Universidade Federal de Minas Gerais
Instituto de Ciências Exatas
Departamento de Estatística

Constructiveness Process in Teaching Psychophysiology

F. P. Souza e S. A. Mingoti

Relatório Técnico
RTA-01/2000

Relatório Técnico
Série Assessoria

UNIVERSIDADE FEDERAL DE MINAS GERAIS

CONSTRUCTIVENESS PROCESS IN TEACHING PSYCHOPHYSIOLOGY

Autores:

Fernando Pimentel de Souza (1)
Sueli Aparecida Mingoti (2)

RTA 01/2000

(1) Prof. Titular do Departamento de Fisiologia e Biofísica do Instituto de Ciências Biológicas da UFMG
(2) Profª. Adjunto do Departamento de Estatística do Instituto de Ciências Exatas da UFMG

CONSTRUCTIVENESS PROCESS IN TEACHING PSYCHOPHYSIOLOGY

Fernando Pimentel de Souza - Laboratory of Neurophysiology and Behavior, Department of Physiology & Biophysics of ICB of the Federal University of Minas Gerais (UFMG), Brazil

Sueli Aparecida Mingoti - Department of Statistics of ICEX of the Federal University of Minas Gerais (UFMG), Brazil

Abstract

Construtive processes for teaching Psychophysiology were applied and evaluated by using the classification of Bloom and coworkers. A total of 238 undergraduate students, who were taking the course of Psychology at the Federal University of Minas Gerais (Brazil), were considered in this study. The majority of the students were between 20 to 23 years old and female (77%). Significant cognitive gains were observed in the majority of questions in the objective test of knowledge and in the subjetive test of mental habits. The topics of affective domain were subjectively evaluated and their majority showed significant variations or high performances. Course structure, pedagogic process and some points of metascience have shown significant results. However, science application, metascience related to the peripherical aspects of the brain, metascience of the superior mental functions and philosophy of science were significant only in a few cases. The consistency of the answers of subjetive topics was made by verifying the agreement of randomly ordered pre-chosen matched pairs of affirmative and negative questions. This analysis revealed a lack of consolidation of learning in many cases. In conclusion, this work had shown important gains in several pedagogic domains that calls for more attention to subjectivity and affection of the student, including personality maturation emphasized by a constructive method. Some limitations of the students and teachers related to the scarcity of a scientific culture of the country were also discussed.

***Key words*:** interactionist constructivism, pedagogy of Bloom and coworkers classification, cognitivism, affectivity, psychophysiology, scientific culture, philosophy of science.

1.0 Introduction

In a more competitive world, Pedagogy has frequently been requested to follow the development of human knowledge and technological advancement with the purpose of finding better measures of evaluation and efficiency in education to accelerate cognitive, affective learning as also personality maturation. A contribution comes from the constructive interactionist process of the genetic epistemology of Piaget (1,2) and from the pedagogic classification of Bloom and coworkers (3,4) .

According to neurophysiology, knowledge acquisition can be conceived when the projection of the unitary sensory fields in the brain sets up perceptions of integrated vision, body forms and movements, shaping mental images in the nervous structure genetically inherited, with the purpose to program motor action, movement control, and mental processing (5,6,7). This interpretation corroborates Piaget's view about the perception of reality. According to him, the most important expression is construction of the mental images, that preceeds and gives elements to the formal operations and other processes of knowledge and language activity, giving support to the need of self expression and the interior language to the so called figurative aspects in human culture. On the other hand, human beings who grow up in strange environments e.g. an animal niche, could fail to involve the proper maturation, language and knowledge, and therefore they could be unqualified to set up figurative aspects (1,2,8).

Piaget looked for the harmonization of learning met with the biological maturation of a child through adolescence as process centered on the student. The existence of a parallel between Piaget's cognitivism and the neurophysiologic gradual processes of adult behavior is becoming more evident in the sense that there is a hierarchy and a sequence to where the integration converges from the input to the output in an interactive procedure (5,6,7,9,10,11).

One of the contributions of Piaget was the evidence of the existence of 4 periods in child development and that a double qualitative jump happens in the cerebral structures as well in the cognitive aspects. The intelligence in childhood advances by stages according to the maturation of the brain. In each stage the process of learning continues from the level reached in the preceeding one. The sensory-motor stimulation takes part in the objective and spatial causalities, in the programs of motor actions, in the consolidation of genetic inheritances, in the acquisition of new dynamic structures and in building up of mental objects, making reafferences in varied feedback networks, stabilizing a more advanced and dynamic way of control. Thoughts of concrete and representative operations interact and develop the language acquisition. Finally, formal and hypothetic-deductive reasonings take place, called of second order to be supported on concrete operations. In such way the intelligence of each individual would continue in an interactive way in learning through sucessive and gradual constructions in adult life (1,11,12,13,14,15).

