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ABSTRACT

This book is the result of a cooperative project of several European countries--Belgium, Greece, Ireland, the Netherlands, Portugal, Spain, and the United Kingdom. Each country involved provides a chapter outlining a national project or a specific organization presents its own approach and initiatives to teacher education, with particular reference to Logo. An introductory chapter presents a discussion of Logo-features, teaching and learning with Logo, the impact of Logo on teaching and learning, constructivism, the potential of Logo, and the dimensions of microworlds. The overall purpose of the.volume is: to present a range of approaches to teacher education in Logo-based environments; to raise issues in relation to principles when using Logo in a teacher education environment; to define the variety of aims of teacher education in Logo-based environments; and to highlight the value of Logo in teacher education programs. Specific chapters feature a variety of examples of teacher education initiatives; key features of initiatives that influence success or failure of teacher education; approaches to the evaluation of projects; references to support materials; theoretical foundations of teacher education approaches, and specific implementations of these theoretical points of view. (LL)

TEACHER EDUCATION IN LOGO-BASED ENVIRONMENTS

Editors
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EDIF - State University Gent

1990

Commission of European Communities

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PREFACE

This book is the main result of the cooperative project of the Commission of European Communities 'Support materials in relation to teacher training in view of the integration of learning environments within the common core curriculum', project agreement 89-00-NIT-007/BE.
The initial project objectives were to gather and discuss concrete examples and information about existing learning environments; to select a common set of learning environments, to adapt these existing Logo-based learning environments to local hardware facilities, mother tongue and cultural differences and to elaborate the common core curriculum for the teacher training, based on the contents of the handbook.

This book indicates that most of the objectives have been attained. It includes a variety of examples of and information about the different approaches, in the various participating countries, of computer-based learning environments used in the context of teacher education. The project team agreed on the selection of specific types of learning environments. They had to be based on the Logo-programming language; they had to sustain a constructivist approach towards teaching and learning; and they had to be used in concrete teacher education projects.
During the various meetings of the project team, it became clear that the differences in the national educational structure, the differences in the national approaches towards educational computing, the differences in teacher education provisions, ... prevented a straightforward interchange and adaptation of the learning environments. It was therefore agreed by the project team to attach more importance to the explicitation of common principles, influencing the use of the learning environments under focus.
The elaboration of a common core curriculum for teacher education can be found in the introductory chapter of the handbook. The common core curriculum puts forward basic assumptions, ideas about how teaching and learning in Logo-based learning environments is to be organised. In relation to this common core curriculum, each particular contribution of the seven countries, involved in the project, presents its specific operationalisation in terms of teacher education projects. Most national contributions even elaborate to a further extent the ideas put forward in the introductory chapter.

I would like to take the opportunity to thank a number of people and institutions who made the meetings and this book possible: Monique Leens of C.E.C., John Macnamara of The Department of Education (The Primary Unit) of Ireland, Theresa Mendes of the University of Coimbra (Projecto Minerva) of Portugal, Christina Metaxaki of the University of Athens, (Department of Informatics) of Greece, Clive Neville of C.E.C. and Martin Valcke of the University of Gent (EDIF) for serving on the Steering Committee; Tom Bultynck, Leen De Clippel, Brigitte De Craene, Katy Goeminne and Vera Meersman for their involvement with the local organization. I would like to give special thanks to the Commission of the European Communities and to the institutes of the seven participating member states for supporting this project, thereby confirming their commitment to educational research and practice. Last, but not least, I would like to thank all the authors for taking part in this event. The intention is that the contributions will give results beneficial to all parties involved.
The production of this book was only possible because a number of people went through a lot of work, such as reviewing, proof-reading, formating and urging authors to keep the deadlines. I would like to thank in particular John Macnamara in this respect. Special thanks goes to Martin Valcke who was involved in the final production of the book from the very beginning and who invested an enormous amount of work in it. Thanks also to Leen De Clippel, Joëlle Pletinckx, Willy Pardon en Eric De Meyer for helping with the preparation of the final manuscript.

Gent, 4 September 1990, Gilberte Schuyten

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GENERAL INTRODUCTION

This book, 'Teacher Education in Logo-based Environments', is the outcome of a cooperative project of several European countries. This project was funded by the European Commission and the following countries were involved : Belgium, Greece, Ireland, the Netherlands, Portugal, Spain and the United Kingdom.

In relation to each country involved, a national project is outlined or a specific institute or organization presents its own approach and initiatives to teacher education, with particular reference to Logo. However, this book only contains a small selection of the rich variety approaches to 'teacher education' and Logo in each region or country of Europe.

The overall purpose of this book can be stated as follows :

a. to present to the audience a range of approaches to teacher education in Logo-based environments;
b. to raise issues in relation to principles when using Logo in a teacher education environment;
c. to define the variety of aims of teacher education in Logo-based environments;
d. to highlight the value of Logo in teacher education.

When writing the specific chapters, the contributors kept in mind the following target audience : teacher trainers, educators, advisors, inspectors, lecturers in teacher training colleges, educational authorities and teachers.
This target population will find in this book a variety of examples of teacher education initiatives; key features of initiatives that influence success or failure of teacher education; approaches to the evaluation of projects; references to support materials; theoretical foundations of teacher education approaches and in parallel specific implementations of these theoretical points of view.

In the context of teacher education, the contributors mainly had the 6 to 14 age group in mind.

The table on the next page will give a brief overview to the reader of the main features of each contribution. It is to be stressed that each contribution in this book reflects responses to local, regional or national needs. The reader may - as a consequence - use this book as an overview of initiatives and approaches that might be helpful in responding to his or her own needs.

Table 1 : Characteristics of the teacher education initiatives
(B. = Belgium, Gr. = Greece, Ir. = Ireland, N. = Netherlands, P. = Portugal, S. = Spain, U.K. = United Kingdom)

Keywords	B.	Gr.	Ir.	N.	P.	S.	U.K.
Local initiative	x	x	x	x			x
Regional initiative					x		
National initiative						x	
In-service education	x	x	x	x	x	x	x
Pre-service education			x		x		
Training of trainers						x	
National policy about N.I.C.T.	x		x	x	x	x	x
Constructivism	x						
Focus on Logo	x	x	x	x	x	x	
Focus on microworlds	x		x	x		x	x
Focus on teacher use	x	x	x	x	x	x	x
Focus on future use of pupils		x			x		x
Top-down strategy		x	x	x	x	x	
School-based strategy	x	x					x
Research oriented	x	x					x
Practice oriented	x	x	x	x	x	x	x
Action research - case studies	x						x
Views of teachers	x				x	x	x
Principles of teacher education	x	x		x	x		x
Single initiatives		x	x	x	x	x	
Continuous support	x	x				x	x
Logo linked to objectives							
- in relation to mathematics	x	x	x	x		x	x
- in relation to metacognition			x				x
- in relation to project work			x		x	x	
Initiative of							
- Ministry of Education						x	
- Teacher education centre		x	x	x	x		
- Research institute	x						x
Use of Logo with gifted children			x				
Support materials (syllabus)	x		x	x	x	x	x
Curriculum work	x		x	x		x	
Assessment			x				

Chapter 1
TEACHER EDUCATION IN LOGO-BASED ENVIRONMENTS - AN OVERVIEW

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1. Introduction

The title of this book 'Teacher Education in Logo-based Environments' , clearly reveals that the authors wish to restrict their contributions to specific approaches in the field of education. The contributors explain the work undertaken in teacher education, with reference to Logo.

The concept 'teacher education' will be used throughout this book, to stress the fact that supporting teachers to use educational technology is more than mere 'training'. Both concepts, 'training' and 'education' are used by some authors. We ask the reader to approach both terms as synonymous.

It is not the purpose of this introductory chapter to give a description of the Logo-programming language. To many readers - familiar with educational computing - the language is already well-known. Therefore, only some key topics about the language will be given. More attention will be paid to the educational philosophy that is associated with Logo.

Presented in this chapter, is the common rationale of the different contributions of this book. Specific topics will be covered.

a. What kind of teaching and learning is linked to the use of Logo ?
b. What is the curriculum relevance of Logo ?
c. What are the problems, one has to tackle when trying to set up Logo-based environments ?
d. What kind of solutions have been developed to overcome problems when teaching and learning in Logo-based environments ?

2. Logo-Features

Logo was developed in the sixties. Right from the start, the aim was to explore the use of the language with children. The language became especially successful when a graphics extension turtle geometry was built into it. It became widespread in schools during the eighties. The Logo-programming language has some special features which distinguishes it from other languages.

a. It is extendable
This implies that the user can use the existing primitives (programming instructions) to build new ones by making use of procedures. Each procedure can be called by its name.

b. It is highly interactive
In Logo, commands are executed immediately; the user gets immediate feedback if errors occur. There are easy-to-manipulate editing facilities to correct mistakes.

c. It has no threshold
The constructors of Logo intended and current practice shows that very young children (e.g. kindergarten level) can work with Logo. On the other hand, the language is also used at university level.

3. Teaching and Learning with Logo

3.1 The Impact of Logo on Teaching and Learning

Logo is only one exponent of what is called **New Information and Communication Technologies (N.I.C.T.)**. It is widely accepted that N.I.C.T. not only sustain 'teaching', but also has an impact on the contents of what is taught and the way 'learning' is achieved. In other words, N.I.C.T. can affect the teaching and learning of pupils. Certain uses of computers confirm traditional ways of teaching and learning. Logo - in particular - gives new opportunities to the teacher and to the pupils. A choice for a specific use of a computer, reflects a subjective preference, implicitly or explicitly, for a certain style of teaching and learning. For example, a computer can help the teacher to demonstrate the way complex geometrical figures can be reconstructed to become a combination of simple, comprehensible geometrical structures. The same tool can also give the pupil the opportunity and the power to explore this 'manipulation' of geometrical shapes. The computer, at this moment, changes the educational structure of the teaching and learning situation. In the first situation, the teacher is in control of what is to be learned and the way the concept or skill of 'restructuring' is acquired. In the second situation, control is given to the pupil, whereby all kinds of possibilities, while manipulating shapes, can be explored. This brings about different learning experiences, which can serve as a basis for developing personal 'conceptualisations' about the phenomena observed. Logo supports this specific approach to teaching and learning and this approach is called 'constructivism'.

