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NEED FOR NEW INFORMATION TECHNOLOGY IN THE TEACHING OF PHYSICS AND CHEMISTRY IN PORTUGAL

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Many of the western industrialized nations are facing severe problems with their economies, authority relations between institutions, and values. Commentators and critics analysing this crisis have spent a good deal of time focusing on the family and especially on the school. The crisis in schools and teaching, they admit, is complicated and widespread, but one step towards a solution may be the rapid introduction of personal computers into schools. It was argued this will give the students new skills, skills that are necessary in international competition for markets and jobs. It will also make the tasks of teaching more interesting and creative (Apple, 1989).

The growth of information technology (IT)* in schools is not a slow movement. In one recent year, a fifty-six per cent increase was reported in the use of computers in schools in the United States. Also France, Canada, England, Australia, and many other countries have recognised their importance. Nowadays, it is nearly impossible to find a subject that is not being "computerised", though mathematics and science remain the home base for a large portion of the use of computers in schools (Apple, 1987).

It is important for teachers to recognise that although IT, and computers in particular, is only one of a range of sources of information it is one with particular qualities, namely, the speed of retrieval, the vastness of some databases and the facility to provide continuously updated material (D.E.S.,1989). Moreover information technology skills need to be regarded as enabling, in the same way that speaking, listening, reckoning, reading and writing are fundamental to all school subjects (Sparkes, 1989). Pupils should be allowed to enter data obtained from their own experiments into prepared programs. This may then be manipulated to obtain results (for example, a least squares plot) and to print out the results for inclusion in the final report. Likewise, they should be encouraged to use word processors to produce their project reports.

Over the next twenty years, almost everyone will need to acquire the practical skills of operating information retrieval systems and the cognitive skills of accessing and interpreting information presented by electronic means (Sparkes, 1989). IT is here to stay and will become increasingly used throughout further and higher education.

* Information technology (IT) may be defined as the technology associated with the handling of information: its storage, processing and transmission in a variety of forms by electronic means, and its use in controlling the operation of machines and other devices (D.E.S., 1989, p.1). Computers are at the core of IT.

(i) Learners enjoy using computers

In our society, the computer has very high positive motivational value. Although the computer is not always pictured favorably, for most learners, particularly most young ones, it is presented as an exciting new device. So students are "prepared" for computers, even eager to have contact with them. In the field of learning these motivational issues cannot be neglected. Although we cannot know what the evolution of the computer will be, for the moment, it generates very strong positive interest in both classrooms and informal learning situations (Bork, 1985).

(ii) Individualization

The time required for learning may differ from student to student. A central problem in any educative system is how to reach the individual student effectively. With good material available, computers can allow individualization responsive to student needs.

(iii) Learning faster

Student time is an important issue, and anything that can increase efficiency, such as the computer, is important.

(iv) Visualization

Computers have an increasing capability to provide interactive visual information, such as drawing graphics.

(v) Simulation

Computers are excellent for simulating the real world, particularly in science. There are programs for investigating wave motion, molecular motion and particle motion in the absence of friction. Chemists have access to programmes that model industrial processes, such as the Haber Process. Biologists can carry out variations of Mendel's experiments and Physicists can run their own "Chernobyl" nuclear accidents, with less damaging consequences to the environment and themselves. Computer simulation can be very important in the process of building and testing concepts and representations of natural phenomena. They can extend the natural world, not in direct observable concepts but in unobservable and ideal situations, for example, a frictionless world.

Simulations can extend the range of manipulable objects, real or "imagined".

Though we don't as yet have a full picture of how students learn in computer simulated environments, a properly designed simulation can introduce a new dimension in science teaching if it allows the student to test his/her naive ideas about the world and confront them with reality. Computer simulations can be based on an established model or on an alternative model, assumed by some students. That is, we can simulate alternative realities.

The situation in Portugal

In Portugal there is a lack of knowledge concerning the extent of the use of new information technology in the teaching of science, particularly in Physics and Chemistry.

The goal of this preliminary study is to identify present trends about the use of new information technology by Physics and Chemistry teachers in middle (8th and 9th grades) and secondary (10th to 12th grades) schools in Portugal*, in comparison

with more traditional forms of teaching resources.

Hopefully, identified trends might be the starting point for recommendations in the training of Physics and Chemistry teachers. To make useful recommendations some independent variables were selected, namely, the sex of the teacher (is the use of IT mostly done by men?), teaching experience (do the younger teachers use IT more extensively?), academic background (which academic qualifications are more related with the use of IT?) and professional qualifications (are professionally trained teachers more able to use IT?).

