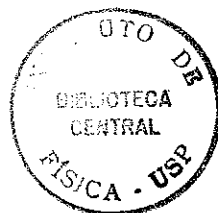


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ANALYSIS OF INSTITUTIONAL RELATIONS IN AN
INTRODUCTORY PHYSICS COURSE

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AN INTRODUCTORY PHYSICS COURSE

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ABSTRACT

An analysis of institutional relations in an introductory Physics course at the University of S. Paulo, led to different representations for the pedagogic processes, which had taken place in the laboratory and theory classes. The theory classes could be interpreted as an instrument for the initiation of students in Physics while laboratory classes could be interpreted only as a process of disciplining the student's time and behavior through experiments and similar activities.

The effects produced on the students in the theory classes can be summarized as the identification of: a) Science as the legitimate representation of Nature and teachers as the representatives of this science, capable to demonstrate their "intimacy" with natural phenomena; b) the hierarchy present in the pedagogical relation as the consequence of the distance between the "World of Science" and the "Common World".

Disciplining the students' time and work in the laboratory classes was achieved by prescribing their behavior, centralizing the planning of experiments and reducing the pedagogical objectives to mere teaching of techniques and

treatment of data in "pre-mounted" experiments.

The predominance of the effects of theory classes with respect to those of laboratory classes may be inferred from the schedule of the two types of classes and their articulation in the composition of the course. This result may be interpreted as uncovering that at the Physics Institute and probably at most institutions in Brazil the theoretical research is overevaluated with respect to experimental research.

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INTRODUCTION

In the research on Physics Education, analysis of courses has generally focussed on the aspect of the coherence and efficiency of their programme or of the adequacy of their content to students' mental level or of their ability in promoting students' motivation (Tawney 1976).

On the other hand, often research in general Education has been pushed by another preoccupation: the wish to discover "implicit" learning transferred to students by means of school social context. This learning refers to the values and world vision of the institution⁽¹⁾ and has no (or very little) reference to the explicit content of teaching and the abilities developed by the students.

The present work is almost a middle term between the ideological purpose present in the latter type of research and the pedagogical preoccupation of the former. We would like to make clear how an analysis of pedagogical relation, between teachers, students and other institutional "actors" involved in a Physics course, may give us extremely valuable support for promoting a deeper understanding and improvement of teaching (Villani 1982).

The results of our work, although restricted to an introductory Physics course at the University of S. Paulo, are a starting point for more general considerations about understanding and experience of teaching. We are convinced that the procedure adopted in the present analysis can be easily adjusted

(1) This type of investigations was inspired, at least partially, in the ideas of L. Althusser (Althusser 1965 and 1970) and of P. Bourdieu and J.C. Passeron (Bourdieu 1964 and 1965). In Brazil was significant the work of B. Freitag (Freitag 1977).

to the teaching situations of other Sciences and subject matters.

1. ANALYSIS: FOUNDATION AND METHOD

Our research had as a standpoint the conviction that there exists a correspondence between the manner in which one acts in an institution and the way he represents himself and others in daily activities. In other words, social relations effectively maintained in daily practice between institutional actors have a parallel in the images presented in the descriptions that the same actors make about this practice. We supposed that the manner, in which every actor was considering institutional roles, would be a condition for characteristic behavior in his role, and the way in which every actor was experiencing his pedagogical relation in the institution would be condition for the formation or reinforcement of his images about himself and others.

As a consequence, the analysis of images, which appeared in the speech of the actors (teachers, students, instructors, technicians), and observation of what was happening daily at the college, gave a basis for localizing and combining coherently social relations that the institution was reproducing continually⁽²⁾.

The theoretical support, which guided our analysis, came from political sociology: it helped us in categorizing

(2) In the articulation of the relations between discourse and social relation, the model was using as a starting point the ideas of M. Foucault (Foucault 1961, 1974 and 1976), E. Goffman (Goffman 1961 and 1963).

the types or relations involved and characterizing institutional actors. So, in our institution we found dominant and subordinate agents, clients, institutional objects, field of action, etc., all of which were identified according to the characteristics of the theoretical model (Albuquerque 1978).