3.2 Constructivism

The constructivist approach to learning is shared by many mathematics educators (Cobb, 1987; Kilpatrick, 1987; Lerman, 1989; Papert, 1980; Solomon, 1986). But it is not our intention to restrict the elaboration of the constructivist principles to mathematics education, although a lot of examples in this book focus on mathematics. Constructivism is a general theory, applicable to all kinds of subjects. Constructivism is essentially a epistomological theory, a theory that tries to explain how pupils acquire new concepts and how pupils build their own knowledge base. It is not a theory about teaching (Schuyten, 1990).

Constructivism is based on the following hypotheses (Kilpatrick, 1987) :
"- Knowledge is actively constructed by the cognizing subject, not passively received from the environment.
- Coming to know is an adaptive process that organizes one's experiential world (...)."
The implications of these principles are clear. Pupils are expected to be responsible for their own learning. Their own experiences are the basis for constructing knowledge.

The adaptive process of knowledge-construction can be described by three properties (Forman & Pufall, 1988, p. 236) :
"- **epistemic conflict** : this reflects the sudden - conscious - perception of differences, errors, misconceptions,... in one's knowledge. Epistemic conflict may originate in the individual him/herself or can be externally induced.
- **self-reflection** : is a response to conflict. It implies objectifying ones knowledge and explicitely constructing or transforming the way of representing reality.
- **self-regulation** : is a kind of developmental restructuring of thought. Through this restructuring, a higher level of thought is acquired.".

But one may ask how teachers can set up classroom activities and sustain learning if everything is to be based on the individual's conceptions of reality ? Constructivism does certainly not demand to leave the pupil alone.

It does also not imply that all learning should be made by self-discovery. Piaget - one of the founders of the constructivist theory - distinguished also social-arbitray knowledge (Spencer, 1988, p. 147) : "Information learned from other children or transmitted by parents, teachers or books in the process of education". So, the teacher does have a role to play in this exercise.

3.3 Implications of a Constructivist Approach to Teaching and Learning

In practice, constructivism is a theory about acquiring knowledge and embodies several points relevant for teaching.
- The teacher should acquire skills to provide the pupils with interesting learning environments.
- The teacher takes the various - intuitive - conceptualisations of the pupils into account, when planning instruction.
- The teacher gives the pupils the opportunity to explore freely the learning environments.
- The teachers presents the pupils learning environments that are interesting and relevant to explore.
- The teacher adopts a 'problem solving' approach to teaching.
- Group work can enhance the exploratory activity.
- Errors in the work of the pupils offer relevant opportunities to reveal the individual's way of acquiring knowledge.
- ...

As suggested, the constructivist theory describes learning not as a 'solitary' activity (cfr. the role of group work). Epistemic conflict, involves two knowing systems. Pufall (1988, p. 23) illustrates this very accurately when he states : "Taken literally, it is suggested that our search for meaning entails a search for shared meaning between knowing systems.". Acquiring knowledge is a self-directed activity, it is not a solitary activity. Cooperative work can help pupils to clarify their meanings to each other and help them to discuss their intermediate conceptualisations.
The constructivist approach to teaching and learning can be found in many contributions to this book.

4. The Potential of Logo

Logo has great potential in sustaining pupil education.
Initially, the use of the language with children, was especially put forward to influence the acquisition of mathematical concepts and skills.
Today, Logo is used to attain a wide range of objectives in different areas. This is illustrated by the many research projects, focusing on the following topics (Valcke, 1990,p. 16-43) :
- cognitive effects;
  - Logo and mathematematics;
  - Logo and metacognition;
  - Logo and problem solving;
  - Logo and cognitive development;
  - Logo and language acquisition;
- Logo and creativity;
- Logo and attitudinal development;
- Logo and social-emotional development.

Part of Logo-research did also focuse on the context-factors, influencing the acquisition of the language and the possible transfer of learning experiences (teacher, classroom context, environment, ...).

The research results are promising. But, they also help to reveal some essential factors, constraining the optimal use of Logo in the school setting. We can summarize these factors as follows.

- What do children learn when working with Logo ?
In normal classrooms, teachers know beforehand what the aims are of the learning activities. This helps them to build lesson series, to support gradual growth,... . Imagine now the following : 6 groups of pupils are working with Logo. Each group chooses its own project. How can a teacher know 'what' kind of learning objectives can be pursued, based on the experiences ? The variety of projects, problems, questions, ... is such that between that a unique teaching strategy is impossible.
As a consequence, the link of the Logo learning activities and the curriculum is weakened or at least the structure of this curriculum is affected.
- How can a teacher support Logo learning ?
Since the normal classroom teaching strategies are curriculum-oriented or objective-driven, many teachers do not know how they can effectively intervene in Logo-situations. Since most Logo-work is done in peer group settings, the management problem becomes more acute.
- How can you evaluate Logo ?
Since the goal-directedness - from the viewpoint of the teacher - is low, a strict evaluation is not possible.
When looking at these issues, one can extract several general remarks in relation to :
- the functionality of the Logo-language;
- Logo as a programming environment or a tool;
- the content of the Logo-language and Logo-experiences.

To answer the questions, related with these issues, adaptations of the Logo-language have been proposed. Some authors focus on Pre-Logo packages (Cohen, 1987, p. 131; Pea, 1986, p. 18). Other authors do not use a full Logo-version, but rather reduced adaptations (Adams, 1985; Clements, 1984; Clements & Gullo, 1984; Cohen & Geva, 1986, duBoulay, 1979, Watts, 1986; ...). In the latter context, especially the concept **'microworld'** is used.

5. Microworlds as Logo-based Environments

5.1 Microworlds

When discussing the role of the teacher in adopting a constructivist approach to learning and teaching, it was indicated that the responsibility of the teacher implied the provision of **interesting learning environments** for the children. Logo can provide such interesting learning environments. To meet the demands for effective learning environments and the demands to adapt the existing Logo environment the use of **'Microworlds'** is put forward. A microworld can be a specific type of Logo-learning environment. Microworlds have been developed inside and outside computer settings; but the most typical examples of them are to be found in computer contexts.
They can be defined as follows : "Specifically, micro- and macroworlds are constructive when they provide new representational systems (...). These representational systems are constructive in that they provide practical and explicit procedures for solving problems within the microworlds." (Forman & Pufall, 1988, p. 249).
The most obvious features of microworlds are explicitated underneath.

a. They present a **clearly defined part of reality**. In literature, we find e.g. microworlds in relation to angles, coordinates, variables, scale,... . Outside the mathematics area, we find examples in relation to history (the Viking microworld of Allan, 1988, p.169) or language arts (the language box of Sharples, 1985 or Valcke, 1988).

b. They can be **manipulated**. Each microworld presents a set of commands and operations, reflecting a specific content area. In a fraction-microworld, there are e.g. instructions to represent fractions, to calculate with fractions, ... By using these new Logo-primitives, pupils can construct, test, explore, observe, etc. phenomena that are typical for the subset of reality under focus.

c. Pupils can **explore** them, or see the effects of their input. The former features of microworlds already suggested the interactive nature of this type of Logo-software. Although microworlds do not put forward questions, problems, pupils can use them as a 'laboratory' for exploring the problems they themselves define or the questions they themselves put forward.

In literature, we find alternative concepts for the 'microworld' idea : 'Learning tools' (Niess, 1988, p. 11); 'laboratories' (Sendov & Dicheva, 1988, p. 213); ... .
This description of microworlds suggests that microworlds present a very consistent family of Logo-based environments. But, microworlds can vary from extremely open-ended to nearly prestructured learning environments. In the following chapters, also the concepts 'toolkits' and 'libraries' will be used. When these analoguous concepts are used, the authors will provide the reader with some examples to clarify their meaning.

5.2 Dimensions in Microworlds

In literature, microworlds are sometimes considered as a piece of software. As Lawler (1987, p. 23) states, microworlds can certainly not be reduced to their technical surface feature. Valcke (1990, pp.208-213) presents, in this context, a description, explicitating 'essential dimensions' of microworlds which are :

- **a technical (software) dimension;**
- **a content dimension;**
- **a pupil dimension and**
- **a pedagogical dimension.**

Besides the **technical** dimension, especially the other three are important when looking at the relationship between microworlds and constructivism. The **pedagogical** dimension refers to the indispensable role of the teacher in supporting the exploratory, self-directed work of the pupils. The **pupil** dimension refers to the typical exploratory activity, already mentioned. The **content** dimension refers to the link between microworlds and specific content areas.
In the Belgian contribution, these dimensions are used to describe an example of a microworld in more detail. In the contributions of other countries (Ireland, the Netherlands, Spain, United Kingdom) there are many references to 'microworlds'. The reader will observe that the 'dimensions', described above, are helpful in characterizing the specific meaning of 'microworlds' in these contributions.

Ill. 1 : Project Work with Logo

5.3 Microworlds and Other Uses of Logo

Thus far, we focused on specific uses of Logo. But the microworld-orientation in some of the contributions to this book, does not imply that other uses of Logo are neglected. Examples were cited of microworlds that were especially oriented towards the acquisition of specific contents or subject areas. But, the content and the pedagogical component of microworlds, can also sustain the attainment of higher cognitive knowledge; e.g. the acquisition of planning skills or the development of metacognitive skills.

In some contributions to this book, microworlds will not be of prime concern. Logo programming can also be a valuable learning environment and provide effective learning experiences (cfr. the Portugese contribution). In this respect, the aims and objectives of each initiative, described in this book, have to be taken into consideration.

