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A METHODOLOGY FOR LABORATORY COURSES

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Abstract. *A learning methodology was developed for laboratory courses, whose main objective is to enable the student to the analysis of results. The methodology is suited to Experimental Physics, Fluid Mechanics and Heat Transfer Laboratories of Mechanical Engineering. The proposal was developed from the criticism on current objectives of traditional laboratory learning methodologies applied, those characterized almost exclusively for the binomial activities: practice-report. From the analysis, it can be argued that objectives of traditional laboratory learning are obsolete, are restrictive to the formation of the student and induce to mistakes in the learning of the scientific method. The results can be verified in any conclusion of report. In general, the conclusions are mere hypotheses without relation with analyses, presents lack of proof or simply inexistent conclusions. This fact leads to reflections on the concept of practical and theoretical classes, on the learning objectives and the resultant methodologies. The main objective of the proposal is to enable the student for the analysis of experimental results helped by the concepts of the Scientific Methodology and the techniques of experimental analysis. The Methodology is composed by computational simulation of past practices, carried through by other groups, which are used as base for new problems considered without script. Lessons are centered in the discussion of results; electronic media are used for presentation of works and are adopted specific book-text and software. The methodology was developed and has been tested for three semesters, in the following courses: FIS056 - Experimental Physics - ME (module of Mechanics and Electromagnetism) and EMA098 - Laboratory of Fluids, respectively of the third and sixth period, both of Mechanical Engineering. The proposal leads the student to produce analyses with the desired content and formatting, from which the professor and class are worked in room with. The positive impact in the formation and attitude of the students can be perceived already in the initial works.*

Keywords: *Laboratory, Physics, Fluids, Heat.*

1. INTRODUCTION

All courses must be inserted in a pedagogical project in which the learning objectives and, in function of this, an adequate methodology are determined. Reciprocally, the methodology that will be adopted will determine the reach dictated by the objectives. It is argued, in this article, the effectiveness and the quality of the practical lessons learning as a function of the choice of the learning objectives. The practical lessons can, for example, aim at a first contact with the laboratory, by means of the accomplishment of simple experiments and reports; otherwise they can serve to the study of basic laws applied to physical problems; or to the study of engineering equipment or only to the visualization of processes. But for any approach, one assumes that the junction of the theory with reality imply in the knowledge of what really occurs in the experiments. From this point of view, it can be argued that the learning objectives and the practical lessons from the resulting methodology are, in general, limited and not updated in face of the professional career requirements. It can be questioned the efficiency concerning to nevertheless how much of knowledge is integrated in current methodologies.

There are many publications about experimental work, for example, book-texts created for laboratory lessons. CAMPOS et al (2007), is an example of text-book whose methodology is perfectly adapted to the proposal objectives, among other good references. It can be thought on the amplitude of the learning objectives considered in this case. It can also be cited, a reference on Scientific Methodology (ANDRADE, 2007) or on Experimentation (COLEMAN et al, 1989), amongst others. But such workmanships are considered generic for the approach. These references can be used respectively, in the classes of Scientific Methodology and Metrology, which constitutes part of the basic formation for of laboratory activities. However, these courses are teaching in a segregated way, in the same way that the contents of the laboratory lessons, becoming without effect any improved assimilation of these pre-requisites in the laboratory lessons.

This work has as general objective, to supply relevant subsidies to the update of curricula projects of laboratory graduation courses of Engineering at UFMG. It is intended the creation of one new course denominated Introduction to Didactic Laboratory, analogous to Introduction to Engineering course, whose integration to the curricula of Engineering Courses had been proved necessary. Another more ambitious goal, in which the author has worked, is the modification of the Experimental Physics course methodology to the considered approach. Such goal require as specific objectives: the development of a suited methodology redirecting the learning objectives for an investigative approach. The production of a didactic material, with adaptations, is also necessary. A book is being elaborated to fill this lack with relevant material.

