Short Papers

During the conference a number of short papers were presented, eight of which are included here. Each contributes further to the themes in the main papers.

Teachers roles are explored by Niess; teachers working in new interdisciplinary teams using IT found their pedagogical knowledge challenged, as they felt they had to re-learn their own subject and how to teach it in a new interdisciplinary way. Although challenged, this left them feeling uncomfortable and insecure. In contrast Bottino and Furinghetti consider the role of software tools to support existing teaching needs. They worked from the assumption that teachers will only exploit the potential of software tools if their use is embedded in existing pedagogic problems. Immediately, therefore, the issue of integration from within, or designing new integrated structures, returns.

Baron and Harrari studied how students perceived informatics in school. Students self-evaluation of their competencies with the computer reflected the frequency of their use in the classroom. Blaho and Kalas introduced an Animation Microworld into their classroom in an endeavour to stimulate cross-curricular activities. This introduced the pupils to software development techniques through the creation of animation and control of the objects they design themselves. Moller also wished to capitalise on pupils' exploration by designing software to enable students to make discoveries. The challenge has been to reduce or even eliminate the amount of prompts needed for them to chart their own discoveries through the software environment. Again, it appears that if the opportunities are created, learners themselves move with ease into an environment where they can explore and use IT for themselves.

Both the concerns of teachers and learners are considered by McDougall, who found that teacher support for the introduction of innovation, in this case laptops, was absolutely critical; after a few years most students appeared to take more responsibility for their work. Tella also focusses on the change process for both, where full communication technologies were introduced to school settings. There, teachers experienced an increased awareness of theoretical constructs and their corresponding teaching practice, while students crossed the barriers caused by conventional lesson structures. Finally, Aston suggests that only forceful government action, making compulsory the use of IT in the curriculum, can enable progress towards integration to be maintained.

1 The teacher's role in a new problem-centred, interdisciplinary approach

Margaret L. Niess

Oregon State University, USA

Keywords: problem solving, interdisciplinary, curriculum development, teaching methods, pedagogy

Introduction

Changes in the work place present educators with formidable challenges, including demands from business and industry that employees know how to use mathematics, science and technology collectively, as well as separately, to solve problems. Educators have been asked to both develop and adapt processes for teaching concepts in a problem-centred, interdisciplinary manner much as in the work place. Traditional curriculum is based on essential concepts of each discipline and those concepts determine the applications students experience. In a problem-centred, interdisciplinary curriculum, problems determine which concepts from each discipline are needed.

What about the teachers who are asked to change from a discipline-based to problem-centred, interdisciplinary approach involving science, mathematics and technology? This qualitative study examined teachers' views of their subject matter and teaching of that subject matter as well as the changes in the teacher's role. Twenty-four secondary teachers, formed into eight teams of three teachers (one mathematics, one science, and one technology from a single school) were selected. Each team experienced a four-week business internship, gaining work place knowledge and skills and investigating mathematics, science and technology skills, and the concepts and competencies to emphasize. They gathered information regarding applications to provide contexts for problems. Next, the teams spent four weeks developing a problem-centred, interdisciplinary curriculum. During the school year, they taught mathematics, science and technology in an interdisciplinary context.

Subject matter structures

Teachers' notions of science and mathematics was composed of two components: concepts and processes used to develop those concepts. Their views were cast in terms of traditional science and mathematics curricula and were influenced by how they learned and taught that subject.

However, the technology teachers had less well-established views of their discipline. Their views were cast within computer skills rather than general concepts and processes. They focussed on applications (word processing, spreadsheets) rather than general concepts about computers and computing. They focussed on problem solving as a process for producing application output rather than developing general concepts. This difference may be due to the infancy of the discipline (computer science) as opposed to the long-standing traditions of science and mathematics.

After teaching in a problem-centred, interdisciplinary manner, all of these teachers' conceptions of their subject matter remained, but integration was added: "I probably think more about integration of knowledge". As Hauslein and Good [1] maintained, these teachers were now concerned with interdisciplinary teaching and they viewed the subject matter in that context.

Teaching Structures

These teachers were experienced, expressing the teaching of their subject matter much as expert teachers do. They were concerned with teamwork, problem solving, and cooperative learning as essential elements in teaching. One teacher depicted the elements of teaching integrated science, mathematics and technology as if it was a scientific experiment. A flask is set on a tripod above a Bunsen burner. Mathematics, science and technology are the three legs of the stand on which the flask, representing the learner, rests. The teacher is the energy source (the flame) providing the motivation for learning. In the flask, liquid made from problem solving, co-operative learning, team work and brain-storming, bubbles. The resultant steam leaves the top of the flask - the learning. In this model, "the teacher directs the learning, applies motivation (the heat), and is a guide rather than a dictator."

The Teacher's role

All the teachers viewed their role in this approach as "a guide rather than a dictator" or "an architect helping the students to build the learning they need." Another indicated that "the students are doing a lot more of teaching each other ... they are teaching each other spreadsheets." Still another teacher indicated "This is a different style for students to learn. They need to learn they have responsibility. I need to learn to let them take responsibility."