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Chapter 2
TEACHER EDUCATION IN THE USE OF LOGO-MICROWORLDS

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1. Background Information

1.1 The Flemish school system

The last twenty years the political, legislative and administrative structures in Belgium are oriented towards a federal system. This federal system rests on the existence of three regions (Flanders, Wallonie and Brussels), three communities and four linguistic regions (Dutch speaking, French speaking, German speaking and French-Dutch speaking). Each of the three communities of Belgium has their own school system.
The school system is also complicated by the existence of different educational 'nets' depending on the organizing instance. Each linguistic school system consists of three categories of establishments :
- the schools organized by the community;
- the public schools organized by municipal and provincial authorities;
- the so called 'free' schools (mainly organized by the church).

The last two categories are financed partly by the state and partly by other means.

Education is compulsory for all children from 6 to 18 years. The following table describes some details of schools in Flanders :

Table 2 : The Flemish educational system - an overview

	Starting at the age of..	Number of years	Number of pupils *	Number of schools *
Kindergarten	2 1/2	3	236,247	2,169
Primary Educ.	6	6	429,567	2,491
Secondary Educ	12	6	259,123	1,368
Higher education	18	3 - 7	121,938	

(* based on data of the school year 1984-1985; source : Ministerie van Onderwijs, 1986, p.101)

1.2 The Teacher Education Structure

Teachers for kindergarten-level, primary schools and lower secondary schools are prepared in "Normaalscholen", a type of higher education. This type of pre-service education is organized, following a three year course.
Teachers for higher secondary schools, are prepared at the university during an extra one-year course.

1.3 Teacher Education in the Use of N.I.C.T.

Pre-Service Education

Since 1985-86, student teachers in higher non-university education, follow a new course called 'Media and information technologies'. The use of computers is to be discussed during this course. The content of this course in restricted and is only organised during the third year of the teacher education.
Teacher education at the universities does not include specific education in the educational use of N.I.C.T..

In-service Education

In relation to in-service teacher education, a **compulsory** in-service programme for all teachers of the primary public schools in Flanders, has started during the schoolyear 1989-90. The EDIF-team has played a major role in this project, especially in relation to the use of Logo-based learning environments.
No comparable in-service initiatives have been set up for teachers in the 'free', subsidized primary schools.

In addition, the Ministry of Education of the Flemish Community took the initiative to set up a **non-compulsory** two-year education course (1989-91) for teachers of all the different educational 'networks' : *'De computer ook in jouw klas ?!'* (The computer also in your classroom ?!). This course provides :

- well-documented books;
- teacher education sessions in regional centres, coordinated by people involved in various N.I.C.T.-projects;
- and television programmes.

1.4 THE EDIF-team

The EDIF working group of the Pedagogical Department of the State University of Gent was founded in the year 1983. **EDIF** stands for **ED**ucational **I**n**F**ormation sciences.
The current activities of the EDIF working group focus on scientific research in the use of Logo, wordprocessing, spreadsheets, ... on the one hand and on setting up teacher education initiatives in relation to computer applications on the other hand.

During recent years, four specific in-service teacher education projects have been set up in relation to the use of Logo. The four education projects were intended for primary school teachers working in community schools of the Gent area. Teachers of grades 3 to 6 were involved.

2. The four EDIF TEACHER EDUCATION PROJECTS

We give a short outline of four projects, set up by the EDIF-team in the periode 1985-1989 (Bultynck & Meersman, 1990). The projects are **"action-research oriented"**. They have certain features in common. These features and more background information are discussed in part 3 of this chapter.

2.1 Project 1

Period : September 1985 - June 1986

Target group : ± 40 teachers from 7 elementary schools in the Gent region.

Organization : The teacher education is organized partly in the local school setting and partly at the university.

Content of the teacher education course :
- introduction to Logo at the technical level (± 15 hours);
- exploration of the relation between Logo and the mathematics curriculum;
- use of microworlds (± 30 hours), based on the manual *'Spelen en leren met Logo in de klas'* (Playing and learning with Logo in the classroom);
- classroom-demonstrations (by the teacher trainer) of the use of microworlds.

2.2. Project 2

Period : January 1988 - June 1988

Target group : ± 45 teachers from 6 elementary schools in the Gent region.

Organization :
- education was organized at the university;
- separate sessions for teachers of grade 3, 4, 5 and 6, once a week;
- schools got extra teachers to enable teachers to attend the teacher education sessions.

Content of the teacher education course.
- During 25-30 hours each group of teachers explored and got acquainted with the use of microworlds and the link between Logo and mathematics.
- In this project, the introduction to the Logo programming language itself was no longer a separate part of the teacher education. This introduction was embedded in the exploration of the microworlds.
- The project also focused on the relevance of the use of microworlds in the daily teaching practice of the teachers. The official mathematics curriculum was continuously used as a point of reference.
- Some new microworlds were developed and worked out by the teacher trainer during the education cycle, in close collaboration with the teachers.

The outcome of this project was twofold :
- a **manual** with an extensive introduction on microworlds;
- a **set of activity cards** containing lesson ideas, based on the use of microworlds. These activity cards were only meant to give teachers suggestions on what might be done in the classroom. They were not meant to impose any structure or any order of lesson activities on their classroom practice.

Ill. 2 : Teachers, during a teacher education session

2.3 Project 3

Period : February 1989 - June 1989

Target group : ± 40 teachers from 6 schools in the region of Gent who did already participate in project 2.

Organization : The teachers were visited in their own school setting.

Content of the teacher education course :
- this project guaranteed the continuity in the teacher education of the specific group of teachers of project 2;
- the education focused on the individual acquisition of the necessary skills to manage the integration in one's own teaching practice of what was learned in Project 2.

2.4 Project 4

Period : February 1989 - June 1989

Target group at the beginning of the project : ± 40 teachers from 6 elementary schools in the Gent area.

Target group for the production of a manual : all elementary school teachers in Flanders.

Organization :
- it was no longer possible to provide schools with extra teachers;
- the teacher education was 'package-driven'; which means that a written extensive manual was produced;
- the lesson packages were delivered at school, fortnightly, by the teacher trainer;
- the teachers worked individually through the training packages;
- the teachers got extra guidance and support fortnightly during a visit of the teacher trainer.

Content of the teacher education course : Each chapter in the Logo-manual is based on the use of microworlds and consists of 7 subparts :
- a technical introduction on the microworld under focus;
- a reflection on the educational potential of the use of the specific microworld;
- a detailed example of a lesson, based on the use of the microworld;
- activity cards (cfr. Project 2);
- exercise cards for the teacher, to become more proficient in the use of the microworld;
- a technical card referring to important issues at the technical and instructional level;
- a 'repair' card telling the teacher what to do when he gets lost, while using the microworld.

3. Theoretical Backgrounds of the TEACHER EDUCATION PROJECTS

When presenting the theoretical backgrounds of our TEACHER EDUCATION PROJECTS, attention is paid to the specific use of computers pursued with primary school children :
- integrated use of computers;
- focus on microworlds;
- focus on constructivist learning and problem solving behaviour;
- high degree of teacher involvement in the projects;
- and focus on group work.

3.1 The Integrated Use of Computers

The main objective of the four teacher education initiatives, described in this chapter, was to scaffold **the integrated use of Logo** to pursue objectives of the mathematics curriculum. 'Integration' means that, wherever possible, the explicit link with the existing mathematics curriculum is pursued. This approach can be considered as rather conservative, and neglecting unique potentialities of computer use, in casu, Logo-use. The latter criticism is accepted, but it is to be remarked that, besides our focus on the link with the mathematics curriculum, the use of Logo is also oriented towards the development of specific problem solving abilities (cfr. 3.4.). Secondly, by using microworlds the approach to teaching and learning is influenced (cfr. 3.3.).

3.2 Microworlds

A particularity in the four projects is the use of Logo-microworlds (cfr. also the introductory chapter). These microworlds can be considered as restricted Logo-environments, focusing on the exploration of specific mathematical concepts or skills. Microworlds can be considered as the operationalisation of what was explained above. They can be described along four dimensions : a software dimension, a content dimension, a pupil dimension and a teacher dimension. These dimensions are described by discussing a **typical example of a microworld : the 'shape'-box.**

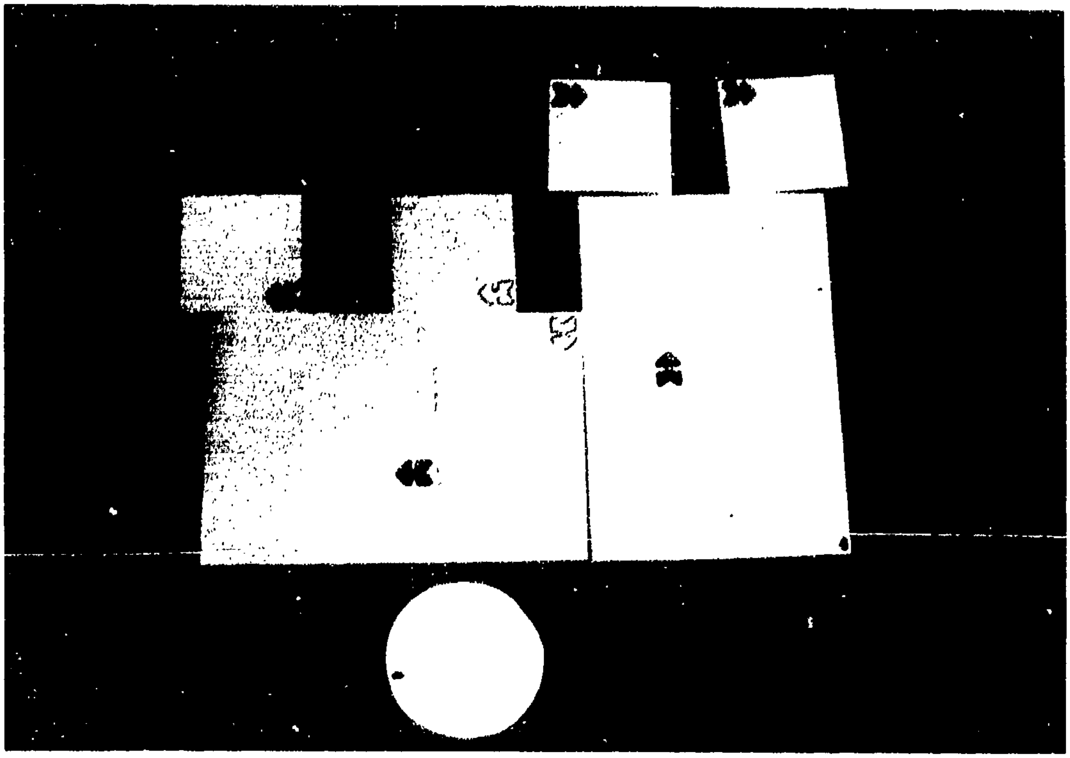
a. Technical dimension
The 'shape'-box is a set of Logo-primitives, which can be used, next to the existing Logo-primitives, to make pictures on the screen. The new primitives help to construct all kinds of shapes. They can also be used to build new procedures.

