IL NUOVO CIMENTO **38 C** (2015) 93
DOI 10.1393/ncc/i2015-15093-2

Colloquia: GIREP/MPTL 2014

An American instructor in an upper-level Italian physics class

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received 26 October 2015

Summary. — In this paper, I report on my experience in teaching a 3rd-year undergraduate physics class at the University of Trento during the Spring 2014 semester. I address questions relating to the application of active-learning techniques, usage of English language in the classroom, and student reactions to an innovative style of pedagogy.

1. – Introduction

Interactive engagement strategies are becoming more and more common in physics classes in the United States. While this approach is utilized mostly in introductory classes, it is gaining favor in upper-level classes as well. For example, the University of Colorado group has been conducting an extensive research program on such methods in the advanced courses at their own institution [2, 3, 5, 6, 10, 11]. In my experience at George Washington University, I have used such techniques (Peer Instruction [9], electronic "clickers", active learning) for over 15 years, and in the past 6 years, we have been employing the SCALE-UP collaborative group-learning approach [4,13] in our introductory classes. When I had the opportunity to come to Italy in Spring 2014 and teach an upper-level class in nuclear experimental techniques, the pedagogical style that I would adopt became a pressing question. How would the Italian students respond to a more actively engaged environment in the classroom?

Before the class began, my initial impressions were that the physics classes in Italy were taught in a rather conventional style, using formal lectures with lessons written on the blackboard and with relatively little input from the students in the classroom. Colleagues at the University of Trento more or less confirmed that this was indeed the case, and that the students in the class would not be accustomed to taking such an active participatory role in the classroom activities. In addition, the class would be taught in

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English, which is not the norm for the undergraduate classes at Trento, and so the issue of language became an important factor to take into consideration. Since the class was offered as an elective for the 3rd-year undergraduate students, their participation was optional (*i.e.* they could drop the class if they did not like it), and so a balance had to be established between trying out some of these active-learning techniques in the classroom and "testing the tolerance" of the students who were mostly accustomed to a more passive classroom environment.

Overall, during the period of my visiting semester in Italy, I wanted to immerse myself in the pedagogical culture and explore the following research questions:

- Is there a predominant pedagogical style in Italian physics classes?
- What are the attitudes of the undergraduate students about science in general, and about doing science in particular?
- What are the reactions of the students towards an active-learning classroom? This can be broken down into 3 components: satisfaction, performance and perception.
  - ✓ Did they like the more interactive environment?
  - ✓ Did they participate fully in the activities performed during the class period?
  - ✓ Did they perceive any educational benefit from the higher level of engagement?
- Was the English language issue a major handicap in teaching the class?

In this paper, these questions are addressed within the context of the limited case study that was carried out over the period of my visit. I describe my experience in this upper-level Italian physics class and present the approach that was followed in introducing to the students some of the pedagogical innovations that have been developed in recent years. The assessment methods used to evaluate the performance of the students in the course are also explained. Finally, I present a retrospective summary of how this experiment fared, along with feedback from the students themselves on how they perceived the active-learning experience in this class.

2. – Course description

The course in question was Experimental Techniques in Nuclear Physics, which was an elective course for 3rd-year Italian undergraduate students in physics at the University of Trento. The course comprised 48 academic hours, which was broken down into two 2-hr classes per week for a period of about 12 weeks. The course did not have a laboratory component. While the undergraduate courses (in years 1–3) are normally taught in Italian, in this case the course had to be taught in English, since the instructor did not speak Italian! However, since the master's courses (years 4–5) are all taught in English at the University of Trento, the students are generally prepared for a course in English at this point in their academic life.

The enrollment for the class was 9 students. In Trento, the 3rd-year cohort of students numbered about 50–60, and with six elective courses available to them, class sizes were generally in the range of 8–12 students for each elective. The course was delivered in a lecture format using PowerPoint slides, but with many active-engagement elements that are described below. The assessments in the course were based on a written mid-term exam (worth 35%) and a final exam consisting of both written and oral components (worth 30% and 35%, respectively).

