Encouraging scientific cooperation and inclusion through microscopy: a case study

G. M. F. V. Aquije[1], **A. M. N. Korres**[2] and **S. Q. M. Leite**[2]

[1]Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo – IFES, Campus Vila Velha, Brazil
[2]Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo – IFES, Campus Vitória, Brazil

With the aim of popularizing, propagating, and communicating the science of microscopy the extension project "Study Group for Microscopy" was created. This project demonstrates the value of microscopy as a technological tool for the community in the process of inclusive education and scientific alphabetization as well as in professional and technical teaching. Microscopy can be used as a potent example of innovation and for encouraging interdisciplinary cooperation. This project has been developed during monthly meetings through presentations and practical activities like workshops. The subjects proposed for discussion always have had microscopy as the central theme, but with a view towards inclusion, and propagation of scientific ideas, highlighting the innumerable applications for which this technological resource can be used. We believe that the activities developed, with the participation and exchange between professionals of diverse areas, have contributed to the interdisciplinary dissemination of knowledge and promote studies using microscopy.

Keywords professional learning; technology; microscopy; scientific alphabetization, inclusion

1. Introduction

Microscopy is one of the most ancient tools in teaching and research activities. With its origins in ancient Greece it remains today, a very current and dynamic teaching approach. Microscopes have over the years, undergone modification principally to perfect the instrument for use in diverse applications.

The fact that microscopy, from the traditional to the most modern applications has always had a place in our teaching cannot be disputed; however we can ask, in what way can microscopy best be used as a teaching tool? Can microscopy be used not only as an imaging tool, but also as an innovative tool to promote co-disciplinary interaction in the teaching-learning process?

In an effort to answer these questions a group of teachers, supported by the Extension Department (Diretoria de Extensão) of the Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo (IFES)/Brazil, working in collaboration with qualified technicians, organized in May 2011 a Study Group for Microscopy (SGM). This is an extension project of an educational, cultural, and inclusive character developed at that Institution with the objective of modernizing teaching through familiarization of the academicians, students and teachers with the microscope and its innovative applications.

The objective of this Group was not only to recognize the microscope as a tool in the teaching-learning process, but also to offer opportunities for the presentation and discussion of relevant themes; providing for the exchange of knowledge between professionals and students working and studying in diverse areas. This coming from the perspective that an education in tune with the future, and which overcomes the limits of the system and the market would be an education, turned more toward social transformation than toward cultural transmission [1].

SGM meets monthly to discuss different themes which are mainly related to techniques and applications of microscopy in different areas of interest. Each meeting is conducted by a professional specializing in the theme being discussed and provides for the exchange of related information and news. In that way the Group also creates a space in which research and extension activity about the process of scientific alphabetization and qualification can be conducted.

With this approach we expect to achieve advances in scientific development in the perspective of the movement Science/Technology/Society/Environment. We propose a contextualized approach to teaching Sciences which will enhance critical analysis by the academicians [2]. This strategy provides for an integration of science with historical, cultural and social interests; in that way contributing to meaningful discussions of the impact of science and technology on society and the environment.

2. Cooperative Activities

Since the first microscopes and the early exciting valuable reports, many centuries have passed. However, as scientists, we know that there are still exciting discoveries to be made, in which all branches of microscopy will be involved [3]. Presently, microscopes and techniques for specimen preparation are very advanced. The models presently available permit extremely precise adjustment of focus and magnification. In the twentieth century, the microscope conquered a place in such diverse areas as Medicine and Engineering. The detailed knowledge of the micro-structure of diverse

materials, the micromanipulation of micro/nano structures, biological and non-biological, allows understanding, and, in many cases, even the prediction of the properties and behaviour of these materials [4].

Because of these considerations researchers, students, and technicians are very curious about the enormously important knowledge that comes from the use of microscopy, its techniques, and their applications. The study of microscopy carried on by the Study Group for Microscopy, developed in an Institution focused eminently on technical and technological teaching can significantly contribute to the development of students, teachers and researchers; indeed all of those involved in the activities promoted by the Group.

To serve this perceived need the Study Group for Microscopy was instituted to involve the community, with such interests and needs, in discussion and study of the many areas in science and technology which require microscopy as a means of study.