This changed role presented difficulties for the teachers. In the traditional, discipline-based approach, teachers prepared lessons to teach

pre-determined concepts. In this new approach, lesson preparation changed significantly.

"We don't do a typical lesson plan. The students come to us and tell us what they need to know. In the beginning we prepared extensive plans in each of our subjects because we were certain the problem would require specific concepts. But, we found that the students wanted to go a different direction and we needed to prepare a completely different set of plans."

Challenges

The problem-centred, interdisciplinary approach presented new challenges for teachers. The interdisciplinary approach called for teams of teachers working together with students. The problem-centred nature required longer blocks of time for investigation. Some schools tried 90-minute class periods, others tried three-hour blocks, and some only allowed the three teachers to swap classes, rather than team teach.

The scheduling challenge was coupled with the challenge of finding time for preparing as a team. Teachers needed time to develop the curriculum, identify the problems and plan for connections; they indicated, "a full teaching schedule doesn't allow for curriculum development." Yet, "If the curriculum is not all planned and well integrated, it doesn't work very well."

Teacher knowledge, both content and pedagogical, posed another challenge. These teachers indicated they were uncomfortable dealing with ideas and concepts in other disciplines. They reported feeling uncomfortable in these teaching situations because, although they felt secure about their own subject matter, they were uncomfortable when stretching beyond the traditional limits. If teachers need to integrate science, mathematics and technology they must have knowledge not only of the interdependence but also of the breadth and depth of each field, both the concepts and the processes.

Finally, teacher's pedagogical content knowledge was challenged. They indicated they knew the "traditional ways of learning the subject matter," but they needed to learn their subject in an "interdisciplinary way." They needed to learn to teach in teams. They needed to learn new ways of working with students in this problem-centred, interdisciplinary approach. One teacher commented, "I need to learn when to let them get confused and when to help them." As Shulman & Colbert [2] suggested, teachers, without the essential content base, find it difficult to discuss content and focus students' thinking and have trouble providing appropriate feedback.

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2 Teacher training, problems in mathematics teaching and the use of software tools

Rosa-Maria Bottino

*Istituto per la Matematica Applicata di CNR
Genova, Italy*

Fulvia Furinghetti

*Dipartimento di Matematica, Università di Genova
Genova, Italy*

Keywords: software, teacher education, teaching methods, classroom practice

Introduction

Our work is grounded on our experience with a group of secondary school mathematics teachers. We have worked with them for many years in research about the teaching and learning of maths and in projects concerned with educational innovations in classroom. We refer in particular to the secondary school level with students aged 14-18.

As evidence from our work with teachers and many studies have illustrated, the mathematics teaching at this school level presents some crucial problems which are related to both contents, for example the introduction to proof, and methodology, for example the role and weight to assign to algebraic manipulation.

The use of software tools has been often suggested, by researchers and developers as a possible solution to some of the problems encountered by the teachers. But even if these tools are available in school laboratories,

they are not often used in classroom practice, or are used in ways which are not very significant in relation to teachers' needs. One of the crucial aspects of the process which leads to the effective integration of technology into the educational environment lies in the way in which teachers acquire knowledge about, say, a given software tool and of its possible use in their teaching.

In this paper we present the main features of a teacher training project, addressed to secondary school mathematics teachers, in which the problem of the use of software tools is considered. In the design of this training course we took into account some aspects which, on the basis of our experience [1] and of the work of other researchers in this field [4], we have singled out as important in order to actually affect classroom practice:

- the 'goodness' of a software tool is not to be judged on the basis of general parameters, but in relation to given didactic problems and teachers' needs;
- in the case of the choice of software tools teachers do not have a consolidated experience and are often dependent by external influences;
- teachers have to be involved actively not only in the phase of the experimentation in the classroom, but already in the phase of choosing the materials to be used and in planning the didactic itineraries;

Starting from these basic assumptions we are working on the problem of training in-service teachers by trying to establish a relation between the mathematics teaching problems and the possible 'solutions' offered by the use of didactic software. Our approach is to consider first the teachers' needs and then possible products. Usually software tools are presented pointing out their 'desirability' such as technical features, opportunities offered and user interfaces available, but the context in which they are to be used is often not considered.

Concern of the work

The target of the course is a group of 50 in-service secondary school mathematics teachers. The course consists of about 20 hours, distributed in 7 weekly lessons. Five teachers with a good experience in educational research participated also in the design of the course. These teachers have the role of co-ordinating the work and mediating the opinions of the researchers (us) and the teachers trained. During the preparatory meetings, we asked these teachers to consider the mathematics subjects they wish to take into consideration; they singled out algebra, analytical geometry, calculus, and euclidean geometry. Afterwards teachers were invited to

produce a schematic list of key-problems encountered in the teaching of the previous subjects that they would like to face; they singled out the following list:

- weight to give to literal computation and in general to routine activities;
- how to introduce and train students in proof;
- role of intuition in the approach to the problems;
- role to assign to problem solving;
- correct use of a formal language.