b. Content dimension
The new primitives are used to construct specific two-dimensional shapes. Variables are used to extend the possible variation in applications :

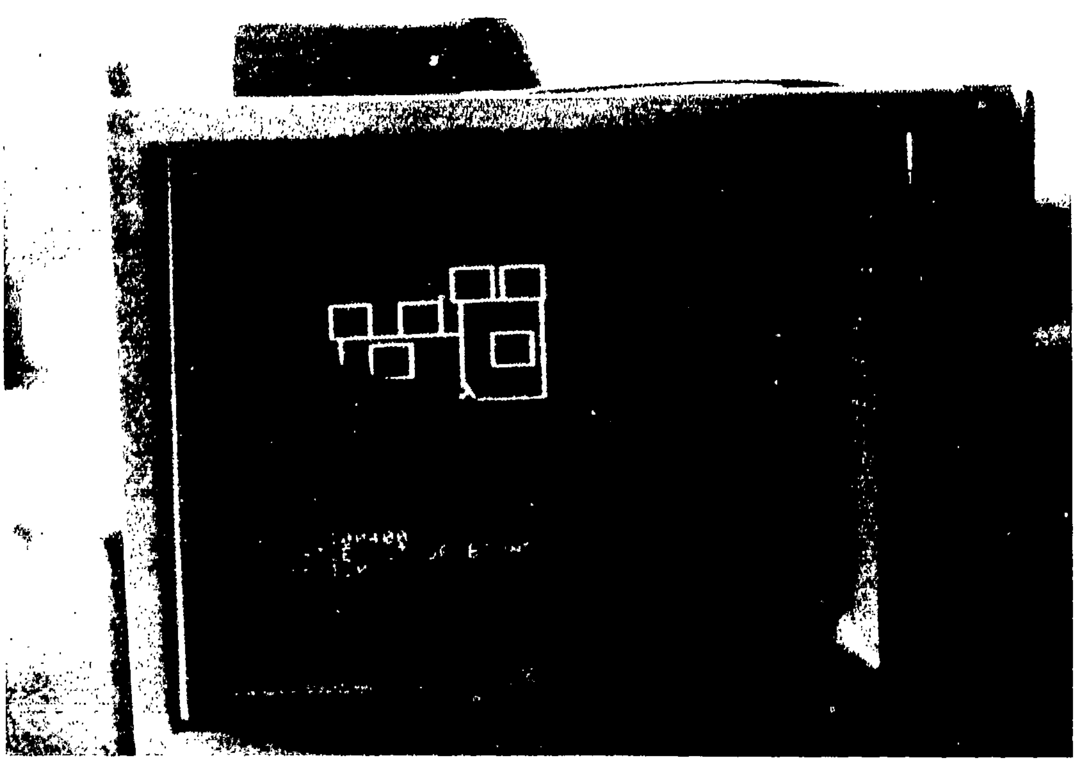
- square :x
- rectangle :x :y
- paral :a :x :y (parallellogram)
- polygon :a :s
- etri :s (equilateral triangle)
- rtri :s (right-angled isosceles triangle).

When a pupil types 'square 40', a square with a side of 40 units will be drawn. When he/she types polygon 6 15, then a hexagon with side lengths of 15 units will be drawn. Because the software dimension makes it possible to combine the shapes, the potentialities of learning activities can be extended. One can e.g. explore the transformation (restructuring) of complex shapes into a combination of basic geometrical shapes. A typical preparatory activity for this kind of learning experiences is playing with a tangram puzzle.

Ill. 3 : Playing with the tangram puzzle



Ill. 4 : Elaborating a complex design with the 'shape'-microworld



c. Pupil dimension
The pupils work in small groups. In these little groups, they explore the possible combinations of the tangram pieces, explore the shape-box and they try to reconstruct the complex shape. During the activity, all attention is on the ideas, hypotheses, solutions, ... the pupils put forward. The pupils themselves 'construct' their knowledge about the interrelations between the geometrical shapes.

In most microworlds, there is a maximum of user control. In some microworlds, the input of the pupils is checked in order to scaffold the activity; e.g. typing errors are catched, the amount of Logo-primitives is limited, ...
But, the learning process is always fairly open in the way that no questions are being asked, and that no fixed sequence of learning problems is presented, ...

d. Teacher dimension
The teacher can put forward specific learning problems.

- He starts the activity by giving the pupils a Japanese tangram puzzle. In this game, the pupils have to restructure a complex shape by looking for the correct combination of 7 basic geometrical shapes.
- After this introductory activity, he presents the shape-box microworld to the pupils. The pupils explore the basic shapes. The teachers also asks the pupils to choose some fixed numbers for the variables (e.g. square 40, rectangle 20 60, etri 40).
- Next, the pupils draw, to scale, the chosen shapes on paper and cut them out.
- The teacher hands out worksheets with complex shapes. The pupils look for the right combination of the shapes to reconstruct the complex shape. If they find the solution with their paper versions of the shapes, they try to reconstruct the solution with the shape-box microworld.
- At the end of the learning activity, the teacher discusses the solutions with the pupils.
  The relationships between the different shapes are explicitated and summarized on the blackboard. The fact is stressed that different solutions to the same problem can be found.

3.2.2 A Rationale for Using Microworlds

The Logo programming language offers a rich and powerful open-ended environment for the learning of any individual. The open-ended character of this environment leaves it open to the user :

- what to do (CONTENT);
- what to learn (PRODUCT);
- how to learn (PROCESS).

The open-ended character of the Logo-language puts forward several problems for the teacher, especially when taking into account the following restricting conditions :

- in an average classroom in primary school, one teacher works with about 25 to 30 children;
- primary education takes 6 years; class levels are strictly separated; each level should prepare the pupil for the next class level;
- there is an official curriculum for primary education; this curriculum is the guideline for the teacher in setting up learning processes.

These three restricting factors do not facilitate the integration of Logo in primary education. Therefore, the EDIF-team adopted the microworld approach. In this way, the teacher :

- knows what his pupils are actually working on, since the potential learning content is restricted (CONTENT);
- knows which are the objectives that can actually be/are pursued (PRODUCT);
- has some idea of the kind of learning processes the pupils are going through (PROCESS).

Rethinking Logo-use with regard to the current schoolsystem does not only favour the identifiability of Logo-use for teachers, but also simplifies classroom management in comparison with the use of the full Logo programming language.

- Neither the teacher nor the pupils need to know many about the Logo programming language.
- It is easier for the teacher to manage the guidance of the learning processes in the different groups of pupils as they are working on comparable learning problems.
- The teacher can develop materials much easier since he can foresee the type of learning problems to occur.

3.3 The Focus on Constructivist Learning

When describing the pupil dimension of a microworld, the word 'construct' was put between quotes. It was also stressed that during the activity, the ideas, hypotheses, solutions, ... of the pupils are the starting point of the teaching-learning activity. In this way, the pupils discover for themselves the meaning and relevance of important concepts or skills. The role of the teacher is to explicitate this self-constructed knowledge and to help to enlarge its application margin.

3.4 Problem Solving Behaviour

Our overall stress on the 'integration' of the Logo-activities into the existing mathematics curriculum can be considered as a conservative approach to teaching and learning with computers. But, as mentioned before, the existing curriculum is also extended by focusing on the development of problem solving skills when using the Logo microworlds. Especially attention is paid to the development of the planning behaviour of the pupils : how they put forward objectives, how they operationalize these objectives, how they analyse their designs, how they anticipate on their activities, ... The 'models of planning behaviour', on which the teaching and learning process is based in the Logo environment, have been described in detail elsewhere (Valcke, 1989).

3.5 The Responsibility of the Teacher

Initially, especially the Teacher Trainer played a major role in the TEACHER EDUCATION PROJECTS (Project 1). But gradually, it was realised that the teacher had to become responsible - to a certain extent - for his own education.

3.6 Group Work

During the teacher education sessions, the teachers were introduced to group work in computer-based learning environments. Although most teachers were familiar with this organizational and methodical approach of the teaching and learning situation, most teachers did rarely set up group work sessions. In our projects, group work was not presented as a pragmatic solution to overcome hardware-shortages, but rather as a way to sustain the constructivist approach to teaching and learning. In group work settings, pupils can exchange their ideas, views, hypotheses about the problems presented and/or

their learning experiences. 'Epistemic conflict', as described in the introductory chapter, is more likely to occur in social settings. A teacher observed this potential benefit of group work : " *When they work in small groups, they criticize each other to a higher extent, but their critics are positive and constructive."*.
The teachers also became aware of the necessity to set up a learning process in relation to group work. This is illustrated with the following words of a teacher : *"Working in groups is not always easy. Therefore, I give - explicitly - different tasks to the group members: Ann will type, Peter will take notes, ... And I ask them to switch tasks time after time."*.