For example, concerning the variable sex, several studies suggest that females are far less likely to use computers than males, and that this tendency holds at all age levels (Durndell et al., 1987).

DESIGN

The study presented is part of a larger project developed since 1986 (Cachapuz et al.,1989) involving a documental analysis of curriculum material (official programmes and textbooks) and two surveys, one addressed to teachers (N=725) and one to students (N=9000, analysis in progress).

In this study only aspects directly concerning the use of IT by teachers are explored. Teachers were asked to appraise the level (frequency of use) of each of nine teaching aids (computer, "diaporama"**, video materials, opaque projector, slides, overhead projector, experimental work, blackboard and work sheets) which are included in their teaching. The questionnaire used to gather background information concerning the teaching of Physics and Chemistry in Portugal was administered during February 1987 to 725 teachers (37% of the corresponding total population) of which a representative sample of 521 respondents was selected for final analysis.

RESULTS

Table 1 shows the percentage of teachers who use each of these teaching aids.

Overall results (table 1) show that only a minority of Physics and Chemistry teachers use new information technology in their teaching: 19.5%, computer assisted teaching; 29.5%, "diaporama"; 45.0%, video materials. As expected, most of the teachers use more traditional teaching aids: experimental work (98.0%), blackboard (99.0%) and work sheets (99.5%).

* Since 1985, a national project, the MINERVA PROJECT, has been developed in order to introduce new information technology, particularly computers, in the schools, from pre-primary to secondary level. At present, nearly 30% of middle and secondary schools are already involved.

** "Diaporama": slides, text and sound.

Teacher's sex

The results (fig.1) suggest substantial differences in the case of the use of video materials and computers. The latter were mostly used by men ($\chi^2 = 6.03$, $\alpha < 0.02$).

Summers (1990) shows that male students, at the start of a one year secondary postgraduate teacher training course, have greater knowledge of computers, were more favourably disposed to computers and were more confident than females.This probably reflects a differential perception of social roles which were reinforced throughout the educational system. It is known that in primary schools boys and girls handle IT equipment with similar confidence. However, during the late primary years and adolescence, the interest boys have in technical artefacts is frequently reinforced, whereas that of girls often lacks encouragement (D.E.S.,1989).

Teaching experience

The results (table 2) show that as teachers' experience increases, the use of video materials also increases. On the contrary, younger teachers with less years in the profession ($\leqslant$ 5 years) are those who use the computer more extensively ($\chi^2 = 4.42$, $\alpha < 0.05$). This result suggests that recent university pre-service courses should do more preparation in this area. It also suggests the need to organise adequate in-service courses for older teachers.

Academic background

Figure 2 suggests that longer academic courses tend to increase the use of IT, namely in the case of video materials ($\chi^2 = 20.36$, $\alpha < 0.001$).

Teachers with a university degree in Physics tend to make more use of computer assisted teaching than teachers with a Chemistry or Physics degree ($\chi^2 = 3.35$, $\alpha < 0.10$).

Professional qualification

Generally, teachers with a training degree tend to make extensive use of IT (table 3). In the case of computers no improvement was detected, probably because a substantial proportion of teachers with a training degree are the older ones, i.e., those for whom professional programmes had no component in this area at the time. In support of that, teachers with no training degree, but involved in recent training programmes, make more use of the computer in their classes (31.1%) than those not involved in those programmes (15.6%).

CONCLUSIONS

The main conclusion of this study is the need to improve, in Portugal, specific training programmes for Physics and Chemistry teachers with a focus on the use of IT. Despite the results of this study suggesting that recent teacher training programmes are moving in the right direction, some recommendations must be made:

(1) It is necessary to promote in-service teacher training programmes with special attention to the use of computers in the teaching of Physics and Chemistry.

(2) These programmes should be mostly directed to teachers (i) without a university degree in Physics, (ii) with more than five years of teaching experience, (iii) so that a more balanced pattern of male/female users emerge.