Week	Topics
1	Basic Nuclear Processes and Radiation
2	Interaction of Radiation in Matter
3	General Characteristics of Detectors
4	Ionization Detectors
5	Scintillation Detectors
6	Semiconductor Detectors
7	Neutron Detection Techniques
8	Basic Features of Nuclear Experiments
9	Particle Beams and Photon Beams
10	Nuclear Electronics and Signal Processing
11	Data Analysis
12	Nuclear Laboratories Around the World

Fig. 1. – The course syllabus, listing the topics in chronological order.

Over the semester of 12 weeks, starting in mid-February and going until early June, we covered a series of topics that are outlined in the syllabus shown in fig. 1. The first two weeks were used to review basic material that is generally presented in a Modern Physics course involving very basic quantum physics. The next five weeks were dedicated to various types of detectors, including gaseous detectors, solid-state detectors and scintillators. With that critical background in hand, the remainder of the course explored various aspects of nuclear physics experiments, including accelerators, production of particle and photon beams, electronics, and data analysis. Three textbooks [7, 8, 12] were used to provide the reference material on which the lectures were based. In the final week of the course, we also had a full-day field trip to the INFN nuclear laboratory in Legnaro (near Padova), which gave the students first-hand exposure to the activities at such a national laboratory and the daily life of nuclear physics researchers.

The lectures were delivered in a rather informal style, more reminiscent of a "running conversation" with the students. There was much back-and-forth discussion, with input being continually sought from the students as things moved along. Beyond these close interactions with the instructor, there were many opportunities for group discussions among the students themselves. This could be in the case of a numerical problem that they had to solve together, spending about 15 minutes to do so, or it could be in the case of Peer Instruction [9], in which they had to respond to conceptual questions using an electronic response system ("clickers").

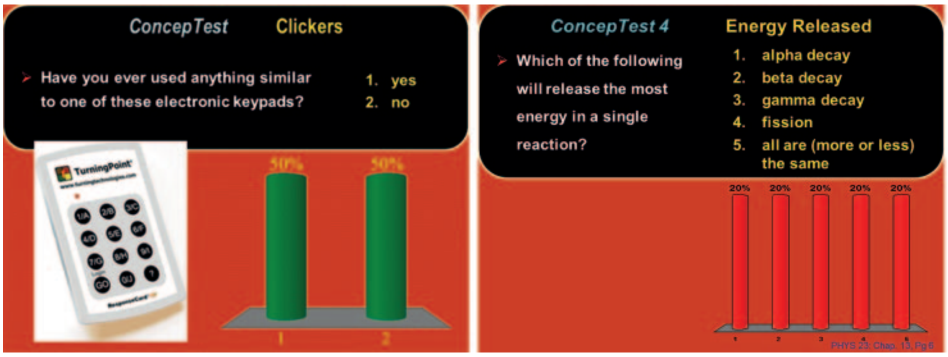

Fig. 2. – Examples of "clicker" questions using the *Turning Point* keypads.

Two examples of the latter are shown below in fig. 2. We used *Turning Point* keypads [14] for the Peer Instruction questions. The small hand-held keypads (shown in the left panel of fig. 2) were provided to the students by the instructor – keypads were distributed at the beginning of the class period and collected at the end. Each question would entail about 2–3 minutes of discussion among the students, followed by the acquisition of their electronic responses, and then the resulting histogram would be shown, promoting further discussion. Ultimately, the group would agree on the right answer, and after a satisfactory explanation was provided (by the students, hopefully), we would move on to the subsequent material.

3. – Results

The first research question related to the typical or common pedagogical style for a physics class in Italy. During the course of the semester, I had the opportunity to observe the classes of two different instructors, for a total of about 10 class sessions. One of these was a 2nd-year class and the other was a 3rd-year class, both of which were required classes for those particular cohorts. Based on my observations, I concluded that these classes were delivered in a very standard and conventional lecture format, where the instructor talks for about an hour at a time and the students sit passively and listen, while taking notes. Very few questions (if any) are posed by the students during the lecture period. Moreover, leading questions posed by the instructor to the students were very rarely answered by the students. In most cases, the instructor was forced to answer his own question, in order to keep the class moving along. Overall, there was very little interaction between the instructor and the students.

