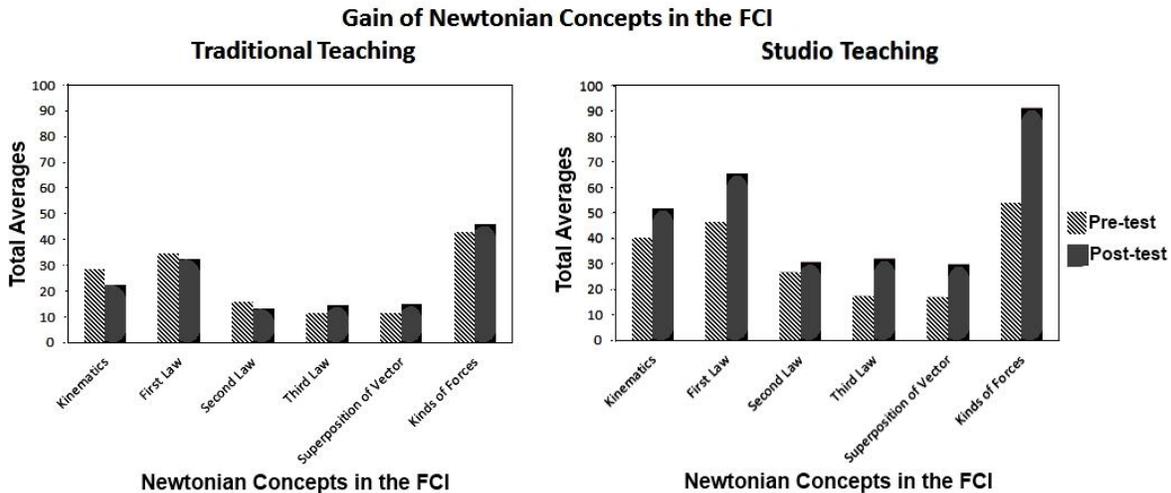


**FIGURE 2.** FCI Normalized Gain overall comparison of Traditional versus Studio teaching courses.

If one compares this overall result with gains measured elsewhere for Studio vs. traditional teaching, the normalized gains are still in the lower side of related normalized gains reported elsewhere [10-13].

The FCI test was designed to assess students overall understanding of basic Newtonian concepts: Kinematics, First Law, Second Law, Third Law, Superposition of vectors and Different kinds of forces.

The FCI items were associated by its authors to these concepts as standards against which preconceptions and misconceptions are tested. Although the FCI must be analyzed as a whole as recommended [9], as it was done herein, it was interesting to explore if gains in understanding those Newtonian concepts by the students could be observed [14]. Figure 3 shows that some gain may be inferred in the Newtonian concepts for Studio teaching versus Traditional teaching, with the largest gain obtained in the items related to different kinds of forces. This result seems to be in agreement with the overall comparison of normalized gains.



**FIGURE 3.** Gain of Newtonian Concepts based in the Force Concept Inventory, Traditional teaching vs. Studio Teaching.

The low Pre-test results seem to indicate that most of the students come to the university with very low conceptual understanding of physics and seem to have well rooted considerable amount of misconceptions despite two to three years of high-school preparation.

The classes of Summer 2008 and Spring 2010 were unusual. Those classes were small ( $\leq 10$  students) with an environment for intense and active interactions between them and with the instructor. There were in both classes a larger proportion of students with high school GPAs of  $>3.5/4.0$  than in other terms. Also, in SP10 some active engagement methods were tried. These factors could be some of the causes for such high gains in traditional as compared to full Studio teaching.

## CONCLUSIONS

After several years of trying to implement Studio teaching in Panama, this system is being developed at FSU Panama. It certainly took more time and more effort than elsewhere [10-13]. The visit to the Studio teaching model originators [2] to see first-hand the pros and cons of its implementation helped us to start this transformation.

There is much work to do. Conceptual understanding gain for traditional teaching was found to be relatively poor, with two exceptions. This is not good considering that students in Panama and neighboring countries may continue to enroll in university physics with many misconceptions and serious shortcoming in conceptual understanding that may remain if not confronted with better teaching strategies based in education research.

We interviewed some students from each country represented to know how physics is taught in different countries at the high school level and to understand why some students and groups had better gains. A related factor sought was the Ibero-American Physics Olympiads in which some South American countries had shown more strength than the rest. These countries have been introducing more consistent physics education reforms than other countries in the region.

On Summer 2008 and Spring 2010 terms there were exceptionally good students. They were more receptive to active-learning methods than students in previous or later terms, and they have expressed so in their course evaluations. Similar gains are now being developed as Studio teaching evolves and matures.

Studio teaching, although it did not result in gains as high as it has been reported elsewhere [10-13], showed that positive conceptual understanding gains can be achieved as instructors review and develop more consistent and integrated active-learning strategies and materials. Studio teaching has shown to

be one promising option to help improve conceptual knowledge of students entering university physics for slowly emerging economies like Panama.

Science education reform which includes implementing Studio teaching in different STEM areas should be encouraged in those countries, perhaps with help from international academic cooperation.

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