Afterwards teachers considered some software tools which were selected on the basis of their availability in the schools where they teach, their wide diffusion and their already existing use in school practice. The following software tools were in particular considered: MATHCAD, DERIVE, CABRI, MICROCALC, LAM. One of these, LAM, is software sold together with a maths textbook largely adopted in Italian secondary schools. We include in the list of software tools to be studied also a spreadsheet, LOTUS, which is often present in school laboratories. Then examples of possible uses of software tools in relation with the educational problems singled out have been selected.

We give an example of how we work. One of the topics which teachers have identify as more problematic in their teaching is the introduction of proof. As is well known, proof involves different aspects, such as intuition, the role of language, and the process of abstraction and generalization. Some software environments can be used to perform activities connected with the informal reasoning level which precedes that of formalization. MATHCAD, CABRI and MICROCALC can be used with this aim. Visualization is one of the features of these tools to be exploited: the work of training consists not only of illustrating the different possibilities of visualization but also of linking the discussion of these possibilities to recent findings of the research in maths education in this field (see, for example, [3]).

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3 School environments and students' opinions on informatics

Georges-Louis Baron
Michelle Harrari

Institut national de recherche pédagogique
Montrouge, France.

Keywords: social issues, learners, classroom practice, management

Introduction

As with many countries, France is being faced with problems of integrating information technology (IT) in secondary schools. There is now a consensus that it should be integrated in every subject. But, if some undeniable "success stories" can be told, current observations show that, except in technical and vocational subjects, and to a lesser extent in scientific subjects, the use of computers is still considered an innovation and, as such, is not fully integrated in every day classroom practice.

Some of the key problems affecting integration are linked to the speed of evolution of technology, to the marginal place devoted to it in the curricula (which, in France are defined at the national level) and to the issue of teacher training. Previous work [1] has shown that this last issue is particularly problematic. As in other countries [2] future French teachers have a high level of expectation regarding IT and low levels of initial competence, while teacher training institutions can't afford much support.

In the meantime, young students are very enthusiastic about popular applications like computer games and appear to show abilities that adults do not easily show. It was interesting to study the issue of young students' ideas about computers and informatics in relation to the school context.

Aims, scope and methodology of the study

An empirical study, supported by the French ministry of education (Direction des lycées et collèges), was led at the INRP in 1993 in order to get a snapshot of the opinions of students attending junior high schools.

In the first phase, semi-directive interviews with eighth and ninth graders obtained preliminary information. This was validated with a questionnaire submitted to 1855 students aged about 14, studying in 28 junior high schools. Our sample was divided into two groups. In the main one (n=1544, 24 schools), the schools were randomly drawn. In the second (n=311), four schools leading innovative work in the field of IT were chosen. In order to avoid bias, in every school, the questionnaire was submitted to every students of the studied grade. Follow up interviews were also organised with teachers and school principals.

The rates of return were high. However, the results given below are only indicators about a reality which we could not study in full detail because it is so fast moving.

Diffusion of computers

About half of the boys and one third of the girls, 40%, claimed to own a 'real' computer ('ordinateur' in French, as opposed to game-dedicated computerised devices named 'consoles'). A majority of these computers were rather obsolete or game oriented; PCs and Macintoshes representing only 20% of the computer owners. A clear correlation was found between the possession of such a computer and the social milieu, with upper middle class students having more computers, more up-to-date and powerful than with the lower classes.

Over three quarters of the students said they played computer games, the most quoted being action games. No significant correlation could be established between the intensity of game playing and school achievement.

The questionnaire asked which five words came to students' mind in response to 'computer'. The most popular theme was about the external parts of the computer-video display unit, keyboard, mouse ... Very few students quoted internal structural components such as processor, or memory. Games were also a popular topic, mainly quoted however by the computers' owners. The major difference between the two groups appeared connected to the 'software' theme, significantly more present in the experimental group (one third) than in the other (one fourth).

Computer use in school

Several series of questions focussed on how students perceived informatics in school, which uses they knew, and which preferences and competencies in information processing they had. On how students perceive computer uses in school, results confirm that 'technology', a compulsory subject for every children during the first four years of high school, whose syllabus explicitly encompasses information technology) is the only subject where computers may be considered as really integrated. Elsewhere, except in some classes of the principal group and in all the four experimental schools, rather scarce usage of computers was mentioned. To a large extent the students' general opinions about informatics appear similar to ideas now widely spread within society such as "the computer will be everywhere", "everybody will have to learn using them", "computers create unemployment".

Concerning the place of informatics in the classroom, significant differences were observed in students attitudes between classes using IT regularly and others. When regular practice can be organised, it appears that IT potential for learning is appreciated. Students manifest a better knowledge of software tools and more positive views about IT utility.

A group of questions asked students to rate their competencies regarding several information processing tasks including word processing, file handling and robot piloting. Students in the experimental group did not rate themselves significantly higher. But, contrary to the principal group where a correlation existed with the possession of a personal computer and hence with the social milieu, no such correlation could be established in the experimental group.