On the other hand, Piaget suggested that the development of cognitive and affective domains in the constitution of a young personality are interrelated. The research presented in this paper intends to evaluate and to compare the evolution of a series of topics on both domains related to the variation of maturity of the adult student, who is no more limited by macroscopic biological development and therefore could be observed in the aspect of evolution of maturity by following Bloom and coworkers classification (3,4,13,14,15).

2.0 Methods

2.1.1 Subjects

A new teaching methodology was applied to the students who were taking the Psychophysiology classes regulary offered in the Psychology undergraduate course of the Federal University of Minas Gerais (UFMG). The experiment was conducted in the 1990-1993 period with a total of 238 students, using about 30 students in two classes in 4 academic semesters of the University. 1992 was excluded for reasons of some unusual occurences in that year related to workers' strikes and personnel retirement. The majority of students were between 20 to 23 years old and predominantly female (77%). In order to avoid any kind of personal bias the Psychophysiology classes considered in this study were taught by the same professor during the whole period of experimentation of the new teaching methodology.

2.1.2 Procedure

The pedagogic classification used in this research was that developed by Bloom and coworkers. The main aspects were used to measure the evolution of learning in gradual order: Memorization, Comprehension, Analysis, Synthesis and Evaluation, for the cognitive domain; and Attention, Responsiveness, Valuation, Philosophy of life, and Vision of the world for the affective domain.

In this new pedagogical experience, an interactionist and gradualist process in the formation of knowledge was applied to young students who were already adults but still affected by the psychophysiological principles of learning. In every period of experimentation the students, who were participating of the class were divided in 4 groups of about 8 students each. All the groups were formed according to the results obtained in a subjective test of "philosophy of science" which was applied to each student in the beginning of the experiment. According to this criterion the students belonging to the same group are homogeneous according to their conceptions about the relation between the genesis of knowledge, nature, and logic (3,4,16).

The emphasis of the new methodology was more centered in the motivation for the development of intelligence and the acquisition of specific language to express psychophysiological concepts, reasonings, creativities and even beliefs than in the pure reproduction of formal knowledge by memorization of concepts often completely misunderstood by the students (18,19,20,21,22). The idea was to center the teaching to the student by focusing more creativity than just memorization by itself. The difference from traditional stages of knowledge of a child developed by Piaget is that the application of processes can succed immediately one after another, because there is no need to wait for biological maturation and general language acquisition, for further development of microstructure in cerebral networks for psychophysiology learning (1,13,15).

The Psychophysiology class taught in the Federal University of Minas Gerais comprises a total of 60 hours which is usually used by the teacher in lectures and groups of discussion. The formal pre-requisites required of the student to take this class are knowledge in basic systems of physiology and neuroanatomy and also in experimental psychology. In the new teaching approach only 18 hours were used by the teacher in a classroom treating the theory and practise of some of the main concepts. The other 42 hours were filled up with activities performed by the students which involves discussion of selected topics, answer of questionaries and writing monographs, stimulating the expression of concrete operation of causality, analysis, synthesis and selection of priorities to approach a theme. The idea was to expose the student to situations where the body experience is related to the sensations, cerebral, nervous, muscles, motor, visual, mental and emotional functions. For all the examples treated in a classroom, the teacher showed clearly the facts which were really demonstrated and those which were just acquired by extrapolation of some concrete facts, reconstructing the epistemology of knowledge. The main point was to exercise the hability of self-learning of the students by creating a new hypothesis of generalization supported by scientific evidences not formally proved or published. These activities were called here as metascience based on the fact that in his professional life the psychologist needs to know how to create a projection of scientific view because many times he or she would be facing real situations where solutions were not taught in any of the classes of the undergraduate course. This activity is always done by a researcher for new projects of scientific investigation (16,18,20,22,23,25,26).