Also of valuable help was the division of the analysis in characteristic levels depending on the type of effect being focussed on: so we considered a level of "practices", in which specific effects - "ideological", political and economical" - were taken into account; a level of "apparatus", in which the effects of articulation of various practices were analyzed, and a level of "social form", in which the global effect of the institution was localized (Albuquerque 1980).

The work consisted in extracting the fundamental images, present in the actors' reports, and articulating them coherently and significantly till the final picture assumed a complete form by which one could understand the meaning of the actions.

Evidently, in articulating the data, we were doing a work of interpretation; the more the interpretation advanced, the more it depended on our theoretical and ideological context, for articulations followed the directions implicit in the theoretical model. This aspect required the establishment of well defined criteria of reliability and validity: we considered internal and external criteria. Internal criteria were characterized by attention to the model's self-consistency, to the coherence of the results and to the completeness of the data. External criteria were characterized by attention to the plausibility and importance of the results with respect to the institutional context. In this sense it was fundamental that

the final picture would contribute in improving the understanding of what was happening daily in the institution. This would be done by the discovery of the "mechanism" for reproducing the social relations between actors and the relations between institutions. It was important as well that the actors themselves, when consulted about the picture, would, at least partially, recognize their roles and their attitudes. It was also relevant that other persons, who had some relation with the analyzed institution, recognized the picture as faithful or, at least, as not incoherent with the context in which the institution was acting.

2. ANALYSIS: PROCEDURE AND DATA

After the description of the foundation and method of our analysis we think it will be useful to describe in some detail the data and the procedure adopted, so that a critical idea of the meaning of the results can be obtained.

We collected 24 interviews with duration between half and one hour. Nine lecturers, all involved with theory or laboratory teaching of the same course and 15 students of the corresponding classes have been interviewed. The interviews consisted basically in describing the course of Physics, mainly the activities and their nature and meaning. Following the informal scheme, we induced the interlocutor to describe as completely as possible the principal activities referring to teaching performed in and out the classes.

The analysis of the interviews was done in various

steps of progressive interpretation⁽³⁾. At the beginning we divided the interviews referring to the theory classes from those referring to laboratory classes and developed an appropriate analysis for each, before comparing them. This separation was motivated by the feeling, experienced during the interviews and in our daily life at the Physics Institute, that the two types of classes had a different meaning in the formation of students⁽⁴⁾. The analysis began with the theory classes.

The first step was to localize the significant images from which to start in the research of pedagogical relations in the theory classes. This was done dividing the actors' talks in little parts with common object of representation. We separated all the passages of the interviews of each type of actors (teachers, students, instructors) in which the discussion was about text-books, experimental demonstrations, lecturers or relevant matter. These passages were a starting point to detect direct or indirect relations between actors and institution and to translate them into images. The resulting images were classified, according to the effects produced by the relations on the actors, as referring to ideological or political "practice" (economical practices were not important in the context of the analyzed institution).

The second step was to try to obtain a synthetic image (or synthetic images) of the opinion of the teachers about every object in theory classes and the corresponding

(3) An analogous work on a Public Agency of Wealth, which inspired our work was published by J.A.G. Albuquerque and A.E. Ribeiro (Albuquerque 1979).

(4) The analysis confirmed, as will be seen later, this feeling by showing differences in the institutional effects. But a similar division, which we operated between two groups of teachers in theory classes, did not lead to differences in the pedagogical relations.

institutional relation: this was done comparing all the passages and reducing them to what was common or different. Progressive articulation of the various images and corresponding relations gave us the final vision of teachers about theory classes.