Word processing came first (three quarters of the students claimed to use it "well" or "very well". They were also a majority for "loading a file from a disk", but only one third for "copy files from a disk to another". In both groups, boys rated themselves higher than girls.

Discussion

If only a minority of students owned a computer at home, most of them appeared to have used one in school. A large majority deemed they could process texts, but had problems dealing with operations on immaterial objects, like when copying files. It might be that they have acquired practical abilities closely tied to the operation of specific software but have little knowledge of concepts. Students in the experimental schools were more conscious of the potentialities and limits of computers.

Moreover, the differences in self-evaluation depended much less from possession of a computer and hence from the social milieu. This shows

that, when favourable school contexts exist, students do acquire some basic competencies in information processing. We could not identify which factors play a major part to create such contexts. However, we noticed, in follow-up interviews, the importance of school managers [3], who are key persons to facilitate the purchase of computers and to support teachers teams leading innovative pedagogical actions. Further research will certainly bring a wider perspective to this debate which has already begun [4].

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4 Animation microworld for children as developers

Andrej Blaho

Ivan Kalas

*Department of Informatics Education
Comenius University, Slovak Republic*

Keywords: curriculum development, creative, classroom, open learning, logo

Introduction

We are developing an experimental curriculum of informatics. It is a separate subject, having 2 hours per week for 12 years old students. Our conception an "informatics as a subject" approach; we would rather use information technologies as powerful tools for cross-curricular activities.

We have described the first year curriculum elsewhere [1]. Our main objective for the second year - inspired by [2] and by our visit to Hennigan School in Boston - is to let children become the developers of educational software. They are still only beginners in Logo - we have not yet spent much time on Logo programming. However, we believe that children will be much more motivated if they develop serious educational material, although the process of developing it is "the cream". For example, we want to equip them with the following mighty and complex software development techniques:

- how to create a screen animation of a certain object (a turtle, as far as we are in Logo environment), and how to develop its behaviour;
- how to control this object from the keyboard or by mouse;
- how to create several animated objects (turtles) which interact both with the environment (with the background) and with each other - for example, they change their behaviour whenever they bump into each other.

Animation microworld

Therefore we decided to start with an Animation Microworld (developed by us in Comenius Logo for Windows). Four goals are the main concern here:

- children should discover how important the techniques listed above are for any attractive modern educational software;

- their design abilities such as planning, defining the goal and means, creating an interface should develop considerably;
- they should experience a *collage* way of work. Animation Microworld is a kit of pre-defined bits of objects and pieces of behaviour. Students develop screen compositions, usually simple interactive multi-agent games, by combining these bits together. This is a promising approach taken even in serious university courses, see for example [3];
- they should learn several new features of Logo programming itself, which they will soon need in latter developments. The Animation Microworld is a Logo project which intentionally keeps the Logo way of work; the bits of the kit are Logo procedures and the result of the development is a set of Logo procedures.

When children start the Animation Microworld, they are presented with a developer's control panel, namely a column of standard Windows buttons with predefined texts and actions, see figure 1. They click on the New Turtle button and choose an object out of the library of all objects which can be extended by anyone - imagine them choosing a Cat. When they press the Start button on the panel, they are pleased to discover that the Cat walks on the screen. Each object in the library brings with it its initial behaviour; children soon find out what happens when they click on the cat - it turns left and keeps on walking.

Beside its initial behaviour, each object brings with it a set of possible moves and events which it recognizes. When children press the Develop button, a table describing the Cat's current behaviour is displayed, see figure 2. Here the object's starting position, heading, the way how it moves and the list of actual events, can be observed and modified.

Figure 1

Figure 2

Let us click the Events sub-window. From the list of Available Events templates we can, for example, compose a new event, see figure 3:

key "S [super.will.footprint]

which means that whenever we press S, the Cat will start to leave footprints. In the similar way we can add some other reactions to other keys: the Cat can fly, jump, stop, fall, or change its behaviour if it steps on a certain colour. The Cat's animation is performed by a sequence of frames.

Figure 3

More complex behaviour can be designed if we create more objects, turtles on the screen. Our students explore this by creating a train, an engine with one or more cars. The problem occurs, however, if we click on the engine - it turns slightly right but the cars don't. To improve this, the way how the first car moves, for example, must be set to:

follow "engine 5

where 5 is the speed of the engine. If we change this number, the car can fall behind or get ahead of the engine.

After getting familiar with the Animation Microworld children start to develop more complex compositions. Figure 4 illustrates a game in which there is a Cat kept in the cage. It angrily walks all around and tries to reach the key by a ball. When the ball hits the key, the cage opens and the Cat walks out of it. The realization is as follows: whenever the Cat steps

Figure 4

on the dark blue colour (the outline of the cage), it turns back - therefore the Cat cannot run out of it. The ball is moving on the screen, its direction can be slightly changed by clicking a mouse or pressing a key (depends on the decision of the designer). If it bumps into the key, another hidden turtle opens the cage, so the Cat can now walk out of it.

