A COMPARATIVE ANALYSIS OF PRACTICAL CLASSES IN CELLULAR BIOLOGY FOR UNDERGRADUATE BIOLOGICAL SCIENCES STUDENTS
(Análise comparativa das aulas práticas de Biologia Celular para graduandos em bacharelado e em licenciatura de Ciências Biológicas)

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Abstract

The purpose of this study is to perform a comparative analysis of the views of first year undergraduate students in Biological Sciences concerning practical classes in cellular biology. The results indicate that the subject is fundamental in the training of future biologists. Practical classes are the means to apply theory taught previously and may lead to alterations in views on relevant topics. Static viewing as well as equality noting between cell types are examples of conceptions modified due to the application of distinct methodological practices. The application of a questionnaire showed that views differed in bachelor of science (BS) Teacher Certification (TC) classes. The BS students preferred practical classes using the light microscope, while TC students preferred classes where visual devices such as movies and /or animation were used. We suggest that practical classes in cellular biology be prepared differently, according to each type of biology course.
Keywords: graduation; cellular biology; practical classes; teaching.

Resumo

O presente estudo teve como objetivo analisar comparativamente as opiniões dos graduandos do primeiro ano do curso de Ciências Biológicas – bacharelado e licenciatura - sobre as aulas práticas de Biologia Celular. Os resultados indicam a importância da permanência da disciplina no curso de graduação em Biologia, sendo fundamental para a formação de futuros biólogos. As práticas são eficientes facilitadoras da aplicação da teoria ministrada e permitem a mudança de visões sobre tópicos em biologia. A visão estática e da igualdade entre os tipos celulares são exemplos de concepções que foram modificadas com as distintas metodologias práticas. Foi observado, através da aplicação de questionário, que as impressões das aulas práticas de biologia celular se distinguem entre os graduandos de biologia do bacharelado e da licenciatura. Os bacharelandos optaram por aulas com práticas experimentais e com análises ao microscópio de luz, já os licenciandos preferem aulas expositivas com data show, utilizando-se da projeção de imagens relativas ao tema proposto, e aulas com filmes e/ou animações. Sugere-se que as aulas práticas de biologia celular podem ser planejadas de formas distintas de acordo com a modalidade dos cursos de biologia.
Palavras-chave: graduação; Biologia Celular; aulas práticas; ensino.

Introduction

The cell is the basic unit in living beings and Cellular Biology (CB) provides grounding in every concept related to the development and functioning of cells, therefore their study is essential to the understanding of dynamic life processes, ranging from the constitution of this basic unit to the body as a whole. For this reason, research in the field of CB can contribute to the advancement and welfare of world population (Albert *et al.*, 2007; Cooper & Hausman, 2006; De Robertis & Hib, 2006).

Due to the complexity and development in scientific instruments that have led to a greater understanding of the cell, and the relevance of this in the training of future professionals in the various fields of health sciences, the CB discipline became part of a number of basic undergraduate curricula in the Federal University of Goiás (UFG) in 1998, being offered initially in biological sciences (TC and undergraduate evening courses), food engineering, and subsequently in biology – BS and TC, as well as biomedicine, after the curricular redesign in 2002. CB is offered as a compulsory subject in biology (BS and TC), biomedicine and food engineering at UFG. It is a prerequisite for developmental biology (compulsory) offered in the sixth period of the courses above and in immunology (optional) in the fifth period. The basic knowledge students acquire in CB is fundamental in several scientific ramifications, among which are physiology, histology, biochemistry, molecular biology, embryology, anatomy, developmental biology, zoology, botany and immunology. The subject has been allocated 64 hours during the semester divided into 32 hours for lectures and 32 hours for practical classes, meaning 4 hours weekly over 16 weeks. Several other courses in the biological field use CB practical classes to reinforce the practical aspects that the theory they are teaching will further require. In the biology course, for instance, different classroom practices are applied to familiarize students with the laboratory environment, besides images and instruments they will later be using professionally.