After repeating the same procedure for students' interviews, we began the third step: to obtain a final representation of theory classes. This was done at first by comparing the students' vision with the teacher's; secondly, different practices with common effects were articulated in order to obtain an ideological and a political "apparatus" and, finally, by analysing them, it was possible to point out the predominance of the ideological effects, aiming to modify the world vision of the students. The same sequence of steps (classification of images, elaboration of a vision of teachers and students, comparison of the two visions) was repeated for the laboratory classes. We obtained a final representation pointing out the predominance of "political" effects, aiming to discipline the students.

The final step was to compare the different representations of theory and laboratory classes with the purpose of obtaining the principal effect of the analyzed institution on students and other actors. This was identified as the change or the reinforcement of the ideological vision of the actors on Science and Teaching. Finally these results were interpreted in the wider context of scientific research and academic formation. We think that all these effects contribute to the actual reproduction of part of conditions, which allow for the existence of scientific research and human domination.

After these methodological considerations we will

describe the final picture⁽⁵⁾, which emerged for the introductory course "Physics 1 and 2" at the Physics Institute of the University of São Paulo, which involved lectures and laboratory activities. Subsequently, in sections 3 and 4 we will present, respectively, the pictures for theory and laboratory classes and in the last section we will discuss the global vision, including the relation between theory and laboratory, not only in the institution but also within a more general context.

3. THEORY CLASSES

A detailed description of the cumulative processes by which we obtained the final representation of theory classes, will give a more concrete idea about the procedure of our analysis.

The descriptions of teachers about text-books, experimental demonstrations, lectures, evaluations, lists of problems, private and public contact with students, etc. were different. Some of the teachers preferred theoretical discussion, others insisted in mathematical analysis, others privileged phenomenological description in their lectures; some of the teachers were more liberal in treating and evaluating students, others imposed to students lists of exercises, suggested them to repeat experimental demonstrations, induced them to read some books. In spite of these differences in the described activities, the images of the relations between students and lecturer were rather alike and uniform. A first articulation

(5) More details about the analysis and the final picture may be found in the master thesis of one of us (Kishinami 1982).

of these images produced a synthesis of them in a relatively small number of "categories"⁽⁶⁾ which served as a basis for the final representation. So, from the point of view of lecturers, the teacher appeared as the one who knew and was in communion with glorious and superior knowledge (Physics), who prevented any deviation from orthodoxy, who was always operating a transformation in the students, who conducted them towards the knowledge, who was continually manifesting to the students his familiarity with the scientific way of observing phenomena, etc.. Therefore, from the point of view of lecturers, the final representation about the role of teacher was to open the mind of students to true knowledge about Nature.

From the descriptions of students about the same objects of representation we obtained a parallel series of categories in which student appeared as the one who adopted the teacher as a guide and a model, who forgot the past or referred to it as a source of incomplete and erroneous knowledge, who was always considering Physics as the most important discipline, who accepted the rules imposed by the institution as necessary to reach the true knowledge, who had a good mind to become a "new man" (a researcher) etc.. So from the point of view of students the final representation about the role of student was to take pains for being transformed in a "new man" similar to the teacher and with the help of the teacher.

These representations were synthetized by a final one in which theory classes appeared as a process of "initiation" of the students to a Superior Knowledge with the teacher as the

(6) The meaning of the term "category" in the content analysis may be found in the work of O.R. Holsti (Holsti 1969); we used this term in an analogous and not completely rigorous manner.

privileged mediator. This final representation, which gave us a synthesis of the developed activities and explicitated the pedagogical relations between students and teachers, has as the most likely analogue the religious initiation.

As a consequence, the fundamental effect in the theory classes was ideological, because there were the transmission and the reinforcement of a certain concept of what is science, what is a scientist, a teacher and a student, what is a "natural" relation between them; this vision involved also the demonstration of how this concept might be reproduced and diffused. The picture had three focusses: Knowledge, teacher and students.