The Logo nature of the Animation Microworld is quite important for us; the complete development work is constantly and automatically being transformed into the four Logo procedures Screen, Turtles, Moves and Events - they correspond with four bottom most buttons of the control panel and can be directly edited by clicking these buttons. Our students have quite soon started to use this direct option for some kinds of modifications.

Beside accomplishing the four goals listed above, the Animation Microworld - being realized completely in Logo - confirms our metaphor of Comenius Logo for Windows as an Environment for Environments [4].

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5 How to develop "discoveries"

Herbert Möller

University of Münster, Germany

Keywords: learning models, creativity, future developments

Introduction

Discoveries represent the highest level of human intellectual work. Therefore it is important to find out how the ability to discover can be taught, learned and trained. Up to now the situation at school is not satisfactory. Although the method of learning by discovery is considered valuable, teachers rarely use it in classes because they have difficulty leading the pupils by questions, hints and a general stimulation of interest. Further obstacles are the science-oriented curricula, lack of time and disciplinary problems.

At the present time there are reasons to discuss once again the pedagogical advantages of discoveries:

- economic competition requires more creativity;
- people have to be prepared for higher intellectual tasks which cannot be done by computers;
- information technology offers new possibilities such as simulation, hypertext, geometric tools and computer algebra systems which may be used individually and interactively.

Since every scientific result has been discovered once, it seems possible and desirable to develop ways which enable interested people to rediscover selected results. This paper gives a very short report of several projects concerning this objective, based in the Heinrich-Behnke Seminar für Didaktik der Mathematik at the University of Münster.

Method and criterion

Since most people need individual help whenever they try to discover, we have created suitable programs to optimize the time and the possible success. The software development proceeds in three phases, namely, planning the steps of the discovery, organizing the screenplay and writing the program. The most difficult task is the path-finding, that is devising the routes the user will take with the minimum of prompts. The aim is to reduce or even eliminate prompts for the user, rather in the way an adventure game interface provides only minimum guidance. We have called this a question of "suggestivity". In many cases the solution can only be found by research which includes new derivations and proofs. Sometimes even new scientific results are needed as in the third of the examples given below. We call this method "recycling of discoveries".

The computer programs offer the working environment and the information chain gives impulses by questions, hints, invitations and other tips. It is left to the user to decide at any time how suggestive the information should be. Most programs are only planned, but the theoretical background is available for any of the following examples.

Examples

i) *The strategy of the game of "nim"*

Two players put an arbitrary number of small things into heaps and then alternately take off pieces from one heap at a time. The one who takes the last piece wins. The strategy of this old game can be discovered by playing against the computer. The development consists of five steps. In order to receive an even low level of "suggestivity" we had to solve two problems, namely, the introduction of the arithmetic XOR-composition by playing with three heaps and the discovery of a "minimum rule" which uncouples the further steps from playing.

ii) *The Fermat-Torricelli point*

Numerous geometric results can be rediscovered by experimenting with the aid of powerful geometry programs (for example, CABRI). But critical situations may also occur. In the case of the Fermat-Torricelli point, which has a minimal sum of distances to the vertices of a triangle, it is easy to conjecture the result. But the only known elementary proof is based on the fact that the shortest polygon between two fixed points is the straight line. Since this idea is not obvious and cannot be suggested, the computer program offers at first two problems which introduce this issue and which give the experience of solving the more complicated task.

iii) *Planetary motion*

Information technology enables the user to select all needed previous knowledge. The main method is simulation of motions that have become discrete in central force fields and in gravitational fields on screen. A long standing missing link in the developmental work of finding the lowest level of "suggestivity" or prompts, has been filled in this case by a new result on conic sections which relates the tangent lines with a directrix.

iv) *Geometric tools in elementary analysis*

The conception called "elementary analysis", which is based on simplified concepts of limits, differentiation and integration, facilitates the universal use of computer teaching analysis. The geometric strand with about thirty "associative sequences of figures" contains all important results discovered with the aid of only five "geometric tools". Since the development of discoveries in analysis greatly depends on the underlying conception, it is important that the transition to classical analysis can be achieved by discovering the general notions of convergence, continuity and differentiability as examples. The simplified concepts help to save a lot of time. Therefore the method of learning by discoveries may also be used in classes. In this case teachers may prepare their lessons with the aid of the programs on the low "suggestivity" level.

v) *Algorithmic linear algebra*

Since we based linear algebra on a sequence of about thirty algorithms, it has become the most exciting field of discoveries for students. The corresponding programs not only give more insight by examples but support conjecturing better than existing computer algebra systems. The further developmental work will make use of a forthcoming book entitled "Algorithmic Linear Algebra" which contains many exercises marked "treasure trove" for encouraging far-reaching discovery.

vi) *A number-theoretical language*

Number theory still offers a rewarding experience in discovering. Therefore we have designed the high level language NTL1 (Number Theoretical Language 1) to handle high precision arithmetics. The user will come to appreciate the possibilities of establishing problems in a programming environment which leans on the necessities of mathematics and a rich collection of already implemented algorithms. Selected discoveries will be developed in modules constituting easily accessible libraries.