4. Gradual Changes in Specific Aspects of the Teacher Education Projects

4.1. Objectives of the four TEACHER EDUCATION PROJECTS

Several objectives of the four TEACHER EDUCATION PROJECTS can be put forward.

- The development of mathematical concepts and skills of the pupils.
- The development of computer literacy of the teacher.
- The development of the ability of the teacher to use the new tools to pursue mathematical objectives.
- The development of the ability of the teacher to rethink his/her approach to teaching and learning in primary school, taking into account a constructivist approach.

A gradual shift in the kind of objectives, being pursued in the various TEACHER EDUCATION PROJECTS, can be perceived. Initially (Project 1), much attention was paid to learning outcomes in terms of pupil behaviour (objective 1) and the technical mastery of the computer and Logo by the teacher (objective 2). Little by little (Project 2 & 3), a strong need was felt to go beyond this level and to influence the teaching skills and approaches of the teacher (objective 3). Finally (Project 2, 3 and 4), **there was the conviction that only through a thorough rethinking one's personal ideas about teaching and learning, one can successfully change current practice.** Especially Project 2 was successful in scaffolding the attainment of the latter objective. This can be due to : the high degree of teacher involvement; the development of microworlds in a collaborative way; the cooperative development of activities, based on the use of microworlds, ...
But this objective is of course the most ambitious and the most difficult to pursue. It is related to the overall methodology of primary school teaching, but, when central in a teacher education approach, it can help to introduce a constructivist methodological framework in primary education.

4.2 The Teacher Education Content

Since the objectives of the teacher education courses changed throughout the years, the content of the teacher education activities also changed.

- During the first teacher education project, the content was dominated by the introduction on Logo and the microworlds.
- In the second project, the acquisition of the Logo programming language itself became of secondary importance. More attention was paid to the link between the microworlds and the mathematics curriculum.
- In the third and fourth project, full attention was paid to the skills in using and integrating the Logo-microworlds in teachers' current practice. Discussion of organizational issues, time tables, ... were also part of the teacher education content.

This gradual change in teacher education content is due to our concern to make Logo a tool for the integrated use of computers in the actual school system.

4.3 The Degree of Teacher Involvement in the Teacher Education Projects

When looking at the degree of teacher involvement in the content and organization of the different teacher education projects, one can perceive the following picture.

- The initial project was clearly a top-down project, in which the Teacher Trainer carried the main responsibility for the content and organization of the education.
- Gradually, in project 2 to 4, the responsibility of the teacher increased. This is remarkable in project 2, where the teachers themselves helped to develop new microworlds in a collaborative organizational setting.
- In project 4, personal and individual responsibility was the largest, since success of the education depended on the teachers' own efforts to work through the packages.

In Flemish schools, there is no tradition of putting teachers of different schools together to discuss their teaching practice. The approach, adopted in project 2, presented the teachers with a very new and exiting experience. In our opinion, the teachers felt quickly comfortable in this new situation and accepted it as a real learning opportunity.

4.4 Outcomes of the TEACHER EDUCATION PROJECTS

Evaluation of success or failure differed in type, content and objectives of the education projects.

- In the first project, the focus was on the learning process of the pupils. Consequently, the acquisition of mathematical concepts and skills was measured (Valcke, 1990). But also qualitative data were gathered; e.g. teacher remarks, questions, problems, ...
- In the second project, evaluative focus was on the teacher concerns about their use of Logo in the classroom.
- In the third and fourth project, during the weekly or fortnightly visits of the Teacher Trainer, the teachers could give feedback about the content of the course.

  When summarizing the evaluative details, one can state that the higher the teacher involvement in the education, the higher the self-confidence of the teachers.

In terms of **teacher outcomes**, the following observations are remarkable.

- Teachers like to cooperate with teachers of other schools. This was a new experience for them.
- Teachers invited - again and again - the trainers to visit their classrooms.
- Teachers seem to be aware of the necessity to integrate computer use into their daily teaching practice : *"Normally, I introduce my pupils on polygons at the end of the third year. But now, since I work with Logo, they already manipulate geometrical shapes.*

  But I don't know how to link these activities with my theoretical lessons.". And another teacher remarked : *"I did prepare working with triangles in Logo during a preliminary lesson without computers."*.
- Group work was welcomed as a valuable alternative to teacher-dominated approaches for teaching and learning. Many teachers observed the positive effects of discussions, mutual information interchange, task division. At the same time, they also discovered the necessity to set up an explicit learning process to support the development of

social abilities of children : *"I think that the latter is much more important and is especially clear when you work with computers : it is a tool to communicate with each other. (...)*
But, working in groups can be a problem for some children. (...) They learn from each other. (...) Working in small groups is not always that easy, therefore I explicitly intervene to help them with task division. (...) I have to intervene in relation to this problem.".

- Teachers also become aware of the potential of Logo to develop the metacognitive skills of the pupils : *"As a matter of fact, I did notice that, when they carefully plan their work, they gain a lot of time.".*
- The teacher manual (already developed to support Project 1), was accepted as a useful source of information.
- The teachers asked continuously to demonstrate the use of Logo and/or the way the teaching and learning context was set up.
- The teachers asked for more support : *"You don't know if there are still other manuals or other courses in relation to Logo ?".*
- Many remarks of the teachers reflected their growing awareness of the curriculum relevance of Logo-activities : *"It is related to many things : geometry, calculating, mental calculation, ...".*
- Teachers reflected on the constructivist approach to teaching and learning : *"Classroom intervention is a problem to me. Therefore, I give complete freedom to the children. I only intervene at the end of a session.".*

In terms of **pupil outcomes**, Project 1 revealed that pupils acquired - to a significantly higher extent - certain mathematical skills and concepts, compared to a control group : estimation skills, measurement skills, use of a ruler, scale, comparison of length, recognition of angles, ... (Valcke, 1990, p. 367-370).

4.5 Differences in the Organization of the Projects

The way of organizing the TEACHER EDUCATION PROJECTS differed, depending on the availability of financial means to provide the participating schools with more manpower.

- Project 1 was a low-budget project. It relied on the work of a single Teacher Trainer, member of the university staff. The teacher education project was part of his doctoral dissertation work.
- Project 2 was an expensive project. The Ministry of Education supplied the participating schools with an extra teacher, the participating teachers visited the university weekly (travel expenses were paid for), ...
- Project 3 and 4 were adaptations to financial savings. There was only money available to pay one extra member of the university staff. Therefore, a different organizational strategy had to be adopted.

These organizational differences were very interesting, because one could consequently observe differences in the degree of teacher involvement, trainee contact, and the transferability of the training experience.
Project 2 implied e.g. a very high level of teacher involvement and trainer-trainee contact, but was not easily transferable at a larger scale. Providing schools with extra teachers is too expensive.
Project 4 implied a very high level of personal involvement, a low level of trainee contact. But, since the education was package-driven, the experience can easily be organized on a larger scale.

5. Ongoing and Future Projects

In part 1.3, the **compulsory in-service programme** was already referred to, for all teachers of the primary community schools in Flanders. Since September '89, EDIF is involved in the support of this project. This support consists of :

- training of the teacher trainers in the use of the LogoWriter-environment;
- developing support materials (discs with examples, transparencies, manuals, ...);
- developing new Logo-learning environments for the teaching of mathematics, mother tongue, writing, ... ;
- developing exploratory environments, based on the use of spreadsheets and databases.

The role of the EDIF-team, in this new project, differs from the one during the projects, described above. The team is focusing rather on supporting ongoing initiatives of the Ministry of Education. At this moment, the research team is not setting up independent TEACHER EDUCATION PROJECTS.

6. Conclusions arising from the Projects

Although the four projects, described in this chapter, can be viewed as major regional initiatives, they can help to clarify how teacher education in the use of Logo-microworlds can be organized in such a way as to guarantee the integration of Logo-use. The four projects enlighten different approaches in relation to different objectives, contents, organizational constraints, ... Although the approach, adopted in the fourth project, could be regarded as a short-term and low-cost solution to the high demands in relation to teacher education, **the EDIF-team prefers long-term projects which imply a high degree of teacher involvement. This is especially true if the main objective in teacher education is to influence the teaching skills and not only their general awareness about the educational use of computers in education.**

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Chapter 3
TRAINING TEACHERS IN LOGO IN GREECE

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1. General Introduction

The state of affairs concerning the use of Logo in Greek schools is characterized by a low interest at all educational levels, apart from the micro-level. The limited amount of initiatives, attempting to exploit Logo's educational philosophy, have been and remain isolated.

In this context, two projects have been set up, independently of each other, the first directed by G. Gyftodimos, the second by C. Kynigos.

The former project, titled "Training Teachers in Logo", involved primary and secondary school teachers in in-service courses, with the aim to introduce them to Logo's philosophy, its educational possibilities and to enable them to apply this knowledge in their daily practice.
The latter, titled "Training Teachers to encourage children to learn with Logo", aimed at training the entire teacher population of a primary school. Its general aim was to perceive and use Logo in an educational way and to apply what they have learned with the children they normally teach. The presentation here concentrates on the teacher training aspects of this project, which includes teacher training, pupil education, evaluation and curriculum design on a longitudinal basis.

The two projects address two important aspects of the problem of spreading the educational use of Logo in a non technologically aware culture.

The former project addresses the demand for effective short-term teacher training, on a large scale in a school system which is being (or will shortly be) equipped with computer technology, but in which inevitably there is shortage of teachers, able to do something useful with it. On the other hand, the latter project confronts the issue of a long-term integration process in relation to the use of Logo with the entire school population (all teachers and pupils), while - concurrently - injecting a constructivist approach to teaching and learning.