3·1. *Student attitudes about science.* – Another question was related to the attitudes of the students about science. Attitudes held by students evolve over time as they develop in their respective fields. Initially, student behavior may reflect a more "novice" attitude, but with growth and maturity, this becomes more "expert" as time goes on. One of the newer surveys that has been developed to gauge this "expert-novice" spectrum of attitudes is the Colorado Learning Attitudes about Science Survey (CLASS) [1]. This survey consists of 42 questions that are grouped into 8 general categories:

- Sense-making/effort
- Personal interest

- Real-world connections
- Conceptual understanding
- Applied conceptual understanding
- Problem solving (general)
- Problem-solving sophistication
- Problem-solving confidence

Based on the students' responses to these questions, including numerous questions that probe the same category along different dimensions, an evaluation of the degree to which the student demonstrates "expert" or "novice" behavior is determined. For the 9 students in my class, the results are shown in fig. 3 below. In all categories, the expert column far exceeds the novice column, and four of the categories are over 70% in the expert column. In particular, the very important categories of Sense-making/Effort (86%) and Personal Interest (78%) scored the highest in the expert column. Almost all of the novice ratings are below 10%, with only one exception (which is only 16%).

3·2. *Student language ability.* – Another research question was related to the usage of English language in the class, and in retrospect, this proved not really to be an issue at all. The students' English language abilities were good, although it is worth noting that not all of the students felt completely comfortable speaking up in class. While the language seemed not to be a hindrance in class, it may have contributed to slow progress on the written exams. In general, the students needed extra time to formulate complete answers on these exams, and so an exam with 8 problems that was intended to last for 2 hours ended up continuing on for 3 hours (or in the case of the final exam, for 4 hours). However, I found that the oral component of the final exam was actually an excellent test of the language skills of the students. Their performance on this part of the final exam was really quite impressive, their knowledge of the material was extensive, and their verbal explanations were clear and always understandable.

Category	Expert	Novice
Sense-making / Effort	86%	3%
Personal Interest	78%	4%
Real-World Connections	69%	6%
Conceptual Understanding	74%	9%
Applied Conceptual Understanding	57%	16%
Problem Solving (general)	74%	6%
Problem-Solving Sophistication	61%	4%
Problem-Solving Confidence	67%	8%

Fig. 3. – Results of the CLASS science attitudes survey.

3˙3. *Active learning in the classroom.* – The biggest question of the entire semester, however, was the reaction of the students to the many active-learning elements that were used in this particular class. The expectation was that this would be very different from their usual experience in other classes, and so it was not obvious at the outset how these activities would be viewed or accepted by the students. What I found was that the students were very excited about the active-engagement techniques (in particular, the use of clickers) and had no hesitation whatsoever about participating in classroom discussions. Questions posed in class were widely argued and debated by the students, and clarification questions originating from the students themselves emerged quite spontaneously. The clickers were used primarily in the first half of the semester, and the lack of clicker usage in the second half was noticed by the students, who wanted to continue using them more frequently. In addition, the organized class field trip to the INFN nuclear laboratory in Legnaro was itself a highly engaging active-learning experience, and moreover, it was specifically cited by several students as one of the highlights of the entire course.

Before examining student feedback in more depth, it is worthwhile to consider a comparison between the Italian students and typical American students. While there were many similarities between the two groups (perhaps not a surprise), there were also some interesting differences. The Italian students were equally active in the classroom, despite not having an appreciable level of such experience in the past. They were equally willing to interact with the instructor on a rather informal level, even though their prior experience had been in a much more formal relationship with their other instructors. The Italian students were very willing to accept new conditions, and they demonstrated a higher level of preparation and background in the basic physics fundamentals than their American counterparts. In addition, as a purely anecdotal remark, the Italian students did not complain about things in the class, which is (unfortunately) a common behavior pattern among American students!

3˙4. *Student questionnaire.* – As a means of gauging the reactions of the students to the innovative elements of the course, an online survey was given in the last week of the semester. All 9 students responded to the survey, and an overview of their responses is given below. First of all, they were asked to rate the level of interactivity for this course, and also for their other courses. The answers were based on a Likert scale in the range 1–10, where 10 indicated the highest interactivity. The results for this question are displayed in fig. 4.