There is no denying the importance of practical activities for learner development and the acquisition of a new view on the subject presented in theory. According to Lunetta: “Practical classes contribute to the development of scientific concepts, teach students how to approach the world objectively, and also develop solutions for complex problems” (Lunetta, 1991). Besides broadening the possibilities of understanding, practical activities allow the experience in the events seen on theory. Thus, “making practical activities as a starting point may be the alternative to a new way of building knowledge. In order to effect the unity between theory and practical, an experience is needed.” (Ghelli, 2004)

Practical methodologies can serve as teaching strategies by providing feedback on material already addressed as well as being an assessment alternative, where concepts learned correctly can be reaffirmed and misconceptions can be corrected. “Teaching practice has shown that textbooks are not always sufficient to explain conceptual relationships. Moreover it is hard for professors to identify conceptual mistakes analyzing texts or diagrams produced by students where they repeat what has been read in books or heard in the classroom. Students may repeat correctly while having misinterpreted the concept” (Soares *et al.*, 2005). As indicated by the authors, practical activities may aid traditional educational methodologies in the meaningful learning, because they allow new ways of acquisition and accommodation of concepts in the cognitive structure of the student.

Practical classes in the laboratory environment can arouse curiosity and awaken interest in undergraduate students as their facilities enable the observation of phenomena presented in lectures. “Furthermore, in these classes, students have the opportunity to handle instruments that would otherwise be unavailable” (Borges, 2002), although this does not imply that these classes could not be held elsewhere with the same efficiency.

At first sight, it could be thought that practical classes in CB would suffer regarding planning and implementation as they appear to require costly specialized instruments, and also since most of the observations should supposedly be made using advanced techniques and electronic microscopes. Yet what is the concept of a practical class? Is a practical class in CB only feasible in laboratories, using microscopes, slides and with a handful of notes?

According to Hodson (1998) practical activities can also be performed in field work, by using computers or studying in museums. The actual classroom can also become the practical environment by moving materials or using classroom dynamics, observations, models, games and videos.

Classes may, therefore, take place in other environments, depending on the teacher's ability to promote interaction, not necessarily including laboratory experiments. Many of the instruments that students consider indispensable in the laboratory do not always need to be in that location, for instance microscopes, magnifying glasses and other materials can be used elsewhere. Besides, "In spite of going against the opinion of many educators, there is no need to interrupt practical classes for lack of laboratories; people forget that their own bodies and the surroundings are available laboratories as long as there is life in them." (Bahia, 2005).

After offering practical CB classes for eleven years the university decided to assess the practical aspect of the subject. This paper, therefore proposes to analyze the different methodologies used in practical CB classes; the importance of monitors; the implementation of new activities; supplementary materials and the assessment system. It also intends to evaluate the teaching-learning process in CB in the biological science courses (BS and TC) at UFG as well as the students' views on the relevance of the subject regarding their future professional requirements.

Methods

Overview

This study was performed with 2 classes in the Biological Sciences Course at UFG, consisting of students regularly enrolled in the discipline of CB, offered in the first half of 2008, i.e., they were beginning the academic biology course.

The students were organized into groups according to their classes: Class B, for BS and class T, for teacher certification. The B class consisted of 30 students, with 12 males and 18 females. T Class consisted of 30 students, 9 males and 21 females. All students gave their consent to the study and agreed to participate.

The practical activities took place after the lectures, therefore all the practical content had been previously taught and discussed. Initially, each group was subdivided into two subclasses for better development of the activities. Each subclass was aided by two monitors, both biological science graduates who passed in the discipline with 80% grades.

Methodologies applied in classroom practice

To examine the different methodologies and the best materials used in the practical classes, the partial content (50%) of the discipline was divided into topics. Each topic was approached with a different methodology, according to Table I.

Supplementary CB material was prepared previously, containing procedures for practical activities, pictures and diagrams on the various topics of the discipline, in addition to transmission and scanning electron micrographic images and questions relating to the issues dealt with in the classroom.

The assessment was based on presentations and group discussions as well as on the projection of images from websites and textbooks, electron micrographic images and permanent slides whose images were captured by photomicroscope (Olympus B071). For this a computer was used (Intel ®, Pentium ® CPU 3:20 GHz, 3:19 GHz, Microsoft Windows XP Professional system, version 2002) with a projector. The slides were made using Microsoft Office PowerPoint 2007. Following the presentation of each image, questions were asked relating to topics in CB. Subsequently, a test consisting of 20 questions was applied, where students had a total of two minutes to answer each question. The purpose being to check learning continuously and gradually, and offer the students parameters regarding what had been discussed.

Table I. Educational methodologies used in the practical lessons of Cell Biology.