Furthermore, the authors believe that these two approaches are complementary. The former meets the problem of a more readily applicable method of spreading Logo use in Greece, while the latter confronts deeper issues concerning the pedagogical use of Logo and generates changes and ideas which might be implemented in the application of the former. At a different level, the combined experiences support the view that there is a need for designing Logo environments, related more directly to the various contents taught in current curricula, but avoiding as much as possible to compromise when exploiting Logo's educational strenghts.

2. Project 1 : "Training Teachers in Logo" An Experiment on the Use of the Computer in the Classroom

2.1 Computers in Greek Schools

2.1.1 The Use of Computers in Primary Education

In primary schools, which covers the education of 6 to 12 year old pupils, the use of the computers is still limited. It is not supported by a national plan and the few initiatives are isolated and are individual efforts.
In private education, all schools have computer laboratories (8 to 30 units of 8-bit or 16-bit technology) and employ specialized personnel, obtaining very important educational results. However, only a small percentage of pupils attend these private schools.
In public education, a number of schools are already equipped with computers, by the parents' associations (usually laboratories with 4 to 8 units), but there is neither specialized personnel nor teacher training facilities. The lack of any kind of support prevents the beneficial use of these units. This, however, is not an unresolvable problem; it is rather caused by the absence of some basic information, that could be overridden by providing the appropriate software and related training.

2.1.2 Second-Level Education

In Greece, second-level education consists of two 3-year sub-levels, gymnasium (age level ± 12-15) and lyceum (age level ± 15-18). A national plan to provide all schools with computer laboratories is in progress. All technical schools and a large number of the lyceums (general education) already have such laboratories (8 to 16 PCs, connected to a server under UNIX). However, the situation in gymnasia is not much better than in primary schools, except that the gymnasium teachers have a more profound scientific background, whereas computer knowledge can be obtained more easily.
Anyway, computers at this level are only used to perform algorithmic computations, and do not serve any didactic purpose. The use of Logo for shifting the focus of computer use from computational to didactic purposes, is very appropriate. It serves both purposes. Note, that this gap is caused - in particular - by the teachers' view on computers, namely as computing machines.

2.2 The Educational Use of the Computer

The Choice of Logo

Logo is the most appropriate choice among a variety of solutions (as BASIC and PROLOG) to solve the problem of finding a programming language that can be used as a tool in the classroom. It is a friendly and interactive environment. It has a simple syntax and it invokes structured programming (modularity). Moreover, it is expandable, gives helpful messages, has extended logical capabilities, offers various possibilities through the use of lists or properties, recursion, ...
Although these facilities already justify the choice of Logo, there is another reason making this choice straightforward : a Logo programme, once loaded, remains resident. The user can build anything he/she wants, possibly using procedures of this programme, as long as consistency is retained.

Through this facility, a specific environment can be constructed in relation to a lesson or a special task. This environment can be used as a context in which the user develops his/her own work, or in which other contexts can be developed. Furthermore, this facility can help the user to organize his/her thoughts and to test whether an application corresponds to his/her initial intentions (Cf. Jonson-Laird, 1988).

From a semantic point of view, there are no limits in this use of Logo. The technical limitations of Logo are not a serious disadvantage. Logo can be viewed as a first step to LISP (Cf. Winston, 1977), which in turn is a threshold to object-oriented programming. So, if someone is experienced in the use of Logo, he/she has acquired a background for more advanced topics in programming and especially for Artificial Intelligence (AI).
From this perspective, Logo offers a great advantage : AI cannot be applied in an area without the collaboration of experts in that area and, given that the experts in education are the teachers, Logo may be used as the crossing point for AI scientists and educators, so that AI applications in education can be efficiently developed (Cf. Harmon, 1985).

Our approach has a different dimension as well : Logo can be viewed not only as a facilitator of the interaction between the user and the computer, but also as a universal language, which can facilitate communication between children of different countries, allowing them to find common interests and exchange ideas.

The Use of Logo as a Tool

Applications of Logo are possible in almost all subject domains in primary and secondary school. There is a pragmatic criterion, which influences the answer to the question : *Do students benefit from the use of the computer more than by the old-fashioned course ?* As "benefit" must be considered not only the probably broader (relatively to the past) knowledge acquired by the student, but also the general skills he/she obtained in view of real life requirements. We must take into account that certain needs are not answered in schools, because they are considered impossible to answer; e.g. there are no special courses on "how to think", "how to become more intelligent" or "how to be more creative". These aims are expected to be attained as "side effects" of more general courses. So, new didactic approaches should also be evaluated in view of the more general development of the child.

A ready-available application-field of Logo is the teaching of mathematics, not only because of turtle graphics, but especially because of some features of the language, such as properties and lists, that allow the classification of knowledge. For example, the following subject-domains can easily be sustained by Logo, thus pursuing relatively important educational objectives.

- In primary education : geometric subjects (turtle movements or Cartesian coordinates); arithmetical operations and their properties; simplified set theory. Moreover, as an extension to these basic subjects, elements of bi-value logic and truth value of relational operators can also be taught through Logo.
- In second-level education : metric relations in Euclidean geometry; topics on analytic geometry and trigonometry; set theory; recursive and non-recursive sequences; recursive curves and series; vectors; graphical representations of functions. Furthermore, elements of propositional and predicate calculus can be taught, extending the use of truth value to any kind of logical relations.

2.3 The Project 'Teacher Education in Logo'

Objectives of the Project

The objective of this project is the training of teachers, in order to enable - at a first level - to teach Logo to their pupils/students and, at a second level, to offer them a new pedagogical tool.
The experience was limited to the field of mathematics, because possible applications in this domain are numerous and easy to develop.
The main focus is on the creation of a new pedagogical context, where the teacher stops to be the *medium* through which the knowledge is received by the student, and where he becomes a creative tutor. Unfortunately, in Greek schools, personal interventions of the teacher are very restricted, because he/she has to follow strict instructions when teaching. In this context, Logo is much more than a sophisticated tool. It gives the teacher the opportunity to create his/her own way of teaching.
We must also take into account that the amount of time, devoted to computer applications in schools, is limited (from 1 hour a week to 2 hours for the secondary school students, even if a laboratory exists). The possible relevance of these computer applications in school seems to be relatively restricted. But, from a *pedagogical* point of view, however, the amount of time is not always a correct standard of the value of the experience. Educational applications of Logo can offer relatively important gains, despite limited time and/or limited resources.

The Training Seminars

During two seminars, one for primary school teachers (12 participants) and one for secondary school teachers (30 participants), an effort was made to teach Logo to the participants and secondly to focus on the use of the language as a tool in their own teaching practice.
In order to achieve the first objective, the course was designed as it should be set up for the corresponding classroom level, but at a higher speed. Starting with graphics applications, the use of variables and the meaning of a procedure, the course continued with logical control and the applications of recursion, finishing with applications of properties and lists.
To pursue the second objective, we presented them with a simplified list of the aforementioned subject fields linked to Logo. We asked them to look for possible implementations of these subject areas, in order to create - for each domain - a programme which could be offered to the pupils/students as an environment to build a specific application. For example, a project aimed at the creation of a library of procedures (with variables) to design polygons and curves. As an application, they had to imagine how students could work in this environment - using these procedures as tools - to design complex schemata.

In relation to the first objective of the seminars (teaching Logo) the participants, more or less, behaved as students, having the problems that can be observed in any classroom: e.g. loss of attention, fluctuating interest, ... However, in relation to the second objective (using Logo as a tool), some hard problems were observed, which solution was time consuming or which were even unresolvable.
By discussing - infra - these problems, we intend to find solutions or at least present alternative approaches, for future projects.

A remarkable fact is that a number of the participants (less than ten) remained in personal contact with the trainer, in order to receive additional information and/or to explain their use of Logo. They try to use Logo whenever it is possible; with the same aims as the seminar and by creating an environment where the student can design his own applications. Due to the fact that there are hardly any programs, guides, handbooks, ... they design these applications from scratch. As a consequence, the results are for the moment very limited.
However, these efforts prove, at least, that it is possible to attain through Logo the objective of reconciling the teacher with computer use, and to facilitate the application of new didactical approaches, which demand a more creative participation from his/her part.

Problems which Appeared in the Seminars

In general, the problems we faced were of **four types** :

The first type of problems includes problems caused by inappropriate material. Due to the insufficient flexibility of available Logo interpreters (PC-Logo) (Cf. Ross, 1984), there were difficulties in embedding them in the available hardware (which in turn consisted of a variety of machines). These problems were somehow resolved, but annoying delays were inevitable.

The second type of problems includes problems caused by a missing or an inappropriate background of the participants. When scheduling the course, it was based on the assumption that the teachers were already acquainted with some basic elements of mathematics and logic. Infra (2.3.4), we focus especially on problems of this type.

The third type of problems includes the difficulties of the participants with the computer environment, ranging from the technical manipulation to the accommodation of their way of thinking to a format acceptable by the computer units. These problems were not only caused by the use of unfamiliar technology, but also by the fact that participants' knowledge was format dependent; a different representation of information was often regarded as new information.

The fourth type of problems includes those related to the participants' worry about issues not directly related to the seminar; e.g. additional work, their responsibilities in the school and the effects of the computer on their prestige (especially for the older teachers, who state that *"pressing buttons isn't serious work"*).

Problems at First Level

The second type of problems is especially acute for teachers of primary education. Teachers of secondary education already have some knowledge of computers and are more able to cope with new requirements. The problems were many.