Most of the Psychophysiology classes were devoted in the preparation of monographs about the following topics: bioeletrogenese, control of movement, sleep, emotion and vision, emphasing applications to the psychologist practising to motivate the students. For each topic, the theory was provided in advance by the teacher in a classroom. Afterwards, every student received a resume about the topic and some questions to be answered. The questions were prepared according to Bloom and collaborators classification (4) demanding comprehension, extrapolation, analysis and synthesis (22,26,28). After a period of discussion with the colleagues, the student could request some teacher orientation. At the end of the class each student was supposed to answer individually, the questions in a paper. Consultation of bibliography references was allowed because the answers of the questions were not in the textbooks. There was no pressure in the memorazition of the right answers because the focus of the questions was in the process of learning more advanced categories of language in the cognitive and affective domains. This activity contributed 50 points to the final grade.

As a last activity of the class, all four groups of students were invited to choose a topic to write down a complete monograph in an interactive group work and to perform an individual oral presentation. The students were stimulated to divide collectively in the group the work involved in this activity. The topics of the monograph were: sleep, physiological foundations of madness, physiological foundations of movement, pain, autonomic manifestation in psychsomatic disease and the ontogenetic development of the brain function and corresponding behavior from childhood to the elderness. Each student was free to consult the teacher for any kind of questions. For each student it was offered the choice of the group subject, which best adjusts to his constructing “philosophy of life”, which is probably the most advanced affective category that could be worked in an undergraduate course (3). In this stage of the experiment the expectation was that the students would be able to exercise the “evaluation” category, selecting only the most relevant topics duely ordered from individual contributions, which is the utmost objective in the cognitive domain according to Bloom and collaborators (4). This activity contributed to 20 points of the final grade of the student and continued at least during a month.

An objective test comprising 60 questions about the whole program covered in the class was conducted to verify the amount of learning attained by each student from the beginning to the end of the class. The questions were the "right, wrong or do not know" type and were constructed following the more advanced categories of Bloom and collaborators cognitive classification as possible (4). This activity contributed to 30 points in the final grade of the student. The grading was done by subtracting the wrong answers.

A subjective test with 60 questions of "true or false" type were applied in the beginning and in the end of the class for all the students in order to evaluate any kind of mental changes of the students as far as learning is concerned. This test was supposed to show the level reached by the student in every subject of the affective or cognitive domains (3,4,29). The consistency (or realiabitity) of the test was verify by looking at the agreement in the answers of randomly ordered pre-chosen matched pairs of affirmative and negative questions that were related to the following topics: mental habit, course structure, pedagogic process, science application, metascience and philosophy of science. Any question with less than 5% of disagreement was considered realiable for this research. A statistical comparison between the grades obtained by the students in the beginning of the class with those obtained in the end of the class was performed. The statistical Chi-Square test was used to evaluate the pedagogic efficiency of each question considered in this study (30,34). The statistical software *MINITAB* (31) was used.

3.0 R e s u l t s

3.1 Objective Test

The cognitive efficiency of the Psychophysiology class was important in the 4 semesters considered. The average amount of knowledge attained by the students increased from 39.6% in the begining of the class to 72.0% at the end. The best learning efficiencies occurred in the 2nd. and 3rd. semesters, decreasing in the 4th., which was considered slightly atypical (Figure 1). About 2/3 of questions resulted in significant statistical variations ($p<0.05$; Chi square > or = 5). In about 20% the cases the variation in the answers was not significant due to the high knowledge that the students had about the topic considered in the beginning of the experiment. The best average final results increased in the following order: motor system, sensory systems, bioeletrogenesis, pain, sleep, limbic system and conditioning. However, bioeletrogenesis and conditioning had the smallest efficiencies because they had the greatest initial scores due to the knowledge acquired by the students in other classes.

3.2 Subjective Test

In each analysed topic the word in parenthesis mentions the category of the corresponding affective domain that the authors considered to be checked following the classification of Bloom and collaborators (3,4). With the exception of the item “mental habit”, that has a proper meaning of personnel cognition, all others were classified in the affective domain because of their psychsocial aspects.

A) Mental Habits (Figure 2A)

This item comprised 5 topics from which 2 were considered consensual (low disagreement). These topics were: understanding of main ideas from the text (comprehension) and understanding of the relation among main ideas (analysis/synthesis). The 3 others showed some unreliability (disagreement above 5%) in the following topics: familiarization with words in psychophysiology (memorization), explanation of ideas in psychophysiology (comprehension) and scientifically proved proposition and hypothesis (synthesis).