Low quality of writing and analyzing presented in the reports of practical lessons justified this work. Its accomplishment had as base, arguments formulated exclusively by the professional experience and personal displeasure about the lack of effectiveness of the institution curricula on formation of the students for the experimental work. There are many bibliographic references about investigative approach, but none of the searched references presented the analogous general approach of this work; it was only found studies about specific methodologies or specifics concepts with a theoretical point of view of education areas. In the case in study, it is discussed by the optics of a lecturer of Engineering, the day-by-day reality of teaching and learning of engineering laboratory courses. Moreover, it must be pointed out that this work does not constitute the proposal of a "new" methodology, but deals with the correction of distortions of the scientific method that traditionally has occurred in the engineering learning. One assumes that the described realities in this work do not need proof. One also assumes, that the lack of a theoretical landmark does not disqualify the subject deferred to the privileged discussion in this forum, because the proposal has innovative character, is recognized by one graduation course, is being applied in five classes of Mechanical Engineering course at two departments at UFMG, since three semesters ago. A relationship with existent theories had not been established yet, but it is in course, *"a work of validation of this proposal, whose first step will be to examine the project by the point of view of the discussions currently concerning about" investigative learning "in literature; to search evidences of the effectiveness of this type of laboratory and of its result. And then compare with the course in current format (structuralized laboratory)"* [1]. The validation work will use as sample, a class of students of Experimental Physics course. By these reasons, it was used in this work, the forensic technique of circumstantial evidences with the rhetorical speech applied to the real problem. The subject sets out in discussion personal preferences and convictions, justifying the necessity of the rhetoric speech, without which, a presumption irrefutable argument still would be insufficient.

Laboratory courses that presents as main activities: scripts, practices and reports, characterize the traditional methodology, thus called in this context. The methodology proposal is characterized by the activities of formulation of real problems, accomplishment of practices and presentation and discussion of the gotten results. The most basic aspect of this methodology is the discussion of results presented by the students, under supervision of the lecturer. The work presents, in section 2, the importance and necessity of the approach and a critical analysis of the current methodologies; in the section 3, suggested corrections that represent the bases of the proposal and in the following sections the results and final remarks.

2. CRITICAL AND MOTIVATION

2.1 How much? Who? Reason?

It is natural to assume that the calculation methodologies, presented in the theoretical lessons of the graduation courses, are better fixed than the basic concepts. This last one is more difficult of being worked, being understood and evaluated. Also it is reasonable to assume that the most general objective of the laboratory lessons is to strengthen the setting of the theory with the aid of the audio-visual-sensorial resources that practice represents. The students learn "to apply" the theory in the theoretical lesson (with a minimum of critical reasoning) and would have to learn "to explain" the theory in the laboratory lesson. For that is necessary that the theoretical lesson is to be pre-requisite of the laboratory lesson. A dichotomy of science exists for simple reasons: the high cost of a mixed lesson and, on the other hand, the necessity of a minimum contact with reality that is required for the future professionals. The differences between practical and theoretical lesson is artificial, but necessary in the reality. In this work, one assumes that the practices must be made exclusively by the students and it serves for verification of the theory; therefore, it precedes it. It has who argues that a practice could precede the theory. In this case, the activity serves to the theory, so becomes part of the theoretical lesson and besides the activity is incomplete as practical lesson. The review of the theory in the practical lessons would have to imply in the answers to the following questions: *How much it was the deviation? Who caused? Which was the reason?* Looking for these three questions in reports, the result will be the following one: the last question almost never is answered or, if answered, it is in error or without fundament. The second question appears, almost invariably in the form: "the error must be due the measures". And the first question occasionally is not answered. Another characteristic of the traditional methodology is the use of scripts, in which all the activities to be carried through for the students are already determined. The use of scripts could be recommended to practices ones whose objective is only the setting of procedures definite by norms. The metrological analysis of the axle diameter would be a suitable practice, for example. Moreover, the following situations happen in practical lessons:
a. model and assembly operating correctly; b. the model is simple in excess for the problem reproduced in the assembly; or the assembly does not reproduce the problem desired because of some additional effect (whose consideration in the

1 Joint project proposed by Dr. Orlando Gomes de Aguiar Júnior. To be carried through in the second semester of 2008 at Education Faculty of UFMG.

model would become it impracticable or impossible to be reformulated); c. the experimental procedure is insufficient to allow conclusive analyses; d. the assembly presents problems.