There is a Superior Knowledge, the possession and intimacy of which are reserved to the teachers, who succeeded in reaching them by means of work and scientific research. This Knowledge is the point of attraction and the final goal for the students.

The teachers' vision of this Knowledge is almost sacred, for they have a compromise of fidelity to it: they could not vulgarize it nor reduce the level of their teaching activities. In revealing this Knowledge to the students, by means of explicit teaching and, above all, by the way of seeing and analyzing physical phenomena, teachers are constituting themselves as guides able to initiate their disciples to the misteries of this world.

The fundamental and implicit objective of all the teachers was the same: to promote the recognition of Physics as the privileged way for the true comprehension of Nature. This implicit objective was fulfilled in different ways, depending on the characteristics of the teachers. But, above the different ways of focussing teaching, the different pedagogical methods

adopted and the different didactical instruments employed, the teachers had always in mind their compromise of fidelity to and diffusion of the Knowledge.

Another implicit objective fulfilled by means of the proposed activities and the maintained relations was the recognition of the hierarchical place of the teacher. He was the privileged mediator between students and knowledge, for his action on the students was transforming and initiating them to the misteries of Knowledge. As a consequence of this way of thinking, teachers considered their hierarchical relations with students as "natural", ignoring the role of the institution in the construction of this type of relations: the hierarchy had its basis in the distance between scientific knowledge and common knowledge.

This picture was not only confirmed in students' images, but was also complemented in a richer synthesis. As mentioned above, the students would reach the Knowledge subject to some conditions: forgetting their past (high-school learning) with its flows and abandoning themselves in the teachers' hands. In this way they would be guided with security towards the Knowledge and transformed into "new man", future researchers.

This work of transformation was operated by means of a series of didactical instruments, in order to discipline students' activities. Therefore more mechanism for direct contact between teachers and students were created, so that the right direction for the transformation could be guaranteed.

The likeness and complementariness of the students' and teachers' visions supported our interpretation that the ideological effect of the institutional activities was dominant.

4. LABORATORY CLASSES

The same type of analysis of the interviews with the coordinating professor, some students, their teachers and a technician, led us to completely different results with respect to the didactical laboratory. The final representation which gave us a synthesis of the activities developed in it, as defined by the pedagogical relations between the students and the other actors was the "training camp for experimental activities", the most likely analogue of which is the scouts' camp.

The principal effect of the institutional activities was a domination on the students' and teachers' behaviour (a political effect), although there were also ideological effects involving reinforcement and change of values in the world vision of the institutional actors. The students (and also the teachers) were learning to behave in a determined manner, executing tasks independently of their meaning. The organizing staff was continuously inventing activities, the effect of which was to discipline the time and conduct of students and teachers.

The picture had three focusses: the coordinating staff and his way of organizing, the relation between the students and the teachers, the daily routine and the ways to "escape" from it.

In the didactical laboratory there was a coordinating staff, composed by a coordinator and some assistants, whose role was to plan the organization of experimental and complementary activities to be executed by students and teachers. Although the coordinator was open to receive suggestions from teachers and students, the complexity of the organization

allowed only partial improvements to the basic scheme of activities. The initial scheme of activities - reading of mimeographed text-book, experiments with pre-mounted equipment, report and its evaluation - was progressively modified with the introduction of seminars, home-experiments, projects, bibliographic research, electro-mechanic workshop. Although this increased the interest of some students, the global effect was to maintain all the students and their teachers more occupied.

The pedagogical relation between the teacher and his students was permeated by the invisible presence of the coordinating staff, who elaborated the mimeographed text-books, established the way of working with the pre-mounted instruments and produced a guide for teachers. The consequence of this type of organization was to characterize the laboratory classes as training camps, in which the role of the teachers was that of "technical assistants" during seminars and experiments and "inspectors" during the revisions and evaluations of the students' reports. This vision was reinforced by the images of the students and the teachers about the knowledge involved in the laboratory classes.