SUBJECT CLASSES	METHODOLOGIES
Lesson 1. Training with a light microscope and distinction between male and female cells	Practical experiments
Lesson 2. Preparation of biological materials	Visit to the Cell Biology laboratory
Lesson 3. Training with electron micrographic images and distinction between conventional electron microscopy	Lecture using projector
Lesson 4. Techniques for identification of chemical components in cells	Light microscope analysis
Lesson 5. Cytoskeleton and cell membranes	Films and animations
Lesson 6. Specialization of the apical surface of cells	Image / electron micrograph analysis
Lesson 7. Cell junctions	Lecture with diagrams on the blackboard and electron micrographs
Lesson 8. Nucleus and nucleolus	Discussion groups followed by the analysis of plates
Lesson 9. Review of previous content	Competitions

The choice of these approaches was made by means of intense review. It is common practice to carry out experiments and visits to the laboratory during practical activities in Cell Biology, and its value is undeniable in developing student learning, as pointed out by several authors (Fernandes & Silva, 2004; Frota-Pessoa, 1982; Galeazzi, 2001). Gaspar, (2005) assures that in experimental practices, the students become more able to build knowledge, as they are interacting with the studied phenomena.

The use of electron micrographs is also of great relevance, because in a great part of federal universities there aren't microscopes that can supply these images. Therefore, the analysis of these images allow for the familiarization with the obtained product through these equipment even in the absence of them.

Group discussions are also very rich, for they allow problematization by the educator and monitors, and the consequent consideration by the undergraduates. In this sense, Freire (1987) outlined the importance of dialog in the teaching-learning process, since this conversation between learners and educators about the knowledge they possess is the fundamental aspect to the problematization of real situations experienced by the learner. To Freire, problematizing is exerting a critical analysis of the actual problem, so that the students realize this question and recognize the needs for change.

The use of animations can be an effective and democratic teaching strategy, because they attend to the individual needs of students (Medeiros apud Smidt, 1982), giving learners the control over the time arrow, allowing them to rewind and fast-forward according to their specific needs. In addition to the animations, educational videos can bring illustrations of real processes, facilitating the students learning. This fact is of extreme importance to disciplines like CB, which brings essentially microscopic concepts and sometimes hard to understand. According to Ferrés (1996), a good video can have several uses, both to introduce new subjects and exposition of content in a systematized way, and to stimulate curiosity and motivation to new themes.

Competition also promotes individual thought, group work and can be effective means to teach, because they stimulate the search for answers and a quick solution to problems. As said by Bento (2006): “Like it or not, competition and concurrence are the soul and great engine of sports and life”. However, it is worth mentioning that has to be a commitment with the educability of the student, and that educators must be conscious of the particularities and functions of competition, because “competition, in itself, is not good nor bad, it is what we make of it” (Ferraz, 2002). Accordingly, the role of the educator is to analyze and coordinate competition as a pedagogical practice, allowing it to reach its real objectives.

Thus, the different methodologies used in this work sought to promote motivation and real learning of the students in all of the approached subjects.

Method of data gathering

After an initial bibliographic study and having defined the research objectives, the methods and technics on collect and analysis of data were determined. At this point, the questionnaire was chosen as methodological option. During the process of elaboration, the following precautions were taken: if the question asked was important to the research (Marconi & Lakatos, 1996); if there were a need for having more than one question on the same subject (Mattar, 1996); and if the participants had the technical knowledge needed to answer the questions (Boyd & Wetfall, 1964; Marconi & Lakatos, 1996).

Questionnaires

As indicated above, the methodological instrument used on the research to obtain data about practical activities was a questionnaire composed of nine questions. To choose the type of the questions, the classification proposed in the studied literature was used (Marconi & Lakatos, 1996; Mattar, 1996). According to this classification, the questions can be: open, closed (dichotomous), closed (trichotomous) or multiple choices. The elaboration of this questionnaire prioritized the use of open and closed dichotomous questions.

On open questions, the participants answer the questions on their own words, i.e. they are discursive questions. The advantages of this type of question, according to Mattar (1996), are: a greater amount of information can be collected; the participants are not influenced by predetermined answers; and are easy to elaborate. However, they have the following advantages: they are difficult to analyze, both quantitatively and qualitatively; and there might be difficulty in understanding, because of illegible calligraphy, misspelling, ambiguous phrases, among others (Mattar, 1996). Besides, this type of question allows for the interpretation of opinions and ideologies of interviewed, throughout qualitative analysis.