The efficiency of all topics were statistically significant showing a measure of knowledge increasing from 30.4% in the beginning of the class to 82.1% at the end with approximately stable scores in all 4 semesters considered in the experiment. To achieve and even to create the obtained cognitive learning in high level topics it should be comprise a consensual and great affective motivation, according to Bloom and collaborators (3). The lack of security of the students was evident in lower categories of the learning process. The reason was that manipulation of specific words and explanation of ideas were not used enough to consolidate learning. The possibility of consulting the bibliography references made easier the process of building the relation among main ideas in high categories of learning.

B) Course Structure (Figure 2B)

This item comprised 5 topics from which 2 achieved reliability: need of prerequisite (attention) and importance of contents (valuation). The 3 others showed unreliability in the following topics: knowledge of the subject of prerequisites (valuation), updating of course (valuation) and creative treatment of matter (philosophy of life). It is natural that lower reliability was found in higher categories of learning, specially due to the inexperience and immaturity of the students. The efficiency of all questions were statistically significant when the answers from beginning to the end of course were compared. The average grade point increased from 34.5 to 73.3%, with better efficiency in the 2nd. and 3rd. semesters.

C) Pedagogic Processes (Figure 2C)

This item comprised 5 topics from which 3 had reliability: interest of teacher (attention), fitness of evaluation (attention) and student motivation to proceed analysis and synthesis (philosophy of life). The 2 others showed some unreliability in the following topics: importance of contents of evaluations (valuation), concentration of students in their own sensations and observations (philosophy of life). The efficiency of all questions were statistically significant and increased from 36.0 % in the beginning of the class to 83.6 % at the end. The better efficiency was found in the 2nd. semester, in spite of very stable scores all around the experiment. The observed insecurity concerned to "self-evaluation" and "judgement of which questions were more important in the evaluation" are more naturaly accepted to be related to high level category, but it expresses also the limitation of maturity and knowledge of student. The high efficiency scores obtained at the end of the classes, conjugated with the attained coherence in more formal questions in lower level of the pedagogic process and even in more advanced topics about analysis and synthesis, have indicated that the students felt very tranquil about the pedagogic process used in this experiment, in spite of mediocre expectation.

D) Application of science (Figure 2D)

This item comprised 5 topics from which 2 had reliability: application of scientific knowledge in clinics (philosophy of life) and application of principles of cause-effects in human behavior (philosophy of life). The following subjects showed low reliability: awareness of limitation of the proof of scientific knowledge (valuation), some dependence of mental functions to the brain (valuation) and influence of unnatural and unlogical reasons in the mind (vision of the world). Questions more specific to the "philosophy of science" and related to "superior mental functions" were more unreliable. The students responded to this subject very well since the beginning of the class and attained consistency in two high level categories that were also emphasized in previous classes, for instance in experimental psychology. For this reason, in the end of the class, only some topics had shown statistical significant learning efficiency in some semesters, increasing from 70 % to only 78.9% in average. However, the topic "natural and logic base of mental functions" was the most critical, had lower performance, did not result in statistical significant variations and the average efficiency varied only from 31.7% to 54.4%, indicating a conflict of scientific conception, that is understandable since this corresponds to the higher category of affective domain.

E) Metascience peripheral subjects (Figure 2E)

This item comprised 5 topics treating broadly extrapolations of more peripherical functions of the brain. Only 2 topics were reliable: code of information between neurons (valuation) and importance of existing pain (valuation). The 3 others were unreliable in the following matters: cerebral code to fine movements (valuation), integrated operation to equilibrate the viscera (valuation) and the meaning of the representation of visceral objects in brain (valuation).

The average efficiency varied from 82.3% to 87.9% and did not show a statistically significant increase which could be justified by the high initial scores presented by the students in the majority of the experimental semesters. So, the approval of generalized application of scientific explanation in these more peripheric functions of the brain was conceived since the beginning of the class and it just improved a little bit. The great lack of consistency showed that the students were not very confident about what was the real meaning of the subject, indicating a strong prejudicial position.

F) Metascience of superior functions (Figure 2F)

This item comprised 5 topics about mental and superior psychological functions of the brain where extrapolation were the least admitted. Only one topic was reliable: intermediation of emotions by the brain (valuation) which was approached in previous classes of experimental psychology. The 4 others were unreliable: consideration of the active part of sleep (valuation), some dependence of mental functions to the brain (philosophy of life), influence upon brain of irradiation of flowings without energy (world vision) and localization in the brain of the center of decision of voluntary movements (world vision). The average learning efficiency increased from 45.4% to 68.7% in 4 of the topics considered and it was statistical significant in about all the semesters of experimentation. The lowest increase was obtained for "localization in the brain of the decision center of voluntary movements" which was not statistically significant. Considering all topics together, related to the superior functions of brain, there was a indication that on average there was a great improvement in the scientific vision of the students caused by their class experience, in spite of being coerced to a domain in which is hard or even impossible to find a solution in the actual state of knowledge. As a consequence the confidence was poorer than further "metascience of peripheral subjects".