In the engineering courses, all the cited cases, of (a) to (d), would be excellent for laboratory classes if the objective was the agreement about what happened and what would be the diagnosis, a clear mention to the consulting activity. To decide problems that would not have, but does occur in the real life, is one of the functions of the engineer, perhaps the main one of them. This would be a good reason so that the courses privileged more the training for the analysis of problems to be formulated, in the theoretical lessons and mainly in the laboratories. Practice and theory have the same purpose, to understand what it is science and how it works. But, it seems that the most of practical lessons are not directed to investigation of phenomena and perform analysis; practical lessons could be considered only extensions of the theoretical lesson. Laboratory has been considered as synonymous of practice, in which the teaching of specific theories on experimentation or application of evaluations would be inadequate. One could affirm that this has been the most general approach adopted in laboratory disciplines.

Laboratory courses should have complementary objectives, not the same of the theoretical courses. The item "techniques of experimental analysis", present in the summary of laboratory disciplines differs from the summary of theoretical disciplines. But what techniques of experimental analysis are these? What techniques have the students learn beyond the basic one, seen in Laboratories of Physics? Linear regression, uncertainties propagation, or the misunderstood notion of how to make a report is the only examples. In general, is emphasized the experiment visualization (not a scientific visualization), the measurement, the process of calculation and the answering the questions already formulated in the script. The elaboration of reports is empirical, with the standard mostly dictated by the preferences of each professor. The result of this approach appears in the analyses and conclusions of practice reports: deficient writing, missed conclusions, without analyses or with incorrect analyses. In general, the answer for all that do wrong is credited to the uncertainties of the measurements, commonly called as "measurement errors" by the students. In the first case, (a), the reports seem coherent because they present the waited results, but without a critical judgment that justifies the reason "everything ok". In second case, (b), it would be very important an analysis of the assumptions made in the model, being necessary a critical vision, gotten in the theoretical lessons, of the used general and particular laws. For example, the study of the force of a jet deflected by a perpendicular wall relative to the jet. Applying lumped formulation,

$$\mathrm{F} = \dot{m}V \tag{1}$$

in which,

F is the force of the wall on the fluid, [N]; $\dot{m}$ it is the mass outflow, [kg/s]; and V is the speed of the jet on the wall, [m/s]. The general laws applied to the problem result in **the EQ.1**, whose uncertainty is mainly caused by the model assumptions than that of the measurements, despite the laws being general. Harder, the problem could be the assembly that would be reproducing the desired physical problem, but only apparently. For example, the determination of the moment of inertia of a cylinder by means of a motion in an inclined plan. Small inclinations do not favor the desired effect, the inertia, producing deviations very above of the waited one. The third case, (c), only was planned to illustrate the theory and it does not allow quantitative conclusions. The last case, (d), is probably one of the bigger occurrence in the laboratories, in which students is not alerted that the assembly also is under critical. With these considerations, it must be demanded the necessity of a training for diagnosis in the theoretical and practical lessons.

When the objective is, simply, a first contact with the laboratory, by means of the accomplishment of simple experiments with the intention to illustrate the scientific process, the report does not need to have closed diagnostic on what it occurred. There are not criticisms about this. The problem is when assembly and model are not adjusted. This has as consequence, the accomplishment of one practice, for example, with a +20% deviation, with explain of nobody about nor the cause neither the reason. This could be considered acceptable? An experiment of this type can be illustrated with the following metaphor: it considers a person who when making a cake, does not verify if it has eggs, uses three measures of flour instead of that is recommended in the recipe, uses oil in the place of the butter, it does not beat the cake because the mixer is broken and it does not observe nor the temperature nor the required time to bake the cake. Any person would agree that really this is an inconceivable situation with total loss of time, money and ingredients. Two conclusions of this case are obvious: the result is not a cake and the person probably does not know what is making. In a normal situation, the person consults the recipe, verifies if the ingredients in the required amount exist and if the mixer is functioning. It plans the stages, organizing the materials in the table, improvises the correct amounts approximately, in the lack of a scale, at last, follows all the instructions of the prescription. In these conditions, the cake can not be tasteful but, at least, it will be a cake. In the case, the cake is the model to be tested and the prescription includes, beyond the experimental procedure, the hypotheses that restrict the validity of the model. For example: to use chemistry instead biological fermentation. In the case of an experiment, a wire can be considered inelastic, in the sense of the elasticity can be neglected. If a wire will be used whose elasticity affects the results, the experimental assembly will start to represent another real problem that is not more what the model describes and the experimental activity loses it sense completely. This also occurs in the practices in greater or minor degree and the student carries through them without full conscience of what is occurring. In other words, one does not know what is making. The analysis of results requires the verification of the hypotheses of the model. In general, it is not possible to know what's wrong simply tasting the cake, is necessary to know and to follow the prescription.