1. **The teachers did not have a sound theoretical knowledge about the properties of mathematical operations.** For that reason they had difficulties in applying the appropriate properties of the arithmetical operators in complex expressions. For example, some people hesitated to interpret expressions as :

```
MAKE "A 5 MAKE "B 3
PRINT :A + 6 * 14 / :B - 3 * (5 / :B)
```

Some participants had difficulties in applying the priority of operators, due to the fact that their knowledge was based rather on semantic rules than on the definition of these operations. They preferred to use parentheses in case of doubt.
They justified their hesitation claiming that *"they thought that the result could depend on what the computer chooses to do first"*. Asking them what they meant, they answered that *"they have met some cases of integer division, when programming in other languages, and they didn't know if it is the case"*. Becoming aware of the fact, that this Logo-version only performs real division, someone even called this a contradiction, claiming that *"it is not possible to have the same machine operating sometimes in one way and sometimes in another way"*.
On the question, whether they believed that all computer languages must follow the same rules and have the same properties, they answered : *"Of course, a computer language is only a translator, which is designed and implemented in order to make the communication of the user and the machine easier, as it is written in the schoolbook"*. It is obvious that they were confused by the fact that they considered the integration and unification of all computer activities as a meta-axiom. The origin of the problem lies in a schoolbook, written to introduce students into Computer science and BASIC, and considered as a sufficient source of information.

2. The participants' knowledge about Logic was insufficient.
The primary education teachers claimed that *"logical operators are part of advanced mathematics"*. It was necessary to use many - naive - examples in order to persuade them of the meaning and usefulness of logical operators. After a while, they seemed to be surprised by the straightforward use of these operators in everyday expressions and by the important role they play in daily life. They were also amazed to realize that *"they were not taught such basic things"*.
The teachers in second-level education had problems in understanding logical properties (except those described in the schoolbook); e.g. the de Morgan law, the "belongs to" property, etc. Moreover, they believed that *"they had enough theoretical knowledge to follow courses on a language as Logo, which - as it is well known - is easier than BASIC"*.
Some of the teachers, who had learnt BASIC, used BASIC structures to understand the structure of Logo. They had difficulties in applying logical operators on relational expressions of objects other than numbers. The following expression was considered as something *"out of computer logic"* :

```
IF NOT EMPTYP :L [PPROP FIRST :L "LEGS 4] [STOP] (IBM Logo)
```

The "strange thing" in this expression was neither the syntax nor the use of properties or the sequential form, but rather the use of the "property EMPTYP to verify a list" They preferred to use the following equivalent expression, which was more comprehensible to them :

```
MAKE "N COUNT :L
IF :N > 0  [PPROP FIRST :L "LEGS 4] [STOP]
```

3. The participants justified their lack of knowledge by claiming, that *"they were not teaching these subjects in school"*. For example, a primary education teacher justified a missing answer in an exercise by saying that *"he would never need to calculate the angle of a star, because his lessons included only convex polygons"*.
It is evident that this answer reflects that he was used to follow the strict format of the instructions in his course. These instructions were viewed as the boundaries of his work.

2.4 Conclusions in Relation to the Project "Teacher Education in Logo"

Teachers' knowledge about 'Logic and Mathematics' is generally format-dependent, because of the confusion between the semantic and the semiotic level of information. As a consequence, teacher education must focus on the distinction between the meaning of a notion and the way it is expressed.
It is obvious, that the Logo seminar could have covered far more topics. But the teachers do not have the basic knowledge required in the computer science area. Moreover, they are not always aware of this lack. So, a specific framework for teacher education must be developed, based on the actual situation and actual needs.
At the **hardware level**, it is clear that the provision of - uniform - school laboratories is of great importance.
At the **software level**, there is no need for a special (Greek) version of Logo. Rather, a more flexible version (in terms of the hardware) is necessary.
Furthermore, the construction of **special "libraries"**, consisting of Logo procedures and corresponding with special topics, is absolutely necessary to use Logo as a didactic tool. These libraries should cover different school areas, in order to help the teachers to use Logo in an efficient way in their courses, without obliging them to do "all the work from scratch".

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3. Project 2 : "Training Teachers to Encourage Children to Learn with Logo"[1]

3.1 Introduction

In this subpart a report is given of an ongoing longitudinal project, now over halfway through a planned 6-year duration, involving the use of Logo in primary education. The project is set up in a primary school in Athens (Psychico College).
The general objective of this project is to integrate programming and the use of computers in the everyday classroom activities of a school, by incorporating them as tools for pursueing educational needs within the school's culture. An implication of this objective is that, rather than simply attempting to "add-on" another topic area in the present curriculum (e.g. "computers" or "programming"), or using computers to teach already established topics with conventional teaching methods, the technology is used to focus on the "how" of teaching and learning, i.e. on process rather than on the content (Cf. Kynigos, 1988, 1989 and Kynigos, in press).

[1] Acknowledgments are due to the "Costas and Mary Maliotes Charitable Foundation.

This emphasis on the process has been a dominating feature of the project for over half of its planned duration. An important aim, for instance, has been to train all 24 teachers of the school to foster classroom environments where the children take active control of their learning and develop original and independent thinking. Ongoing in-service training for the school's teachers has consequently been an essential aspect of the project. This aspect, however, is an integral part of a "real-life" school project, involving the following topics :

a. teacher education;
b. curriculum development;
c. research on the development of the teachers' strategies and the children's learning.

After a first year of piloting, an **important principle underlying the method by which the above topics were implemented, was to maintain implementation, evaluation and development - concurrently - throughout the project.**

The subpart of this chapter is thus structured accordingly. Although what follows is essentially a chronological account of the first four years of the project, the following elements are emphasised : a) how the project was implemented each year, b) the objectives, method and results of evaluating research and c) the way implementation changed as a result of the research findings. This particular structure was chosen to facilitate the paper's readability, to convey the project's developmental nature and to emphasize the importance of evaluation. Important issues concerning the project's features, the education of the teachers and the related educational objectives are discussed in section 3.3 within the above structure. Finally, translated examples of children's work and activities and of their teachers' feedback are given, analyzed by the writer with respect to the teacher's developing strategies in implementing the program's educational aims.

3.2 Year 1 : the Pilot Study

1985-86 was a year of piloting. Teachers did some work with Logo and were asked how and if they might use it with their children. A group of children participated in an informal "Logo Club" and information of the way they learned was collected (Cf. Kynigos, 1989). In the following year, one teaching period a week was made available for each class to work with Logo. It was by no means compulsory for the teachers to participate, but they were encouraged to do so by the school authorities. Although the pilot study revealed considerable variation in teacher attitudes, they all agreed to give it a try. However, a heavy schedule was quite forbidding in finding extra time for teacher training, apart from a week given before the school started in September.

The results from the pilot year, the available conditions for implementing the programme and the objective to exploit Logo's educational strengths within the school's own culture were the main factors in forming the programme's features and deciding on a strategy for teacher training.

3.3 Year 2 : a Preliminary Implementation of the Programme

3.3.1 The Programme's Main Features

Educational Objectives

The results from the preliminary year's experience of the teacher's reactions and the Logo Club, helped to pinpoint and clarify the educational objectives and the design of the programme. The central aim of the programme was for the computers to become a classroom tool in the hands of both the teachers and the students, for encouraging and actively exploring the social and cognitive aspects of learning. This implied using Logo and an informal, investigative, group-work style of classroom organization in order to achieve an atmosphere encouraging :

a. active thinking (e.g. to solve own problems);
b. initiative (in thinking, creativity and decisions);
c. cooperation (cognitive, effective, social).

Classroom Setup

The setting is as follows. There is one computer room with ten Apple IIc each linked to one of the three available printers (Imagewriter II). The Logo-version used is L.C.S.I. Apple Logo II. One computer period a week is allocated to each class of 30 children, during which they work in freely formed but permanent groups of three with their own teacher. The teacher's role is to encourage the children to cooperate within their groups and to develop control over their own learning. The teacher therefore avoids adopting the role of the transmitter of factual knowledge and instead supports the children in their exploration of ideas. Each group of three children uses one computer, disk, and writing book. There is free collaboration and the groups are responsible for presenting results.

Contents

From the beginning of 86-87, all the children were exposed to the programme, each class by its own teacher. The programme extends from the third to the sixth year inclusive, i.e. it involves ± 500 children and 16 (24) teachers. **Its contents depend on a working framework within which a non-prescriptive educational atmosphere is sought.** A major component of this framework is based on collaborative **"investigations"** carried out by each group of children.

These "investigations" consist typically of a four-lesson project, which is either totally up to the group or is based on an initial idea or drawing set by the teacher. Thoughts, activities, results and manner of collaboration are recorded by the children. Every four or five weekly periods, each group is responsible for giving a "presentation" of their investigation, i.e. a report consisting of a printout of drawings and commands/procedures and a group essay on activities, thinking, collaboration, further ideas and conclusions. Examples of investigation presentations are given at the end of this chapter (Appendix 1). The children's essays and the teachers comments are translated in English and, in each case, the writer has made some analytical remarks on issues concerning teacher strategies in implementing the programme.

3.3.2 Objectives, Principles and Method for Teacher Training

From the outset, the main concern regarding the training of the teachers was **to allow and encourage them to form their own strategies and take control of the way in which they would implement the above educational objectives.** Thus, one reason for focusing on the process, was for the teachers **to use Logo as a tool to teach something that they considered familiar, relevant and useful** in relation to their experience so far : they felt that the children had very little chance to engage in active thinking, to take initiatives and to cooperate in their normal classrooms and that these experiences would be of great value to them.

A second reason for focusing on the process, however, was that by encouraging the children to learn by doing rather than by receiving information, Logo is exploited as a tool for learning. Once a culture of children building control over their learning could be established, with the teachers feeling that they are using this new tool meaningfully, then it would be time to **progressively throw more emphasis on exploring the mathematical and programming ideas embedded in the Logo-language.**
The support of the Teacher Trainer was in line with the above teacher training objectives. He spent five months in the school at the beginning of the programme, supporting their work, but at the same time handing the responsibility of decision-making back to them; ultimately, they were the ones who knew what the children needed to be taught and not an outside trainer or "expert" ! Furthermore, they were given intensive seminars were at the beginning of each year and some classroom observations were carried out towards the end of each year for evaluation purpose, as shown below.