G) Philosophy of science (Figure 2G)

From the 5 previous topics only 3 topics were considered related to the philosophy of science. All of them showed lack of reliability: influence in mind of natural and not logic reasons (world vision), influence upon brain of irradiation of flowings without energy (world vision) and localization in the brain of the decision center of voluntary movements (world vision).

The average efficiency varied from 33.3% to 54.6%, showing a great decrease from the first to the last studied semester which was considered atypical, showing interaction of the social condition of learning. The topics had questions in the frontier of scientific knowledge where the lack of demonstrable or controllable facts of cerebral or mind working induces controversial interpretations. The questions did not have a scientific solution. The tendency of explanation would depend on the predominant credibility of a certain "philosophy of life" or better considering on "world vision". Considering that the generalization of each individual is more an act of belief, it would be possible to conclude that the class collaborated in the sense of the approval of a psychology more scientific than phylosophic, in spite of the difficulty of the question in a very uncultured scientific community. In the beginning of the course this theme was used to classify the students in two groups: half with a consolidated philosophy of life (experimental-deductive or metaphysic) and the other half without (neutral or controversial). The main gain was observed from the group with the philosophy of life not consolidated.

3.3 Final Monograph (Figure 3)

This part was the most creative of the course, in spite of the subjective judgement of quality of a monograph by the teacher. There was motivational space for more discussion, work division, bibliograph research, interviewing with experts, individual oral presentation and final writing of a monograph, which theme was the students preference and the most adequate with the “philosophy of life of the group”. The learning objective was pursued more deeply in the cognitive domain. The practice of the category “evaluation” was performed by the students when they had to select and to order the most important parts of contents of each individual contribution of the members of the group by attributing values to colleagues works. The final monograph achieved an excellent evaluation in the 3rd. studied semester. A great and unrecoverable decrease was observed after the 3rd. semester due to the unusual activities occurred in 1992 and 1993 such as strikes, lack of institutional and material support for the University. All these factors combined profoundly affected the image of teacher and of the learning process, showing how far brazilians are to attain the higher categories proposed in this phase in the two domains. In part, this fact is due to the federal government policy applied for science and superior education, which went on a decline phase of quality since then.

4.0 Discussion

There was a great development of the personality of the student during the course as far as the collaborative aspect and in the interest in searching for more information in personnel researches are concerned. However, the tradition in our scholar milieu supports a great separation between teacher and the student mentalities which negatively affects the improvement of the collaboration of both parts. On one hand, there are many students who are moved by instantaneous results and more interested to be approved or to obtain good degrees in the course than to really learn. On the other hand, the tradition of many teachers is to focus their teaching only in the cognitive aspects of learning, which induces a conservative behaviour of the students, with lesser charge, and an attitude of accomodation by the teacher, with lesser class demand. This way both the student and the teacher lose the dimension of the affective domain, which is more often misunderstood in Brazil, a country where the process of learning is more centered in low categories such as “attention” and “responsiveness”, without any visualization of high categories such as “philosophy of life” and “world vision”, not supported by a scientific culture of the country. Sometimes the affective domain is rediscovered in the process of teaching when a emphasis is given in the “valuation” category. Examples of valuation process in teaching, where the learning to love reading or knowing about their surroundings habitats are emphasized, are the awarded Ângelo Machado‘s and Ziraldo's inspiration in their children’s books and the alphabetization experience in the outskirts of Chicago. Unfortunately isolated facts do not have the power to influence substantially the country culture which is in need of a firm national mandate concerning a continuous education of the society to support superior education and scientific research as fonts of diffusion and influential sources.

Another negative factor in the teaching system in Brazil is the lack of a broad view of the objective of learning, showing more similarity to the late Coimbra University in Portugal than to the new moderns models. Usually the undergraduate courses which are offered by the Universities focus the emphasis in the practice of “memorization”, “comprehension of application” and sometimes “analysis”, aspects that are based upon the inferior categories of the cognitive domain in learning. This approach causes a premature lack of modernization of students and professionals. This aspect makes a big difference between the more traditional and the developed countries, where chain of reasoning and group working are emphazised considering high categories of "philosophy of life" and "world vision".