On dichotomous questions, the person chooses the answer, having only two options to choose from, e.g., “yes” or “no”. According to Mattar (1996), amongst the advantages of this type of question are: fast finishing; easy counting and analysis of data. As a disadvantage, can be cited the occurrence of systematical errors: in case the participant doesn’t agree with both options, he can opt to one of the alternatives, even though it isn't his opinion, or just skip the question entirely. However, categorical data obtained in dichotomous questions can be submitted to statistical tests, providing quantitative results.

During the elaboration of the questionnaire, it was sought to minimize the disadvantages presented and opt for question types that were more advantageous according to the literature that was used. Additionally, previous tests were made with students of TC, on the purpose of verifying if the questions were clear or if there were barriers to the understanding of the content.

They were also encouraged to express their views in writing. This research methodology was applied to provide anonymity and credibility to the responses and to give the interviewees time to think and express their opinions, besides enabling subsequent statistical analysis.

The questionnaires were applied in one subclass of class B and one of class T, each subgroup with 15 students. Lots were cast to decide which sub-class would take part in this phase. The questionnaires were not answered immediately before or after tests to avoid any positive intentionality in the responses and there was no preparation or anticipation of issues.

Qualitative and quantitative analysis

To qualitatively analyze data, there are a variety of technics; Mayring (2002) mentions seven of these: a) grounded theory, b) phenomenological analysis, c) social-hermeneutic paraphrase, d) analysis of qualitative content, e) objective hermeneutics f) psychoanalytic interpretation of texts and g) typological analysis. In this study a qualitative analysis of the content was made, without excluding quantification, according to Mayring (2002) who emphasizes that the important function of qualitative approach is to allow a quantification with purpose. Thus, the choice of using either qualitative or quantitative is based on theoretical-methodological grounding presented on the consulted literature: "As part of the process of constructing the knowledge, ideally, the researcher shouldn't choose between one method and the other, but use the various approaches, qualitative and quantitative, that adapt to its research question" (Günther, 2006)

Statistical analysis

Statistical analysis of data, collected from student written responses, was based on the use of statistical package BioEstat 4.0 (Ayres *et al.*, 2005). Responses were classified under two categories, in 2x2 contingency tables, undergoing Fisher's Exact Test, and in the cases where the data fell into an ordinal scale, they were analyzed by ANOVA with two criteria, so that the analysis took into account the variation between treatments (e.g. the different methodological practices), and the variability among blocks (students). The Student t test was applied for comparison of sample mean values. The significance level was set at 5% ($\alpha = 0.05$).

Results

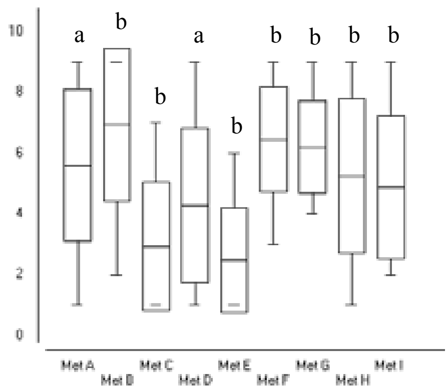
Importance of practical classes in cell biology

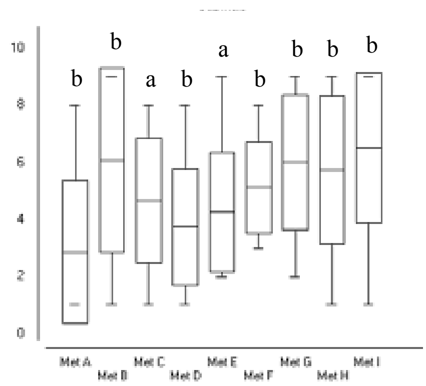
All Biology students (100%) considering both lines of study - BS (B) and teacher certification (T), view the practical CB classes as important for their academic education. Moreover, the students in B (93.33%) and T (100%) see these as an aid to understanding the subject matter presented in lectures ($p = 1.0$), which means that practice is an efficient facilitator in the application of theory taught.

As students began to understand the cell better, their views on CB also altered - B (80%) and T (100%) - after studying the cell using different practical methodologies. In general, visualizing the cell, the "perfect cell" model and the equality of cell types, without their complexities, as studied in basic education, were seen as positive modifications in the discipline by both modalities. There is no evidence that BS and T differ on their views on CB at the university ($p = 0.22$).