The accomplishment of an experiment in laboratory is analogous to the example of the cake. The instruments must be in order, the measures must have the adequate precision and the experimental procedure, planned with antecedence, must be followed. Planning means to know before the practice, the nominal value and the uncertainty that are waited for. A previous results simulation is necessary. The monitoring of uncertainties, during the experiment, allows evaluating if everything is running perfectly. If something unexpected occurs, the experiment still is not qualified for the attainment of results. The researcher must have answer that three questions: *How much it was the deviation? Who caused it? Which was the reason?* Thus, the researcher will be able to decide which the action to be taken. Of this form, it will be possible to implement a good solution, to accomplish extra measurements and to repeat then until getting the final conclusion: everything "ok". The certain answers to these three questions are important always whenever is desired to elucidate something. In the case of a robbery, (that it could not, but occurs in the reality) a police inquiry must find answers for the following questions: *How much it was the robbery? Who was the guilty? What was the reason of the crime?* On the contrary, nor it will be possible to prove if suspicious one is innocent or guilty. The case of a consulting work, acquired by contract after detection of a problem, is also analogous to the cases of the cake and the robbery.

2.2The traditional methodology

For everything what it was cited, it can be suggested that the traditional objectives and methodology give chances that occur the following problems:

a. The preparation of the students for the practice one is null or insufficient - the physical problems already are formulated in the script;
b. The visualization of the physical problem is the same one of an outsider – unfamiliarity of the theoretical model;
c. The contact with the equipment is superficial - sufficient for the measurements;
d. The measurement procedures are carried through mechanically - without objectives others beyond the stated class period;
e. The calculations are normally restricted to the nominal values - without the qualification of the uncertainties, that restraint to very limited conclusions;
f. The analysis of results is totally insufficient - for the previous reasons and the techniques used for subject-matter settlement, carried through in the theoretical lesson, without criticism about physical modeling;
g. Reports maintain standards of low quality during all the graduation course - the students does not acquire nor improves its own writing standards and capacity of analysis because of traditionally adopted methodology and lack of integration among laboratory and theoretical courses.

3 THE METHODOLOGY

The objectives of the proposal aim at to previously correct the pointed potential problems of the traditional methodology.

3.1 Objectives

a. To enable the students to the analysis of results and writing technique.
b. To integrate the knowledge of the laboratory with the theoretical pre-requisites of the Scientific Methodology, Experimental Analysis techniques and Metrology concepts.
c. To prepare the students for next laboratory courses and for the professional career.

3.2 Methods

Accidentally was understood, during the development of the proposal, that the redirecting of the learning objectives reproduced, essentially, the activity of consulting work, a high level task of engineering. This approach could be adopted in engineering courses, although particular. The simple reason is that anticipates the formation of the professional that we want. It is within of the consulting engineer scope:

To identify problems from that it was told to it; to verify if the problem is the same; or if is another one.
Formulate and solve problems with available historical data.
Plan the form to get extra data, if necessary, and to get them, stopping the production, if unavoidable.
Analyze, to conclude, to diagnosis and to implement viable and satisfactory solutions.

In this type of process, the engineer must:

. To find answers to the questions:
How much? The deviation between the foreseen value and the real value was of -30%.
Who causes de deviation? The instrument X.
What is the cause? It was defective.

b. Known the problem, to implement an adequate solution.
Solution: to change the instrument X or to fix it; Fixing: to supervise the exchange of measurer X; Check: verification measurements, if necessary.

c. Gotten the solution, to finish the work communicating the result.
To elaborate: technical report; To announce: verbal presentation; To receive: payment.

The proposal reproduces this situation in the laboratories. In such a way, any methodology with the necessary pedagogical requirements serves. Since that it takes care in maintaining the cited objectives, considering the scientific method in first place and not the problems imposed by conjuncture: number of students, of groups, of professors, of laboratories, etc, that can be (and they had been perfectly) by-passed. The methodology that was developed will be cited, but only as an example. The important to observe is the main requirements, while that the specific details will depend on the profile of the professor and the characteristics of the course: credits, pre-requisites, if the practical lessons were teaching in parallel with theoretical lessons or constitutes individual courses, number of groups and laboratories, an so on. It is observed that this proposal suggests that the students must have the prerequisite ones, being more adjusted to laboratory courses after corresponding theoretical pre-requisites courses. The proposal is incompatible when occur that the practical lessons are part of the credits of a theoretical course.