In its first year (2011-2012) the Study Group for Microscopy held nine meetings. The themes were diverse (Table 1), ranging from aspects of the history of microscopy to specific themes such as wavelength-dispersive spectrometers (WDS), and the applications of those themes. An average of 15 people attended the meetings; among them were professionals from several different areas (Biology, Education, Engineering, Physics, Geography, Mathematics, Metallurgy and Chemistry), from different institutions and academic levels, including as well: high school students, college students, and technicians (Table 2).

Learning is a dynamic activity which may be carried out in several different ways, for example, by individuals, in groups or in teaching institutions. For some people, group study is the best learning experience [5]. Although Study Group for Microscopy considers subjects in which microscopy is utilized, which are more related to the Biological Sciences, Biochemistry, and Biotechnology, as well as areas like Chemistry, Physics, and Metallurgy. The Group has been open to participation by academicians and students in general because we believe that by providing the opportunity for a cooperative group learning experience, using microscopy, as a way of teaching and learning, the Group affords an extra experience added to formal schools. This is made possible by the interface existing between the Sciences discussed. This interaction was defined as a coordinated action in cooperation and dialogue between the different areas of knowledge [6].

Besides that, the exposition of microscopy carried out by this extension project provides an opportunity for discussion about current technical advances in, and applications of microscopy, permitting in that way compensation for any deficiency of formal teaching as well as creating a true link between the different areas of the Sciences (Physics, Chemistry, Biology, and others). We believe this approach stimulates people to learn.

The forum organized by SGM, by synergizing interaction among the diverse professions (Table 1) involved with microscopy also offers to fill a lacuna in respect to qualification in the technology of microscopy, especially for the installation and maintenance of equipment. The lack of such qualification in countries like Brazil can be understood in terms of their low population density of electron microscopists, the lack of specialized EMjournals in their libraries and also by an apparent disinterest in the topic because of those deficiencies [3].

The Study Group for Microscopy (SGM) with its unique characteristics and acting in a teaching institution has demonstrated its role in permitting conceptualization of microscopy as an integrative tool in the teaching-learning process while involving professionals from very different areas of study and consequently with the most diverse profiles. It is possible to appreciate that SGM not only gives an opportunity for discussion and exposition of important topics, but also for the exchange of ideas between professional representatives from the most varied areas of knowledge.

Table 1 Themes discussed during the first year of activity of the Study Group for Microscopy.

MEETINGS	THEMES
1st	"History, evolution, and applications of Microscopy"
2nd	"Principles of operation of optical Microscopy" "Uses of Optical Microscopy in Metallurgy"
3rd	"Basis of Electronic Microscopy" "Electronic Microscopy and Experiments with WDS"
4th	"Principles and bases of Electronic Microscopy"
5th	"Light Microscopy in Botany"
6th	"Microscopy for visually deficient people"
7th	"Microscopy in Microbiology: study of interactions between microorganisms"
8th	"Advanced Optical Microscopy"
9th	"Historical considerations of Microscopy: from Greece to current times" and "Microscopy in microbiological analysis and its contributions to environmental quality"

Table 2 Number of and area of knowledge of the audience at each meeting of the "Study Group for Microscopy" (SGM).

	Meetings held								
[1]Knowledge areas	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
[2]Biology	2	3	3	6	4	6	4	1	2
Education	1			1		2	1	1	1
[3]Engineering	4	3		4		1	2	1	6
[4]Physics	2			2	3	2	1	3	
Geography			1	1					
Mathematics			1	1					
Metallurgy	3	2	2	6	3	1	1	6	
Chemistry	1	1	1	3	9	4	1	4	
Occupation Safety									2
[5]High school technical students	1			2				1	5
Total	14	9	10	26	19	16	10	17	16

[1] Information collected at each meeting from the audience during registration. [2] Including professionals and students who work with Microbiology, Botany, Biochemistry, Nutrition and Environmental Engineering. [3] Including professionals and students who work with Engineering (electrical, environmental), electromechanics, and automation. [4] Including professionals and students who work with Astrophysics and Condensed Matter Physics. [5] Including students of integrated technical and high school courses of Electrotechnical, Mechanics, and Construction Contracting.