Conclusion

The ability to discover is considered valuable in learning and in practice. Information technology offers a lot of new possibilities to support discoveries. Learners may be guided by computer programs which provide a working environment and a mentor at the same time. In many cases it is a challenging task to develop sequences of proposals with a low level of "suggestivity".

6 Integration of portable computers into Australian classrooms: issues and outcomes

Anne McDougall

*Monash University
Victoria, Australia*

Keywords: classroom practice, curriculum policies, integration, learner centred learning, logo

Introduction

The first major initiatives in the use of portable "laptop" computers in secondary schools in Australia began in 1990, with projects in some private girls' schools in Victoria [1,2] and a primary-secondary school pair in Queensland [3]. Now there are many such initiatives throughout the country (see for example [4, 5]), and a number of these projects have been running for sufficient time to enable some useful evaluative comments to be made. This short paper outlines the issues that this experience has shown to be important, and summarises outcomes reported from these initiatives.

Funding

In most cases the school has provided the portable computers for students to use, often in class sets for borrowing for limited times, and sometimes for longer term individual use. In some of the more elite private schools parents are required or recommended to purchase or lease machines of particular types for their children to use at school and at home.

As well as purchase of the actual machines, funding is also needed for technical support, facilities for charging batteries and for whole-class display, and for secure storage, repairs and possible upgrading of the

machines. The costs of these initiatives, and the fact that they are being taken predominantly in the private school sector in Australia, raise some serious questions of equity.

Practical Problems

Problems that have been reported include difficulties obtaining printouts, batteries running low in class, screen breakages during transport, students forgetting to save files, students not having computers because they have forgotten them or they are being repaired, and student complaints about the weight of the portable machines. Most of these seem to have been overcome in the first semester of the projects.

Teacher Support

All the projects have been associated with at least some levels of staff anxiety, predominantly due to inadequate articulation of purposes or to technical problems, or of stress due to the increased workload and amount of change that seems inevitably to accompany this type of innovation.

Teacher support for these innovations is absolutely critical. This can include subsidising teacher purchase of their own portable computers, clear articulation of the purpose and philosophy of the initiative, provision of time to work with the new equipment and software before using it in classrooms, provision of classroom support for technical problems, attendance at workshops, courses and conferences, and facilitation of development of networks of people with expertise available to help.

Parents

Significant initial parent opposition to use of portable computers was reported in one case [1], where the parents were required to provide the computers for their children. Other reported sources of parental concern are the possibility of deterioration in handwriting, that time previously spent on other subjects will be sacrificed to make way for computer activities, potential effects on students' vision, that the computers will be dropped, damaged or left on trams, trains or buses, that carrying the weight of the machines in addition to other school materials puts undue stress on young bodies, security of the machines at home, ergonomic considerations, that computers might induce epileptic fits, and that parents will no longer be able to assist students with school work as the parents do not know enough about the computers [5].

Generally however parents have been most supportive of these initiatives, as they expect a relationship between increased school computing and workplace success.

Curriculum

Several of the portable computer initiatives in this country have deliberately involved change in the existing curriculum and in teaching practices; some, see for example [1, 3, 5], have made extensive use of LogoWriter programming to this end. With LogoWriter, computers have been used as intellectual tools, suggesting implications for curriculum design, redefinition of curriculum goals, and exploration of non-disciplinary approaches to secondary school curriculum, with commensurate changes in assessment and reporting procedures [3]. This is a particularly interesting development in the light of the more vocational approach implied by parental, and in some cases governmental, expectations.

Outcomes

The Queensland Education Department project has been thoroughly evaluated as it proceeded, with separate reports being published at the end of its first, second and third years; these are described elsewhere [3]. After the first year there was substantial evidence to suggest that students had become more willing risk takers, demonstrated more flexible approaches to solving classroom related problems, and established a network of cooperative practices. Increased cooperative learning and risk taking have been observed in other projects as well [1]. However, despite intensive and committed efforts by the teachers, the tasks of constructing and supporting a learning culture, attaining technical knowledge and implications of its use, and choosing models, metaphors and practices as starting points for students remained elusive [3].

After the second year students in the Queensland project were reported to have improved in knowledge and skills related to computing. However some students, a minority, were unhappy about the prospect of a third year in the project, feeling that they were missing out on some learning and social activities. Although some students had become excellent programmers, many were not using the higher level thinking skills that Logo can sustain; this was attributed to the peer teaching approach used and the lack of modelling of advanced programming skills. This result might be found more widely, as other projects also report greater use of peer learning [1]. Some gender differences became evident in attitudes, motivation and computer achievement [3].

After the third year substantial changes in classroom organisation and management, teaching approaches and relationships with students were reported by teachers, and collaborative work had increased further. Teachers believed that most students had taken more responsibility for

their learning, although not all students had achieved improved outcomes. Students were more confident with risks and challenges, and had improved research skills. Parents cited students enthusiastically doing homework, projects, assignments and research. This enthusiasm and sustained attention to tasks has also been reported by other projects [1]. Marked gender differences in attitude appeared in the Queensland project classrooms, with a substantial number of Year 8 girls declaring a strong dislike of programming.