The average level of interactivity was 8.6 for the present course, as opposed to 4.2 for the other courses. It is also clear from the bargraph that the responses for a given case were more or less consistent with each other — that is, they were generally clustered together and there was not a great deal of variability in the responses for a given case. As shown in fig. 4, the responses for the present course ranged from 7 to 10, whereas the responses for the other courses were in the range of 3 to 6.

The students were also asked how much they think they learned in the course. The responses were also based on a Likert scale in the range 1–5, where 5 indicated the highest knowledge gain. The responses to this question are shown below in fig. 5. As can be seen in the figure, the majority felt that they had learned a lot in the course, with all of the responses being at the level of 4 or 5 on the Likert scale.

Finally, several qualitative questions were posed to the students, with open-ended responses. These are listed below, and a summary of the student comments is given. Several aspects were covered in these questions, such as: 1) differences between this course and the other courses in the students' curriculum, 2) reactions to the use of

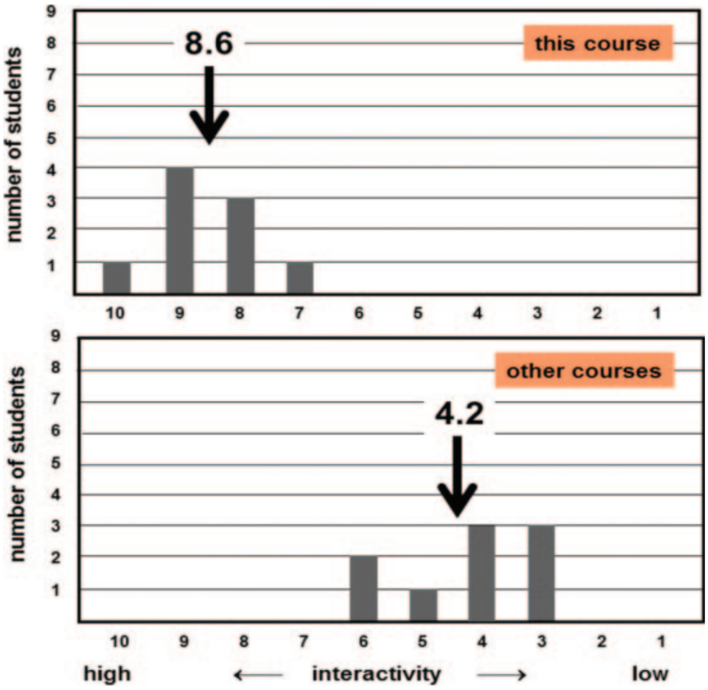

Fig. 4. – Student feedback on levels of interactivity in the present course (top panel) and their other courses (bottom panel). The average for each case is indicated by the arrow.

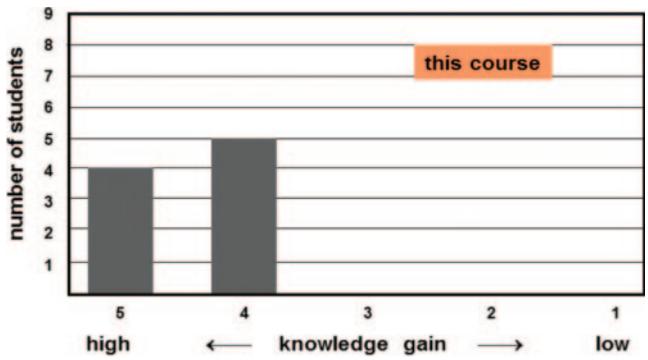

Fig. 5. – Student feedback on perception of knowledge gain in the present course.

clickers in the classroom, 3) most useful features of the course, 4) things that should be changed in the course, and 5) any additional comments that the students would like to make. The students' responses are faithfully reproduced, directly as written by them, with only minor corrections for some spelling mistakes. Other than that, the words are the students' own words.

(1) How did this course compare to your other courses in Trento? In what way(s) did you find it to be different?