It was not a "glorious Knowledge", the possession of which was guaranteed by means of continuous activity of research and whose image constituted the stand pont and the reference for all the activities. On the contrary it was a "technical knowledge", which might be obtained by simple training and which ultimately was restricted to a manipulation of the instruments and a naive treatment of the experimental data obtained during the experiments. The image of daily routine, repeated during each experiment, was a mixture of oppression and cheerfulness. A more spontaneous and friendly

personal relation between the students and the teacher, a joyful exploit of ludical elements during the experiments and, sometimes, an imaginative working up of the projects, formed a picture of pleasant activities. On the other side it was not difficult to find also some behaviours of "flight" in the students. Sometimes they copied their reports from those elaborated by colleagues in antecedent years; sometimes they "adjusted" their experimental data to the theoretical previsions; sometimes they dedicated a desproportionate time to the elaboration of the theoretical introduction of the report, although they know that the teacher would consider this work of little importance. In this manner the students were avoiding the painful repetition of a training activity such as a report, the patient research for the causes of unexpected data, the sad sensation of working far from Physics.

The teachers themselves presented also some attitudes very similar to "flight", as when they did not consider some activities of the students or substituted them by others equally distant from the introduction to experimental Physics. In this way they protested silently against the organization of the laboratory classes and the lack of meaning of some activities.

5. FINAL CONSIDERATIONS

After completing the representations of theory and laboratory classes, we compared them in order to find the relationship between these classes and consequently to identify the fundamental effect of the course Physics 1 and 2. As we have mentioned previously, the subject matter of Physics

developed in the laboratory was not original, because the knowledge aimed at was technical in its nature. The Knowledge which constituted the object of the students' desire was introduced fundamentally in the theory classes, leaving to the laboratory the function of confirming or demonstrating the plausibility of that theoretical Knowledge. Not-with-standing the importance of this function in the students' formation, from the point of view of the content the laboratory classes were subordinated to the theory ones. However, the structure of the laboratory, with the organization of its activities, was independent from theory: not only because their programmes were elaborated by different groups of teachers, practically without communication between them, but mainly because theory and laboratory produced different effects. This difference - changing of mentality for the theory classes and disciplining for the laboratory ones - produced a sub-product: it was the competition between the two programmes in order to maintain in their sphere the interest, the time and the behavior of the students. From this point of view, laboratory and theory constituted two (half-dependent) disciplines, in similar position than Chemistry or Calculus, with respect to Physics.

In order to understand better the difference between theory and laboratory classes, we have focussed the role and the behavior of the teacher: the following table will give us a global insight of their asymmetrical activities and relations.

Teacher of theory classes	Teacher of laboratory classes
- The owner of the programme of the course.	- Little participating in the planning of the activities of laboratory.
- Completely autonomous in his decisions, being able to change the programme.	- Relatively autonomous in this decision: he had to obey to a common sequence of detailed activities.
- Using the knowledge acquired in scientific research.	- Very little using the knowledge acquired in scientific research.
- With a compromise of fidelity to theoretical knowledge.	- Without compromise with technical knowledge of the laboratory and treating it only instrumentally.
- A model, guide and tutor of students.	- "Technical assistant" and "inspector" of the discipline.
- Always with a hierarchical relation to the student, being the mediator between Knowledge and the student.	- Frequently acting as a adviser, sometimes putting himself on the same level as the students.

According to this vision, theory classes had a predominantly ideological effect and developed a teaching model like initiation, in which the professor was a dominant figure with the role of model, master, guide and sage. On the other side, laboratory classes had a predominantly political effect and developed a model of teaching such as training, in which rules and behavior (not wisdom and ways of thinking) were learned, and the teacher might be substituted by a technician

or a well trained instructor⁽⁷⁾.