On the other hand, the opinion of the students about the process of learning has to be considered carefully because many times they do not have enough experience to answer some of the questions asked, being influenced by immediatist interests. In fact many high scores obtained from students performance are accompanied by low level of reliability, which means that they do not have enough comprehension about certain subjects they take opinion and lack of personal maturity. Many educational evaluations based on students opinions reveal a sort of paternalism or demagogy (32,33).

It is necessary to emphasize the importance of higher categories of affective and cognitive domains in personnality development of the students which were evident since the beginning of the class. "Evaluation" must accompany the evolution, because "erosion" of affective objective can easily occur as was verified by Bloom and collaborators (3). In fact the decrease in the topic "philosophy of science" (Figure 2G) from the 1st. to the 4th. experimental semester with a posterior decline in monograph evaluation (Figure 3) support this theory. Some possible cause for this to happen could be the difficulty to consolidate affective and cognitive progress in short courses of 1 semester or 1 year, and some resistance of the student to accept a high demanding class. The atypical perturbations occurred during the years of 1992 and 1993 could also be responsible for a great deal of the decrease in learning.

It is important to observe that the evaluation of the topic "philosophy of life" in the affective domain decreased and the evaluation of the cognitive aspect increased until the 3rd. studied semester. This indicates a possibility that the student maturation could be reached previously as in the cognitive domain as in the affective domain. This fact seems to support a more organizational core model of learning in which these two domains interact with the environment corroborating in part the ideas of Piaget and Bloom and collaborators (3,4.14).

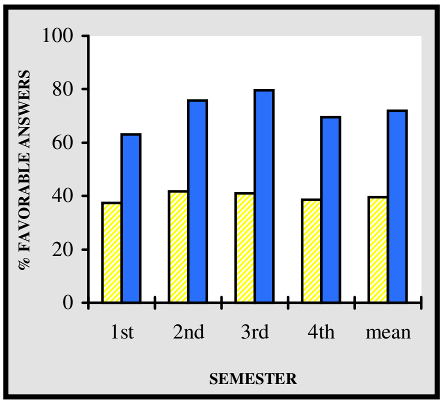
One of the main objectives of this experiment was to put the student in a position where he or she has to face the experimental and the factual verification of facts under the control of other people and under the support of the logic-mathematical deduction, which is not always mastered by an inexperienced teacher in scientific research. The idea was to help the student to reach a better assimilation of the external observations upon the mental structures that base the scientific psychology, because topics as "scientific methodology" and "the personal own knowledge and sensitivity", or even the highest performed themes as "application of science" had shown low confidence. Considering that biological science has a "philosophy of science" very close to the experimental-deductive, analytical and neo-positive schools of thinking, to improve the learning of the student is necessary to improve his or her motivation (affective domain) and his or her hability of critical analysis (cognitive domain) in observing his or her own creature and to assure better understanding of his or her own knowledge instead of verbalization only. In that way the student will be able to develop a scientific psychology that is not only a pure phylosophic or metaphysic psychology (3,4). Piaget considered that any closed process which depends only upon the introspection and the same believed ideas always ends in a metaphysic process not related to the nature and logic(1).

Acknowledgements: We wish to thank the trainees M.R.A Correa, P. Barroso and C.A. Carvalho for the help.