Methodologies for practical classes in Cellular Biology

Opinions on classroom practices in CB differ between B and T students. Among the nine types of practical classes offered, the BS class stated through oral and written reports, that they preferred classes with practical experiments and analysis using the light microscope (LM). Preference for the first two methodologies is significantly different from the others (Figure 1). In contrast, the T class stated their preference for class lectures, using the projection of images about the subject, and classes with movies and / or animations. In this class, only the first teaching practice differs statistically from the others (Figure 2).





Figures 1-2. Analysis of biology student preferences regarding practical methodologies in CB. Responses from students in BS (1) and biology teacher certification (2). MetA (classes with experimental practices); MetB (Visit to the Cellular Biology laboratory); MetC (lectures to present data); MetD (light microscope analysis classes); MetE (classes with films and animations); MetF (image / electron micrographs analysis); MetG (lectures with diagrams on the blackboard and electron micrographs) MetH (Talk group followed by plate analysis), MetI (competitions). Equal letters indicate no significant difference.

The BS students, therefore, prefer practical learning that involves using the LM and handling instruments whereas the T students would rather methods that provide the visualization of cells in motion and three-dimensional structures. There was no significant variability among students of the same type (Table II). Oral reports from the B class stated that they do not consider classes with animations and / or films, discussion groups or dynamic activities as practical classes. However, this opinion was not noted in the other group.

Table II. ANOVA of two data paths on different methodologies for practical classes in cell biology for the Bachelor of Science and the Teacher Certification students. The students were considered as a block and the different questions as treatments.

	BACHELOR DEGREE	DEGREE
F (treatments)	6.4900	3.4451
P (treatments)	< 0.0001	0.0017
F (blocks)	0.0000	0.0000
P (blocks)	**1.0000**	**1.0000**

Supplementary Study Material for Practical Classes

Both the BS and T groups, considered the supplementary study material for practical classes of assistance in following the classes and fundamental for practical evaluation. The classes considered the material well organized, presenting quality and clarity in addressing the issues. However, the quality of the illustrations needs to be improved. The views on the supplementary material did not differ between students in the same BS modality, F (Trat.) = 8.9241, p (Trat.) <0.0001, F (block) = 2.6235, p (block) = 0.0043; and teacher certification, F (Trat.) = 4.2043, p (Trat.) = 0.0024, F (block) = 2.8715 and p (block) = 0.0021, (Table III). The students were considered as a block and the different questions as treatments. For students, P (block), there were no statistically significant differences.

Table III. ANOVA for two criteria of data on the supplementary study materials used in practical classes in cell biology for the Bachelor of Science and the Teacher Certification students. The students were considered as a block and the different questions as treatments.

	BACHELOR DEGREE	DEGREE
F (treatments)	8.9241	4.2043
P (treatments)	< 0.0001	0.0024
F (blocks)	2.6235	2.8715
P (blocks)	**0.0043**	**0.0021**

Practical evaluation in cellular biology

Biology undergraduates generally agree that practical class tests using the projector, and with 2 minutes per question, in a test with 20 questions, is an efficient assessment method. Opinions on assessment do not differ within the same modality (for BS, F(blocks) = 1.2884, p(blocks) = 0.2544; and for T, F(blocks) = 1.5785, p(blocks) = 0.1260).

Monitor Analysis

Two instructors per subclass (consisting of 15 students) proved sufficient for the implementation of practical activities in CB, both in the BS class (86.66%), and in the T class (80%) (p = 1, 0).

All the students (100%) both in the BS and T subclasses considered the instructors suitable for the implementation of practical classes (p = 1.0).

General remarks

Students from both groups, BS (73.33%) and T (93.33%) requested extra study time (p = 0.33). By this they mean access to the Internet, book CDs, other books, blades, plates, molds and models. 100% of the BS and 93.33% of T students stated the importance of having an academic environment for further learning CB. Both groups felt the need for out of class assistance (p=1,0)

Discussion

This study confirms the need for the CB discipline to remain in the training program for professionals in biological fields. This is because information on cells is essential in many subjects in the biological sciences curriculum and is fundamental for scientific research, particularly that related to biological diversity. "Whatever the biodiversity identification, evaluation and exploration project, scientific methods and special biotechnological procedures must be taken into consideration, particularly those related to molecular and cellular biology, biochemistry ..." (Garcia, 1995); not to mention the importance of CB in technological development, bioengineering and human health, as quoted by Radovan Borojevic (2009) from the Advanced Program of Cellular Biology Applied to Medicine “Bioengineering encompasses the processes that employ autologous, allogeneic or xenogenic living cells as therapeutic agents”.