Conclusion

Many of the portable computer projects have not had extensive formal or public evaluation. However a reading of such material that is available, and discussions with teachers and others involved in many of the projects indicate that some exciting student outcomes are occurring. They indicate that as experience is gained and shared, many of the difficulties encountered by the pioneers can be overcome, that some interesting developments in curriculum might be sponsored by these changes, and that a cautious watch should be kept on issues of gender and equity.

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7 Developing an open learning environment with communication technologies

Seppo Tella

University of Helsinki, Finland

Keywords: networks, electronic mail, telecommunication, classroom practice, learner centred learning

Introduction

Information technology was introduced into Finnish schools in the 1980s mainly through CAI/CAL packages and by using the computer as a tool. It was soon noticed, however, that the revolutionary influence of the computers across the curriculum was downgraded as schools turned IT to an autonomous school subject. A shift in emphasis took place in the early 1990s when careful attention was paid to computer-mediated communication, electronic mail, computer conferences and other telematic tools, which could help create an open, multimedia-focused and globally networked learning environment based on a constructivist conception of learning [1, 2].

The Utopia project

As a logical step onwards, a 2½-year long research project was launched in 1992 by the Finnish IT Centre for Schools, part of the Helsinki University Continuing Education Centre, in cooperation with the Helsinki University Department of Teacher Education. The project was mainly funded by the Finnish National Board of Education but also indirectly sponsored by the Finnish Academy. The project was called Utopia, an acronym for the Finnish words 'New Technology in Education-Pedagogically Innovative Thinking', comprising ten schools, comprehensive and senior secondary, in the Helsinki Metropolitan Area and involving about 120 teachers and headteachers with their pupils and students.

The project, in line with the qualitative research tradition, was designed as a developmental action research relying on collaboration between teachers, and aiming at developing an inter- and intra-school teaching and learning communications network. The methodological approach was focussed on evaluative, pragmatic and collaborative action research with ethnographic data gathering techniques. The formal part of the project was completed in mid-September 1994, though the social and

telematic network formed between schools, teachers, the researcher, and a number of IT experts still continues at a very active level [3, 4].

Theoretical background

The topicality of the project was motivated through a number of changes - administrative and educational - in Finnish schools. Global networking was understood also to enhance human communication and gradually make up a new kind of telematic infrastructure.

Instead of merely transmitting information, teachers are generally argued to become many-sided consultants and facilitators, "guides on the side" instead of what they used to be, "sages on the stage". Teachers' visions, beliefs, and conceptions are also underscored when developing the schools and teachers' own work. Active learning and flexible uses of information sources are underlined in a technology-rich learning environment.

The conception of learning and knowledge is focussed from behaviorism on contextualism and constructivism [5]. International communications networks and various tools of modern technology contribute to creating a constructivist learning environment.

An open multimedia-based learning environment can be depicted as a symbiosis of a virtual, that is, telematic school and a physical school, where a number of levels of computer proficiency are possible. Telelogic communication has gained considerable ground at the expense of traditional monologic communication, leading to a number of changes in learning paradigms, learning and knowledge conceptions, IT applications, communication as well as in the status of teachers, students, and schools [3].

The research task and objectives

The research task of the Utopia project was to create an open, multimedia-based, network-focussed learning environment, whose development and study was one of the main problem areas. Research was also focussed on the change processes of the school itself, teaching practices as well as teachers' beliefs, preferences and attitudes. The participating schools were chosen through pragmatically informed and deliberate selection.

The background philosophy was based on the principle of ethogeny of the anthropomorphic model, and on symbolic interactionism. Ethnographic data gathering techniques included analysis of the communication transmitted via the common computer conferences,

personal e-mailing, school consultations, participant observation and teachers' questionnaires.

Levels of expertise towards telematic proficiency

Enhancing teachers' and students' expertise in computer-mediated communication and telematics takes time and calls for a conscious effort. A good command of "telematic proficiency" can be divided into various levels of expertise. For instance, a fair command of e-mail and telecommunications software is based on a sufficient control of the man/machine interface of the computer but equally on the person's skill to use a word processor. We argue that beside e-mailing modern teachers of any subject need to master various telematic tools, such as Gophers, and, more recently, World Wide Web (WWW), Mosaic, etc. The levels of expertise towards telematic proficiency are depicted in Figure 1.

Figure 1: Levels of Expertise Towards Telematic Proficiency [3]

Results

One of the main results was a successful establishment of a constructivism-based, network-focussed learning environment, in which both teachers and students could master and control the structure of their own learning milieu and their own learning and studying processes to a certain extent, with the tools of modern communication and information technologies (CIT). The teachers experienced an increased awareness of

the relation between certain theoretical constructs and the corresponding teaching practices. They also grew more professional users of CIT.