Did we succeed in obtaining a coherent vision of the discipline or must be satisfied with two opposite pictures? To answer this question we had to enlarge the perspective of the analysis and to consider theory and laboratory classes in the context of the formation of physicists.

What was the meaning of two different dominant effects in a same discipline? Which of them was the fundamental? In our opinion four considerations may be done to clarify the problem.

In the first place, the ideological effect was, without doubt, more important, for it was constituting the basis for a reproduction of the conditions which, in the present situation, make the continuity of scientific research in Physics possible. On one hand, this effect is actually the beginning and the interior impulse to desire, to realize and to continue a research, and on the other hand it makes possible that the society recognizes the importance of Physics and its research.

In the second place, the effect of "disciplining" (learning to act according to previously determined rules) was present also in the theory classes. It is important for the students' formation, because when they have to act in research or in teaching, they must learn rules, make reports, submit their behavior to an external control, at least if the present situation should not be radically modified.

In the third place the difference between theory and laboratory classes, when analyzed in a more general context,

(7) A more detailed discussion on the characteristics of "initiation" and "training" and its consequence in the course may be found in our work in preparation.

was interpreted as a "cristallization" of two competitions existing at the Physics Institute and probably at most institutions in Brazil. From one side there was the most evident competition between the formation of students able to think in a proper manner and the production of students trained to act with efficiency. From another side there was the competition between theoretical and experimental activities.

With respect to the first competition we can present the following considerations. The almost void of "initiation" to the "wisdom" of experimental Physics in laboratory classes is actually object of polemics at the Physics Institute. Some people hopes that the laboratory will become the place in which students will be introduced to the "misteries" of experimental research, some others are considering this vision unfit to the students' reality. On the other side we think that the tendency to render teaching more similar to training is reinforced by the pressure made by agencies supporting academic research.

With respect to the second competition we may say that the priority of theoretical activities was not restricted to our discipline or to the period of time of our analysis. We had notice that the same type of lamentation occurred in a Brazilian Congress about Physics teaching in the decade of fifty (Prado 1980; Hamburger 1982).

These considerations reveal, in our opinion, important characteristics of the conceptions of the Scientific Community about the formation of Physicists and make clearer the conditions for two different types of course to exist in the Institute of

Physics⁽⁸⁾. We hope that our analysis will help in further clarifying these aspects.

In the introduction of this paper we suggested that the procedure adopted in the present analysis could be useful in a more general context. Without doubt, the observations done on laboratory classes of the discipline Physics 1 and 2 and the comparison between theory and laboratory may be enlarged to the Physics teaching in every level. But we hope that the same considerations may be useful also for other types of Science Education. There also, either the teacher is a center of the pedagogical process, in the sense that he is the owner of the programme, establishing the priorities of teaching and starting from his knowledge, or an external instancy imposes a series of didactical materials, methods and programs. In this case the relation between teacher and knowledge is not direct but is mediated by his continuous reference to an external institution or to another field of activities socially recognized (research). Consequently, the relation between the students and the knowledge is principally mediated by these didactical materials, allowing many times the modification of the teacher's role to a burocratic one, the by-product of which is the disciplining of time and behaviour of the participants in the teaching process.

We think that these situations observed in the relations between students and teachers may be easily extended to a more general analysis about the effects of general Education.

(8) We think that these considerations are consistent with the description of T. Kuhn (Kuhn 1962) about the formation of future researcher in the Scientific Community. On the other side, in our opinion, the difference in the manner of realizing this formation may be linked with differences in the distribution of the power in the Community.

In our opinion in all educational institutions the teaching involves, at least partially, some manifestation of power on persons. At times this power is legitimated by knowledge and the pedagogical process assumes the characteristics of an initiation; at times this power is based on the ownership of the organization and the teaching becomes a training.

What changes, when we change the subject matter of the teaching, are the activities and their articulations to produce the named effects; for this reason we think that the adaptation of our analysis to other educational institutions will help to clear up their nature and mechanisms.

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