Another important comment is on the amplitude of the considered objectives. It is impossible to the students, to carry through all the intended objectives, mainly in a laboratory of two credits. One becomes necessary, a selection the most important activities to be learned. What prevents a bigger learning is not the potential of the students, but its limited theoretical and experimental knowledge available by the traditional methodology and the curricular structure.

3.3 Materials

Along with experimental apparatus, specific electronic media and software were necessary.

Software to be installed on laboratory computer(s): EES™ - Equation Engineering Solver (available in < F-Chart.com >) for simulations; Word™ - (available in < Microsoft.com >) for presentations.

Electronic media: Home Page of course, course management system for on-line learning or electronic school register of the institution; data-show for presentation and discussion of results; computer for each group with up to four students; or at the very least one computer in the laboratory; one pen drive for each group of students, for the transference of its works for the computer.

Other materials: The minimum of a laboratory book-text for each group of students; the minimum of a book used in the theoretical course for each group of students; a individual notebook for annotations.

3.4 Examinations criteria

The correct answers are not the most important. It’s up to the professor and students to evaluate the basis of the analyses and veracity of the conclusions, on the contrary case the guilty will not be arrested. The students must have the requested homework over, but does not lose points for errors in the homework. The requirement of exact final results inhibits the students, induces to the copy of results of others groups and, after all, it is not object of the evaluation. Quality of writing is argued with the students, in the measure of the possible one, during the presentations. In contrast with the traditional methodology, complete reports are not requested nor corrected. The practice is to the students; to the professor, the orientation, not the answers. 60out of 100 points is distributed among works and participation. And 40 points are distributed in two tests. This almost guarantee to the groups the minimum of 60 points, but the total points depends on the individual capacity and interest. The qualities: ethics, punctuality, frequency and participation are evaluated specifically. The lecturer must not teach theoretical lessons in the laboratory, in the beginning of the practical lessons, what normally occurs in the traditional methodology.

3.5 A methodology for Experimental Physics course

As example, the methodology currently used by the author will be described for courses of two and three credits. Experimental physics ME - Module of Mechanics and Electromagnetism, third period of Mechanical Engineering. Course has three credits.

In the traditional methodology, each group has 18 students, distributed in 9 groups that carry through one practice, one per week. Each room of laboratory has 3 sets of 3 experimental apparatus in a total of 9. Each group attend classes in one of the laboratory room, three weeks until completing 3 practices, one per week. After that, groups accomplish more 3 practices on the same module, in another laboratory's room. Then follow an individual written evaluation. In the second bimester, the module changes to Mechanics or Electromagnetism, and, in the same way, 6 experiments more and a second test are fulfilled. In the total, the students carry through 12 experiments and 2 tests along with the initial lesson, resulting in a course of 15 weeks.

The methodology has been tested in one of two registered classes for the course of Engineering Mechanics. There are diurnal and nocturnal courses of Mechanical Engineering, so that one class is chosen alternating along the semesters. The limitation imposed by availability of practices and laboratory rooms did not affect the objectives, but it determined some characteristics of the lessons: the initial lesson and the two tests remain as in the traditional methodology; but six groups of 3 students carry through 2 experiments in cycles of three weeks. The project can be summarized in: practices-practices-presentation.

In the first week, each group carries through two practices, in accordance with the book-text and according to traditional methodology. This corresponds to a first contact with the practical problem (- the day-by-day of the engineer). In the second week, each group must present, in the beginning of the lesson, its experimental procedure and its computational simulation of the problem from practical data from past semesters (- historical data and planning for attainment of new data).This corresponds to the previous preparation for the practice, whose initial contact was carried through in the previous week. Each group carries through experiments in the same assemblies of the previous week, but to analyze a specific problem (- detected problem), considered without script for the professor (- the client). Each group carries through the considered problem launching the results of measurements in its simulation programs for verification of the quality of the measurements and monitoring of the practice (- methodology of acquisition of more necessary data). In the third week, each group brings a presentation in Word^{TM} your results in this sequence:

- ✓ Standardized report cover;
- ✓ Conclusion 1: deviation, cause, reason;
- ✓ Analysis 1 (heading of the analysis): analysis with extracted simulation results, that corroborate the conclusion 1;
- ✓ Conclusion 2: deviation, cause, reason;
- ✓ Analysis 2 (heading of the analysis): analysis with the extracted simulation results that corroborate the conclusion 2; and so forth.