The implementation of these courses raises some problems. The area of instructional computing is so recent and evolving so rapidly that it is difficult to keep abreast with it. Software is still emerging. Hardware is changing rapidly. All of these conditions make the task of trying to teach teachers and potential teachers about instructional computing very difficult. Perhaps the best approach in the training of teachers is to develop in them the ability to select teaching strategies and media in relation to their objectives and students. Sometimes, the best answer will be the computer, but sometimes it will not. Educators need to look at what they know about teaching and learning, about curriculum and students, and take all factors into account in deciding when to use a computer and when not. The issue of deciding what computers can do well is an important one (Langhorne et al.,1989).

It is important for teachers learning about computers to understand that computers, like any component of modern technology, are neither inherently good nor inherently evil in learning applications (Bork,1985). Possible negative consequences of new technology in education include the de-skilling and de-powering of teachers, and also the creation of inequality which is brought about by the high costs of this particular technology as it applies to education in the limitation of access to new technology. The cost of computers is still comparatively high. So, the addition of computer curricula most often means that money must be drained from one area and given to another (Apple, 1987).

Clearly, not all content and not all objectives are best met by having students interact with information technology. Decision making based on understanding of content, understanding of learning processes, and understanding of students can guide educators to use technology to its best advantage and opt for other strategies as appropriate. The success of innovation is dependent on sound decision making, on looking at the potential applications of innovation, studying current status, comparing needs and capabilities, and selecting where that innovation fits best. So it is with computers. It clearly has specific capabilities (Langhorne et al.,1989).

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Teaching aids	Teachers' use (%)
Computer	19.5
"Diaporama"	29.5
Video materials	45.0
Opaque projector	42.0
Slides	57.5
Overhead projector	86.0
Experimental work	98.0
Blackboard	99.0
Work sheets	99.5

Table 1. Teachers' use of different teaching aids

New IT \ Professional experience (years)	< 1	1 - 5	6 - 10	11 - 15	16 - 20	> 20
Computers	24.5	25.2	12.7	21.6	12.7	18.5
Video	32.1	36.5	46.3	46.4	50.0	56.6
"Diaporama"	38.5	29.8	27.8	28.1	30.4	24.7

Table 2. Teachers' use of IT (%) vs years of teaching experience

New IT \ Professional background	Teacher training degree	No teacher training degree
Computers	19.6	20.1
Video	53.5	27.9
"Diaporama"	31.1	27.3

Table 3. Teachers' use of IT (%) vs professional background

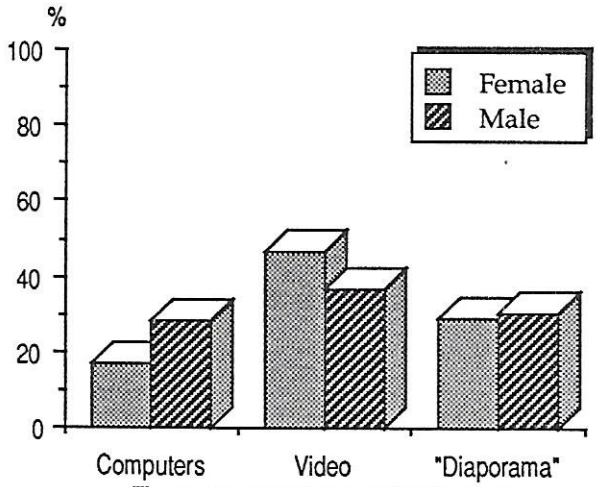

Fig. 1 - Teachers' use of IT (%) vs sex

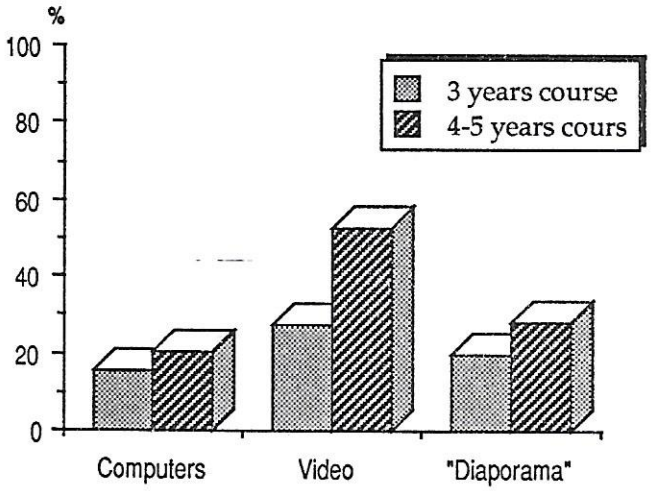

Fig. 2 - Teachers' use of IT (%) vs academic background