- In this course there was much more interaction and discussion than any other attended courses.
- I've found this course very different from the other courses in Trento. I've really appreciated the way in which the professor interacted with us asking quick questions that helped us to better understand the concepts.
- It was less formal then the other courses and the lesson were lighter to follow. Especially at the start when we have to answer simple problems with "clickers", it was a nice way for having a small break!
- From all other courses it's different because of the high interactivity between the students and professor which makes it easy to follow and highly explicative.

(2) Were the electronic keypads ("clickers") used in the first half of the semester useful to you? Did they help enhance your understanding of the course material?

- Yes, they were useful as they allow to test immediately our understanding of the concepts.
- Yes, it was really useful both for introduce the argument and for understanding if we have really understood the concept of the various lessons.
- They were useful: the need to give a fast answer to a question makes you realize if you really understood a concept.
- Yes of course. I like it, because in another classes, the teacher asked to us a question, but only one or two persons answered, in this way all the people have to answer.
- They were really useful because they made the class discuss on the question right after a topic had been explained by the teacher.

(3) What aspect of the course was the MOST useful to you?

- Slide used was a nice way to keep the attention. Few people use it in Trento but they are good because if you lose yourself in some thinking when you get back to the lesson you can easily recover what was lost.
- The way things are explained! Everything is explained clearly and in a simple manner in class and then is well integrated by the textbooks.
- The English language.
- The talking, or, more generally, the interaction. During the semester I realised that I was more prepared on this course rather than the others, with less studying.
- The use of English to improve this language, but also the examples in every argument.
- I think the experimental argument, because in Trento there aren't courses like this. If you want to do experimental physics, you have to know this stuff!

(4) If you could change ONE thing in this course, what would it be?

- So I think it could be useful to have a little amount of laboratory hours, just something like three or four hours, for touch with hands some easy detector and detection circuit.
- I don't know how but I want to see an experiment from the beginning to the end (maybe little stupid experiment).
- Exam modes.
- Number of exercises in the written exam.
- Maybe more exercises in the second part of the course (the one with particle beams and accelerators).
- Also use the electronic keypads in the second part!
- I would not change anything!

(5) Any other comments?

- The trip in Legnaro was very interesting and stimulating! It was a great opportunity for us to visit a laboratory. The teacher didn't correct our English, it was a good thing for communication especially at the beginning of the course.
- More keypads! More keypads for everyone! Ok, apart from jokes, this course was a really nice experience, I'm glad I took it.
- I like this course and I will explore these topics again!
- We should definitely have a pizza in July.

4. – Summary

As an English-speaking American instructor, I spent the Spring 2014 semester teaching a course (Experimental Techniques in Nuclear Physics) to 3rd-year Italian undergraduate physics students at the University of Trento. The course employed an active-learning approach in which the students were fully engaged in the classroom activities and were enthusiastic participants throughout. This was accomplished through frequent questioning, generally achieved by using an electronic student response system ("clickers") and also by posing numerical problems that the students would solve collaboratively in class.

The end result of this pedagogical experience proved to be highly favorable, as perceived both by the students and the instructor. The overall student performance in the course was excellent, and student engagement seemed to be maintained at a high level, from the perspective of the instructor. Student reactions were explored in an end-of-semester survey, and the self-reported responses in that survey were quite positive. The level of interactivity in the course was judged to be extensive, and the student perception of knowledge gain was also considerable.

While the study reported in this paper is admittedly limited, it is my opinion that the disposition of the Italian students was quite appropriate for an active-learning environment and that they would benefit tremendously from such an approach in the introductory classes. Working through the physics material together in class and solving numerical and conceptual problems in a collaborative manner could yield sizable learning gains. It would be very interesting to try a similar experiment in one of these lower-level classes, with a larger student population, to see how those students would respond to an active-learning approach in that particular case.

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I would like to thank the U.S.-Italy Fulbright Commission for the Fulbright Fellowship that made my semester in Italy possible. I am also grateful to the Department of Physics at the University of Trento for additional support and for their warm hospitality. Finally, I would like to express my deepest gratitude to G. Orlandini and W. Leidemann for their friendship, insights, and experience, all of which greatly enhanced my visit to their institution and their city.

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