Telematic proficiency, the Utopia teachers advanced far beyond an "average" teacher. The students, when simulating a virtual school, easily crossed the barriers caused by conventional lesson structures and classrooms. A shared computer conference proved a fruitful concretion of virtual school concept, combining the participating schools and providing them with an electronic resource bank and a repository of ideas. The appreciation of the schools in their own municipalities increased thanks to the project, which also helped them have a modern profile among the rest of the schools in their municipality. Implementing CIT turned out feasible in teaching different school subjects, while the teaching-learning process could equally combine various teaching forms, such as collaborative learning, self-regulated learning, autonomous studying, and problem-based learning.

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8 The British approach to the integration of IT into the curriculum

Mike Aston

*The Advisory Unit: Computers in Education
Hatfield, United Kingdom*

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Recent history

The UK's efforts in stimulating the use of IT in the curriculum have been well chronicled at international conferences and in academic journals since 1970 and at the 1st World Conference on Computers in Education, held in Amsterdam. The pace of change has been so great during the last few years [1], that little time has been devoted to reporting on the policies and strategies causing these changes. The U.K. Government's Education Reform Act of 1988 has prompted unprecedented and fundamental changes in the way in which education is delivered and assessed [2]. Information technology is firmly embodied in both the policy and the strategies that have ensued. The key features of the Act are:

- The legal status of a well-defined National Curriculum;
- National testing against specific criteria;
- Significant increases in autonomy of schools;
- Regular inspection of schools within a published national framework.

In essence, IT has a curriculum of its own (from age 5 to 16) with level descriptions and programmes of study [3]. IT is also expected to be used in both the teaching and learning of all subjects in the curriculum. National tests are intended to be carried out at certain ages. Schools may expand their technology resources without recourse to local or national government controls. The IT provision, along with all other aspects of the school is being evaluated every four years by independent inspection teams, who will report to the Office for Standards in Education, the school management and governors and the parents of children in the school. Teachers are only just beginning to come to terms with this new regime.

Convergence

The progress of the integration of IT into the curriculum can be measured by looking at the convergence and cohesion of four key elements:

- the curriculum
- the software
- the hardware

and most importantly,

- teacher education and professional development.

If any of these elements become out of phase with the other three, or worse still, two elements become detached from the time cycle of the other two, then nothing changes in the classroom or even regression may occur.

Different agencies are, of course, responsible for the progress of each of the four elements. In the UK, the curriculum is determined by the School Curriculum and Assessment Authority, influenced by a wide range of professional bodies. Software, apart from a relatively small number of government sponsored projects, emanates from private educational software houses and the commercial giants such as Microsoft. Hardware developments in schools are largely driven by market forces and the commercial interest in staying ahead of the field. Teacher education, in many ways, is the least well-provisioned element in the progress stakes.

The curriculum

Teaching and learning in schools clearly influence the development and subsequent marketing of software. The UK curriculum for Information Technology in England and Wales is delivered in two distinct ways. These two ways can be summarised as

- The nature of IT and the skills associated with its application;
- Using IT in the teaching and learning of the whole curriculum.

The first is well defined by programmes of study and level descriptions describing the types and range of performance which students working at a particular level should characteristically demonstrate. The second way is not so clearly defined but may be encapsulated in such statements as "where appropriate, pupils should be given opportunities to use IT to support and enhance their learning of mathematics". The words "where appropriate" are of little help to the teacher in the classroom. Guidance will need to be given, but it is highly likely to be non-statutory i.e. strictly for guidance only.

Evaluation

For the first time in the history of the English and Welsh Education System, a formal and standardised system for inspecting schools has been put in place under the 1988 Act. Teams of trained inspectors, contracted by the Office for Standards in Education, visit schools on a rotating basis every four years and report on all aspects of the activity in the school. The inspection is carried out according to an agreed Framework [4]. Schools, governors and parents all have access to the Framework and to the subsequent report. The inspectors focus on how the curriculum is delivered through the quality of teaching and learning in all areas. The teams are expected to have a specialist IT inspector and the various subject inspectors should have a supporting brief to look at the use of IT in their particular specialist field. All reports are summarised and stored in an electronic form for further research by such bodies as Her Majesty's Inspectorate.

Concerns

It would seem that all is in place for successful integration. The curriculum has been given a 5-year moratorium on change - this might be a problem in itself. Could it be too bland as a result? Software development is slowing down for a variety of reasons, not least among which are those concerning financial viability in a fragile market. The hardware manufacturers continue to surprise us with new platforms, interfaces, learning environments, often without any upwards compatibility. Teachers, with the best intentions, cannot find the time or resources to maintain their own confidence and competence with the technology.

In the UK currently, the use of knowledge bases on CD-ROM in primary schools, 100% access to portables by students, integrated learning systems and multimedia are being evaluated. Next year, there will be a different list, perhaps voice input, tapping into the global highway, personalised databases and so on ...

Conclusion

It could be argued that a good mix of "carrots and sticks" works reasonably well in Britain. Teachers like to have a good deal of autonomy but with some strong guidance and a framework within which ideas can be consolidated. We should be celebrating 25 years of remarkable progress.

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