The results are presented and discussed (- verbal presentation); and each group receives your points for the work (- the payment). The course is composed by the initial lesson, 4 modules of three weeks with 8 practical problems and 2 tests with total duration of 15 weeks.

3.6 A methodology for Fluids Laboratory course

This course has 2 credits: Fluids Laboratory is teaching in the fifth period of the Mechanical Engineering Course. Prerequisite: Fluid-Mechanical Systems.

The methodology has been developed and tested in the nocturnal and diurnal course, alternating to each semester. The methodology is for being a mirror of the used one in Experimental Physics, but in function of the 2 credits and number of students, the following differences exist: twelve students for group distributed in 4 groups; cycle of two weeks for experiment; one laboratory room and one assembly of each practice for all groups. The project can be summarized in: practice-presentation. Each group must present, after 1 week, in the beginning of the lesson, its experimental procedure and its computational simulation of the problem from previous practical data of past semesters, corresponding to the proposed problem, without script, by the professor. In the lesson, the students carry through the experiment together in one group. Each group supply results in its simulation program for verification of the quality of the measurements and monitoring of the practice. In the following week, each group brings a presentation in Word^{TM} for presenting and discussion of the results. In 15 weeks they are carried through, beyond the initial lesson, 6 practices and 2 tests.

4. RESULTS AND DISCUSSION

The students of the tested courses agree to the arguments of this work. A substitute lecturer, guest to use the methodology also agrees to the presented arguments. The cited lecturer will go to adopt the methodology in the second semester of 2008, although not be able to visualize with clarity the easiness of the proposal. The methodology may seem complex to first sight, but what it occurs is the exchange of tasks of the traditional methodology for others, whose degree of difficulty is bigger, but that it must be dosed to an adequate value. If necessary, the rules of evaluation and distribution of points must be modified. In the traditional methodology, the difficulty of the students is the accomplishment of the practice in the stablished period, to know what teacher asks for and what the script asks for. In the methodology proposal, the difficulty of the students is the realization of the practice in the stated periods (one of the qualities of the engineer), to know what it must think, what we must decide and how he must make.

The "main goal" of the project, however is automatically obtained in the first lesson, when the orientation is given to the students who, when making its reports, to define clearly: how much it was the deviation, who caused and which was the reason. For a project still in the development phase, without the appropriated didactic material, there is a difficulty among the students in assimilating immediately, the intended objectives. Despite this, the students are able to demonstrating, in its works, a good evolution in the communication capacity, analysis, auto-critical and writing self-standards.

A comparison between the traditional and proposed methodology, permit formulate three negative factors due to objectives of traditional laboratory methodology.

1. They are obsolete. If all the media, equipment and instrumentation will be removed of the laboratories, practices in the traditional way can continue being done in the same manner that ones in the beginning of the last century. In the point of view that, software is used, but only for the elaboration of graphs, it does not are used extensively for simulation and analysis of results. The graphs are worse of the ones that were made, at least 30 years ago, manually in the proper paper for graphics. In turn, assemblies made simple, rustic or until improvised do not constitute problem for the experimental inquiry. The problem is in the objectives of its use. The indiscriminate use of scripts for all the types of practical lessons is one of the main problems.
2. They constitute restraint factors to the formation of the students. The methodologies of practical and theoretical lessons do not allow students to improve its limited knowledge. Practically, the students do not have formation for the experimental work. What techniques had been taught to it? They are enough? Laboratories classes put students in way of independence to the experimental work?
3. They induce to mistakes in the learning of the scientific method. For example: lack of scientific justification, even in the practices that "everything was ok". The requirement of the section introduction of a pre-report, without the explanation of that this is not the Introduction of its report. The fact of making one practice only to illustrate the theory, that in principle would be ok, but that it does not, absolutely do not show to the students what is the "scientific method", definition that, probably, many students are unaware of.