It is precisely because of the importance and need for studies in the area of CB that more research and investments in teaching should be made, in order to improve and develop alternatives for more efficient higher education, both for centers where there is appropriate infrastructure, and for those with limited laboratory equipment.

Other practical devices, such as animation and movies, contribute to the understanding of cellular dynamics and mobility, especially in aspects related to cell division, the dynamics of the cytoskeleton and the movement and organization of sub cellular structures. As quoted by Leite & Silva (2005), “…oral and written language are important in constructing the human being, however, the computer, video and TV involve the students due to their familiarity, providing a new perspective and significantly altering the classroom environment". Thus, is made necessary that the teachers in initial formation or even the BS students have practical experiences with this differential methodologies, so that themselves can use them later in their pedagogical practices or in activities of socialization of the scientific knowledge .

The plates containing images obtained by light microscopy, and by electron transmission and scanning electron microscopy have helped students to see that cells can differentiate according to their functions, directly relating morphology and functional activity. Furthermore, the images shown in the 3D movies helped them understand the three-dimensional structure of the sub-cellular components that form a whole, the cell. Thus, the cell can be seen as a living, moving and dynamic structure. This is an important aspect in the discipline since students enter UFG with a static view of biology and of biological processes and structures in general.

Eunice and Fleith (2004) emphasize the importance of preparing the students to think for themselves and solve new problems, requiring the development of creative and independent thinking, i.e. teaching practices should be based on creativity and its development in the educational context. Thus, practical classes in CB have penetrated different ramifications of scientific knowledge, offering biology students, both the BS and T students, the opportunity to study different dimensions of the cell, and develop aspects of creativity, sensitivity, and artistic thought. "Modern and creative scientific practice should therefore include procedures that encourage students to work more rigorously and creatively, more in consonance with the mode of production of scientific knowledge" (Vasconcelos *et al.*, 2002). Thus, it is worth to point out that the production of the scientific knowledge is not structured nor take place in only one way, existing opportunities of creation and innovation in the process of investigation and research.

The biology BS students at UFG sees themselves as future researchers, whose professional practice is related to the use of instruments and reagents. Their view of practical classes is focused mainly on the use of traditional instruments and methodologies, where the microscope plays a very important part. The teacher certification students, on the other hand, value activities that require the use of different teaching materials, probably because they need training as future elementary and high school teachers.

The teacher certification students' choice of practices using the projector shows interest in current educational technologies. The use of MS PowerPoint® in the classroom leads to better content presentation, encourages discussions, improves image and film quality by increasing the color scale (Keefe and Willett, 2004; Voss, 2004) as well as being a valuable tool for professors regarding the study of cell structure and dynamics.

The understanding of the three dimensional structure of the cell may possibly contribute towards the building of models and molds of different textures that will enable various teaching approaches in CB where student involvement and inclusion can be heightened both at the basic level as well as in higher education.

According to Vasconcelos *et al.* (2002), syllabus review and research into new laboratory practices can urge students and professors to form a critical mass dedicated to science. This is essential to improve the teaching of science. Therefore suggestions regarding teaching based on the use of practical classes and the interaction between learners and professors as applied in undergraduate biology courses in recent years in UFMG, for instance, where a "Virtual Cellular Biology" Website with images and scripts (http://www.icb.ufmg.br/mor/biocelch/citologia.html) makes the course more learner friendly.

The purpose of this study is to become part of the effort above and to this end the following points can be highlighted:

- Practical CB classes can go beyond the methodologies that restrict teaching to blade analysis under the light microscope, i.e., new educational environments can be created to teach the cell syllabus, such as the use of films, animation, competitions and group discussions.
- Supplementary study materials or guidebooks for practical classes are a necessary aid to practical procedures, syllabus organization and class preparation.
- The use of transmission and scanning electron micrographic images in the classroom is a useful tool to help students understand cell morphology and intracellular aspects.
- CB practical classes can be planned in a number of ways according to the type of biology course. BS groups preferred practical classes using instruments in accordance with the topic studied, whereas the teacher certification groups chose alternative materials such as projection and visualization of cellular structures by means of films and animation.
- Classroom instruction performed by biology graduate students not only aids the implementation of practical work but also encourages research in the discipline taught.

This study emphasizes the importance of research focused on the different approaches necessary when teaching BS and T students, mainly regarding practical classes since the theory must obviously be the same for all, thereby ensuring the subject is always updated, an essential element in training the future generations.

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