References

1. Piaget J (1969a). *Psychologie et Pedagogie*. Paris, Denoel.
2. Flavell JH (1975). *A psicologia do desenvolvimento de Jean Piaget*. São Paulo, Pioneira.
3. Bloom BS, Krathwohl DR & Masia (1973). *Taxonomia de objetivos educacionais, (2) domínio afetivo*. Globo, Porto Alegre.
4. Bloom BS, Engelhart MD, Furst EJ, Hill WH & Krathwohl DR (1973). *Taxonomia de objetivos educacionais, 1) domínio cognitivo*. Globo, Porto Alegre.
5. Zeki, S (1993). *A vision of the brain*. Blackwell, London.
6. Ghez C (1985). Voluntary Movement. In Kandel-Schwartz (ed), *Principles of neural science*. Amsterdam, Elsevier, (38):487-501.
7. Gregory RL (1979). *Olho e cérebro, psicologia da visão*. Zahar, Rio de Janeiro.
8. Malson L (1964). *Les enfants sauvages*. Union Générale d'Éditions, Paris.
9. Luria AR (1981). Zonas sensitivas-motoras e pré-motoras e a organização do movimento. In: *Introdução a Neuropsicologia*. EDUSP, São Paulo, (VI):145-160.
10. Luria AR (1987). *Pensamento e Linguagem*. Artes Médicas, Porto Alegre.
11. Maturana H & Varela F (1984). *El arbol del conocimiento, Las bases biologicas del entendimento humano*. OEA, Santiago.
12. Graeff F & Brandão ML (Editors) (1993). *Neurobiologia das doenças mentais*. Lemos, São Paulo.
13. Bloom FE, Lazerson A and Hofstader L (1985). *Brain, Mind and Behavior*. WH Freeman, N. York.
14. Tomlinson-Keasy C & Eisert DC (1981). From "Structure d'Ensemble" to separate organizations for cognitive and affective development. In Meacham and Santilli (Editors) *Social development in youth*. Karger, Basel, 1-19.
15. Pimentel-Souza F (1981). A edificação do cérebro e a aprendizagem. *Revista da Associação Médica de Minas Gerais*, 32(1/4):5.
16. Bochenski F (1962). *A filosofia contemporânea ocidental*. Herder, São Paulo.
17. Piaget J (1969b). *Sabedoria e Ilusões da Filosofia*. Difusão Européia do Livro, São Paulo.
18. Santos TAM & Vaz NM (1981). A universidade como prática pedagógica (algumas reflexões). *Ciência e Cultura*, 33(10):1330-1332.
19. Frota-Pessoa O (1985). Como ensinar na era da contestação. *Ciência e Cultura*, 37(7): 1125-1137.
20. Ivanissevich A, Ferreira F, Muniz, Carvalho R & Costa VR (1988). Documento: A Universidade em busca de si mesma. *Ciência Hoje*, 8(45):58-67.
21. Pimentel-Souza F (1989). Dois decênios de um instituto básico numa universidade federal brasileira, com ênfase em recursos humanos e produtividade científica. *Ciência e Cultura*, 41(9):888-896.
22. Moreira ESA, Caixeta FN, Carvalho HC & Beirão PS (1991). Ciclo básico em questão. *Ciência Hoje*, 13(78): 18-20.
23. Hegenberg L (1969). *Explicações científicas*. Herder-Edusp, São Paulo.

24. Guattari F (1990). *As três ecologias*. Papirus, Campinas e Editora Nacional, São Paulo.
25. Beraldo WT & Alvarenga GP (1966). Ensino não-diretivo da Fisiologia. *Revista da Universidade Federal de Minas Gerais*, 16:113-128.
26. Ferreiro E (1986). *Psicogênese e Educação*. Coletânea AMAE, p 1-5.
27. Carreher DW (1983). *Senso crítico*. Pioneira, São Paulo.
28. Macedo L (1982). Método clínico de Piaget e avaliação escolar. *Revista de Psicopedagogia*, II(23):10-15.
29. Lafourcade PD (1969). *Evaluacion de los aprendizajes*. Kapelusz, Buenos Aires.
30. Goode WJ & Hatt PK (1973). *Métodos de pesquisa social*. Nacional, Rio de Janeiro.
31. MINITAB (1998). *Minitab reference manual*. Wadsworth, Forence.
32. Coelho EC (1988). *A Sinecura acadêmica*. São Paulo:Vértice.
33. Pimentel-Souza F (1974). A participação ativa do aluno precisa ser controlada? *Ciência e Cultura*, 26(7): 626.
34. Bhattacharyya, G & Johnson, R. (1986). *Statistics: Principles and Methods*. John Wiley and Sons, New York.



<u>Fig. 1: Objective Test:</u>

Favorable responses, in average percentage, in the beginning and in the end of 4 experimental semesters with 8 teams of about 30 students each in an objective test of formal knowledge of the matter.