Summarizing the main problems pointed:

- ✓ Didactic objectives and the traditional methodology are compatible each other, but the objectives are considered limited.
- ✓ Script is a didactic resource used indiscriminately, for any type of practice.
- ✓ Laboratory course are considered only synonymous of a simple practice. Writing evaluations in the course are exceptions. The inclusion of exclusive laboratory subject-matters could be erroneously delineated as theoretical course.
- ✓ And the main problem that motivated this work: **reports with consistent analyses practically do not exist**.

As all political pedagogical projects, the main difficulty can be illustrated with the following citation: *"… to conceive new ideas, to place them in the paper and to distribute it does not represent more than 5% or 10% of the efforts for the accomplishment of a change. The others 90% or 95% are come back to reach the mind and the heart of the people and, thus, to transform ideas into beliefs, the beliefs in actions, and the actions in habits. The changes also require time and ability… "* 2

5. FINAL REMARKS

The development of a methodology for undergraduate laboratory courses had as main objective to enable the students to the analysis of results. The proposed methodology was developed from the criticism about current objectives of traditional laboratory courses, those characterized almost exclusively for the binomial of activities: practice-report. By definition, such proposed methodology must be kept in constant refinement. From analysis, it can be argued that the objectives of laboratory are obsolete; they constitute restraint factors to the formation of the students and induce to mistakes in the learning of the scientific method. The proposal takes the students to produce analyses with the desired content and the format, from which the professor and the classroom are worked in room with. The positive impact in the formation and attitude of the students can be noted already in the initial works. An important complement of this proposal Is being produced a: a specific didactic text-book for the clarification of the proposal and therefore it will serve as a guide for its implementation. The book is to be finished in 2009, when will be offered an optional theoretical course, called: Introduction to the Didactic Laboratory for the second period of Mechanical Engineering before any laboratory course. It is intended to explain this approach to students and to provide to them the necessary basic knowledge and materials to the development of the experimental work in the next laboratory courses.

The methodology proposed will be able to supply excellent subsidies to update curricular projects of graduation laboratory courses in Engineering of the UFMG. But only after the admittance of: validity of the justification; thoroughness of the objectives, scope of the results, viability of implementation and the degree of pleasure and learning of the student staff. Despite the rhetoric, the presented arguments do not have the persuasion purpose but to create the aptitude for the dialogue between students, lecturers and coordinators of courses on real possibilities of learning improvement.

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2 COUTINHO, Gledson Luiz. *Comments on the functioning of the University of the organizational point of view after the Reformulation of University of 1968*. in: Ways. Magazine of the Professional Association of the Lectures of the Federal University of Minas Gerais, n.23/24 -2004/2005.Belo Horizonte, APUBH - annual publication Ways 2005, pp115-146. ISSN -1517-3038.

Overcoming these bounds, it remains to each group to develop and to keep their solution. A political pedagogical project with this justification also would make possible the extra improvement of the conditions for experimental learning by means of the request of materials and resources. The challenge for changes comes with a traditional feeling of inability because the odds of improvement of an entire system from individual actions seem very remote, by the necessity of "persuading" of people. For this, two obstacles need to be overcome. The first one mentions difficulty of the visualization and establishment of what is the "problem" inside a lot of variables of the learning system. The second difficulty is in the search of a "solution", that it must be more practical, more efficient than the current methodology and totally acceptable by the lecturers and students. The feasibilities of success of any political pedagogical learning project that does not take care of to these three requirements probably will be null. In another words, the methodology, beyond correct, understood, accepted and functional has to be pleasant. The cited problems are complex and of systemic nature. However, the majority of the necessary corrections consist on simple individual actions. It is incredible but the possibility is real. The presented argument lacks of quantitative evidences, but being based on the experience of the author as students and later, as university lecturer, was possible to point enough evidences to permit the establishment of the hypothesis that the scientific method is not yet well established oneself in the engineering courses. The evidence of this hypothesis will consist of future work. In the place of "old" and the static traditional methodology, the proposal awakens the scientific interest of lecturers and students and allows working some useful and necessary didactic objectives.

The author would like to receive opinions concerning this work and has interest in the divulgation and to inspire the application of this methodology in other Institutions of education.

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The author is only the responsible one for the information that constitutes this article.