3. Inclusion

The microscope's history is an integral part of mankind's history as man has sought to understand and improve vision [7]. The beginning of the optical sciences can be found in Greece, in Plato and Euclid's postulates in the periods 500 and 300 years before Christ, respectively.

The first experiments with lens combinations used in instruments for magnification resulted in the creation of the first compound microscope. The credit for this invention, around 1595, has been given to the Dutchman Zaccharias Jansen. This equipment aroused great interest and induced the creation of many other prototypes [8]. Robert Hook, in XVII century reported the first visualization of a cell after examining cork. Marcello Malpighi was one of the first to apply the microscope in the study of animal and vegetable structures. From that time on, microscopy evolved into a well-defined area in science and fascinated people as new details about the organization of biological and non-biological systems were revealed [8].

During the XVIII century the microscope became fashionable and was produced by workmen as an authentic work of art and adornment. However, also in this century, the microscope became part of the learning process for nobility and the upper classes of society.

Currently, teaching institutions see microscopy only as an auxiliary tool for study and teaching. Many reports can be found describing the microscope as an instrument for acquisition of knowledge in formal schooling at different levels. We believe this vision has its origin in the initial conception of microscopy that understood the microscope as a tool to be used to visualize structures that could not be seen with the naked eye.

We recognize that the use of microscopy in teaching at different educational levels is of great importance, however, in our extension experiences, we have learned that the study of the microscope in teaching/learning can greatly exceed this value by producing a basic change in the scientific paradigms normally encountered in the academic environment.

Contact with microscopy and the study of the microscope by young people in technical courses, adults in undergraduate courses or even those in post graduate studies, will provide opportunities for them to acquire new concepts and change their vision of the world.

Microscopy should be regarded as more than simply the use of an imaging instrument and its use by students as an individual activity, to be seen as a means of interactive learning. It also helps to address the challenge of teaching biology, as it is practised, enabling students to generate and present images as data, using state of the art technology, and in the process, enriching their understanding of cells as living machines [9].

Scientific alphabetization can be understood as a way of enhancing commitment in education. It is necessary to point out that this should be of as much concern in Elementary School as in High School and even though the idea may seem shocking it's inclusion at College Level is also desirable [10].

"the alphabetization process in Sciences is continuous and transcends the school period, demanding permanent acquisition of new knowledge. Schools, museums, radio and television programs, magazines, newspapers should be used as partners in this business of socializing the scientific knowledge in a critical way" [11].

We believe the use of microscopy promotes scientific alphabetization. As a technological resource, microscopy can be utilized in the process of scientific inclusion and alphabetization. Microscopy is useful as a tool for innovation and cross-disciplinary connection in professional formation at all academic levels.

Of the innumerable ways that there are to realize scientific alphabetization, microscopy functions within the educational paradigm defended by Edgar Morin in his theory of epistemology of complexity. For Morin, the term epistemology of complexity, from the Latin "complexus", that which is "woven together" [12], integrates the mode of thought; in opposition to the linear reductionist manner of thinking.

In the field of scientific education, the movement Science/Technology/Society/Environment is in resonance with Paulo Freire's educational ideas, because it supports teaching science in a more humanistic way, in which social awareness that science and technology are elements of the culture and that the classroom is a place in education for constructing citizenship, are considered [13, 14].

The Study Group for Microscopy with its extension activities is living this new paradigm of scientific alphabetization in a perspective of the philosophy of the Science/Technology/Society/Environment Movement. This strategy of teaching/research/extension provides for contextualization of science with history, culture, and socio-environmental questions contributing to discussion of the impact of science and technology on society and the environment.

4- Considerations

The organization of activities of the Study Group for Microscopy into different themes, even though related to each other and to Microscopy, has attracted the attention and interest of the academic world from many different areas. This is very useful because this public brings additional professional experience to the theme under discussion. In this way, the meeting contributes to the appreciation of different applications and approaches to the techniques being considered.

SGM has identified microscopy as an important tool in the learning-teaching process. We believe it provides for exchange of knowledge and cooperation between professionals and students involved in teaching/research/extension in different areas of study. This diversity has been demonstrated in the meetings sponsored by the Group, as well as by the creativity evidenced during the discussions.

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