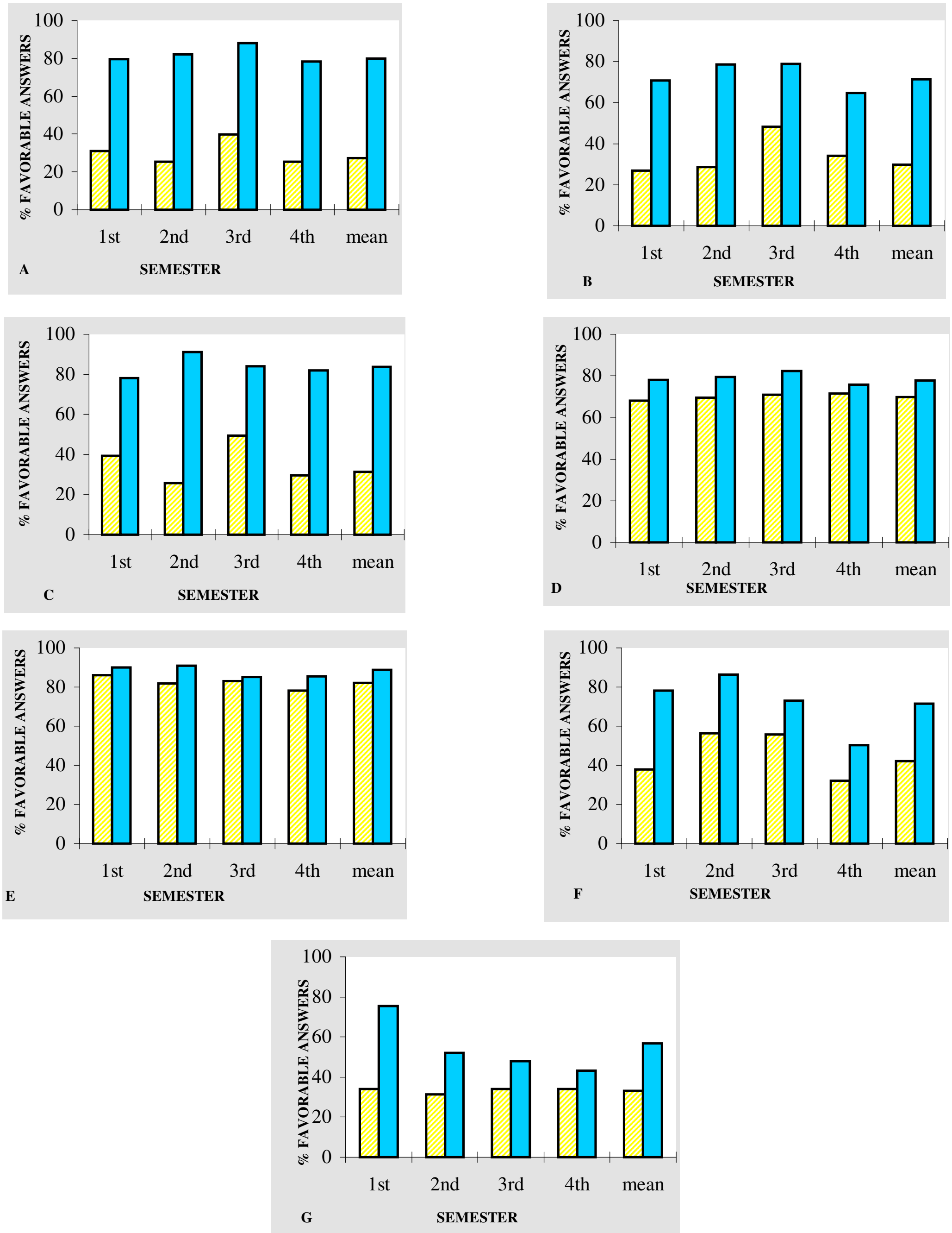


Fig. 2: Subjective Tests:

Favorable reponses, in average percentage, in the beginning and in the end of 4 experimental semesters with 8 teams of about 30 students each in a questionnnaire with several twin opposite questions about: **A) Mental Habits, B) Course Structure, C) Pedagogic Processes, D) Science Application, E) Metascience of peripheral subjects, F) Metascience of superior mental functions, G) Philosophy of science.**

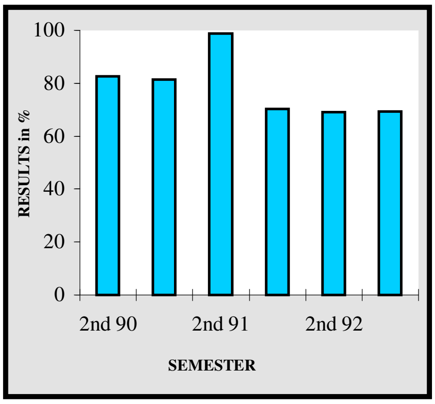


Fig. 3: Final Monograph:

Evaluation of a bibliographic research in group in the end of a course of six teaching semesters, corresponding to twelve teams of about 30 students.