Emphasis on the mathematical and programming ideas in Logo has been placed in the final two years of the programme. Extra time has been given for this purpose by the school. I will be visiting the school for 30 days each year, giving seminars and participating in classroom work.

3.3.3 The Role of the Presentations of the Children's Work

It seems worthwhile at this point to discuss why the presentations of children's investigations have been a crucial element of the programme.
Firstly, they provide the opportunity to both children and teachers to reflect on what they learned/taught and how they learned/taught it. This is proving to be a powerful way of increasing the awareness of an active, investigative and cooperative kind of learning. It is also a sophisticated means for the children to express their work, enabling them to address the classroom and hold fruitful discussions.
Secondly, the presentations are advantageous from a point of view of dissemination due to quantity (there are 160 presentations every 6 weeks, roughly 600 per year), quality and clarity for anyone concerned; parents, educators, other children, authorities.
Finally, they serve as a powerful data base for evaluation research. Besides, they can be used for wider research into a multitude of issues concerning the use of technology in primary education and related educational problems (for example, one teacher is interested in carrying out research into the sociological aspects of learning in small groups). As mentioned above, examples of presentations are given at the end.

3.3.4 A Series of Key Teacher Seminars

In September 1986, a series of intensive seminars were given in which all the teachers participated. A central aim of the seminars was **to meaningfully convey the teachers the educational objectives of the programme** (as shown above), i.e. what they would be "teaching" and why. The seminars also consisted of **technical support, practical guidance for starting-off with the children, a careful analysis of the content of the programme and suggestions for encouraging an informal classroom atmosphere.** Each day started with the teachers carrying out a Logo project in groups of two and then discussing the above issues in relation to their personal experience from the Logo project. The three main aspects of the seminars, i.e. objectives, content and classroom atmosphere were carefully documented beforehand and made clear to the teachers.

3.3.5 Evaluation

Method

At the end of the year, informal questionnaires and semi-structured interviews were given to the teachers investigating their perceived difficulties during the first year and their view on what the children may have carried over from the programme into their normal classroom activities.
The most important source for evaluation, however, was the children's own work, i.e. the presentations of their investigations.

Results

The most important conclusion from the preliminary year's experience was that **the process of assimilating the legitimacy of an informal classroom atmosphere and the teaching objectives of cooperation, initiative and active thinking was much slower than anticipated** (for teachers and children). However, such an atmosphere was achieved in varying degrees in all the classes. **Other conclusions** were :

- there was a certain confusion between the teaching objectives, planned, and the objective of teaching a programming language for both teachers and children;
- most teachers hesitated to comment on the children's reports;
- the idea of an investigation was often not put across clearly to the children;
- the younger children found it difficult to realize that a project lasted for four periods, often treating each period as a new project;
- more time was needed to get the idea of investigations across, especially at the beginning;
- time was needed after each investigation for groups to discuss their presentations with their peers in the classroom context;
- presentations could not be prepared in the computer room;
- the programme needed to show more sensitivity to the age and experience of the children;
- initial ideas for investigations would sometimes be confused with teacher required tasks.

3.4 Year 3 : Implementation of the Main Programme Begins

3.4.1 How the Programme was Reformulated

In the light of the experiences of the first year, the programme was reformulated firstly to clarify to the teachers activities, emphasis and a framework of techniques for establishing the desired classroom atmosphere.
Secondly, the uniformity of the programme across year groups, was broken down to year level; the programme was made more sensitive to the age of the children. The younger ones were provided with more time to clarify the idea of investigative work. The older ones were introduced to and encouraged to use some Logo programming ideas, such as writing, debugging, saving and loading procedures and using variables.
Thirdly, the content regarding the technology (e.g. the programming aspect, the use of the printers) was clarified for each year. Also documents were prepared for the teachers regarding technical difficulties encountered during the first year of application and the syntax of certain commands. However, the fourth and most important aim of the reformulation was to stress that the emphasis remained on using the technology for existing educational needs (active thinking, cooperation, initiative).

In September 1987, an intensive seminar was given to the teachers analyzing the content of the programme for every year. All the teachers were present at the seminar.

3.4.2 Evaluation

Method

By visiting the school, late March 1988, all teachers have been observed in action. Analyzing the observations of one teaching period with each teacher and class in the computer room during their normal Logo programme activities, revealed the following points.

Results :

- classroom atmosphere was generally informal and the children seemed to be in control of their projects;
- the degree of the teachers' awareness and control over the program was generally higher than that of the previous year - for instance, personal strategies in supervising children's presentations were more noticeable;
- the suggested reformulation of the program was implemented by all the teachers;
- there was a markedly increasing level of confidence amongst the teachers compared to their original lack of expertise;
- several teachers began to develop their personal style of intervention;
- it was felt that the teachers' method of commenting on the children's presentations needed to be worked at - for instance, many groups of children would benefit from comments encouraging them to give some structure to their presentations;
- although classroom management improved there were still some problems;
- there were certain problems with the maintenance of the hardware.

In this way, from the year 87-88, the design of a specific curriculum for each year has started to develop, maintaining and refining the original pedagogical objectives, but also shaped by the increasing experience of both teachers and children. Apart from the emphasized aims of the programme, i.e. encouraging cooperation, active thinking and initiative in problem solving situations, it is well established that children benefit from such environments in their meaningful learning of mathematics and programming. Further training of the teachers, however, would help to enhance the children's performances and allow more overt emphasis on their mathematical learning.

3.5 Year 4 : the Second Year of the Main Programme

Due to administrative difficulties, it was not possible to begin further training of the teachers on mathematical and programming content during this year. However, the programme was fully implemented and the opportunity was given to carry out a rather more systematic evaluation towards the end of the schoolyear.

In May, one teaching period was spent with each teacher and class in a normal Logo session, as in the year before. This time, however, my observations were more focused on specific issues that would allow me to form a picture of the extent to and the way in which the teachers were implementing the program's objectives. Some examples of these issues were how often children would require the teachers' intervention, what kind of intervention was required (factual, motivation-linked, lack of creativity, etc.), how involved each group of children seemed in their work, children's readiness to experiment, teachers' circulation in the classroom and classroom management, the type of interventions the teacher made of his/her own accord, etc. Furthermore, after collecting nearly all presentations written during the year (around 500) the presentations of each class were analyzed in an attempt to gain further insight into the work of each teacher separately (class level), and each year (year level). Then a picture was formed of the progress of each teacher individually, on the basis of the above observation data and classroom presentations and constructively used the information in teacher seminars in September 1989.

The evaluation results are now being processed. However, preliminary results reveal :

- in nearly all the classrooms there was a lively atmosphere of children involved in their work and demonstrating considerable learning independence from their teacher, in relation to the norm in their non-Logo school activities ;
- the teacher generally seemed to be meaningfully educating the children regarding the process-oriented objectives of the programme ;
- all the classes (except one) wrote presentations of their investigations and in slightly more than half the classes there was evidence of a lot of self-motivated and enjoyable work on the part of the children ;
- there was evidence of originality and creativity in a number of presentations.

However, there were some deviations from the analytical programme for each year, usually consisting of falling short of the content to be introduced to the children. Even at this stage in the programme, where content was not emphasised, some teachers felt reluctant to introduce simple programming ideas, especially in the 5th and 6th year. Finally, interventions about the content of children's work in the classrooms were disproportionately few for eight of the teachers.

As mentioned before, time is finally made available in the following two years to concentrate on content. The analytical programme has been reformulated and clarified and teacher seminars involve the teachers of one year at a time.

The aim is for the teachers to have more time to do Logo for themselves and reflect on the ideas they use and might employ in the classroom. Working out a more explicit plan of teacher activities, using children's presentations to convey and discuss ideas (both about process and content), giving small-group seminars in mid-year and participating for short periods of time in the classroom activities are the main methods by which teacher training is focused on content in the final two years of the programme.

3.6 Conclusions

Throughout the first four years of the programme, the issues of teacher training and support have proved crucial for its application. Since the project involved the entire teaching staff, a range of attitudes towards computers had to be addressed from the beginning. Furthermore, it was felt that the teachers' relative lack of experience with Logo programming and the importance of encouraging an investigative child-in-control atmosphere in the classrom provided justification for a relative de-emphasis of programming as an objective for the programme.

With the benefit of hindsight, it is seen as crucial for non-computer expert teachers to have clear educational objectives for using new technology. Furthermore, the objectives must be such that the teachers can relate them to their own day to day experience of educational practice. In the case of Psychico College, the objectives of active thinking, initiative and cooperation were related to existing every day issues enabling the teachers to initially perceive the technology and Logo as tools for teaching something familiar. A further aim of the project is to progressively provide further teacher training on issues related to content, for instance on Logo programming and on related mathematics.

The allocation of one hour per week for each class to use the computer room made the seminar directly relevant to the teachers' immediate needs. This, of course is not a typical case of in-service teacher training, where there is often substantial difference between what goes on during seminars and what is possible in a classroom. However, the seminars were not of a prescriptive nature, despite the fact that the content was immediately applicable. **Rather, the strategy was to offer the content structure of the "investigations" and a set of suggestions for classroom organisation as a flexible framework not only for the children to take control of their learning but also for the teachers to develop personalized reasons and strategies for using the technology.**

During the observation of the teachers "in action" with their classes, it seemed as if the initial problems of "computer anxiety" and not perceiving a meaningful reason to use new technology, had been substantially reduced. Moreover, a "personalized" use of computers as a tool for teaching something which was perceived as useful for the children, has started to spread amongst the teachers.

However, it was felt that the teachers would have a lot to gain from furthering the degree to which they see the power of programming in Logo for themselves. Although the present educational objectives for the programme are proving useful for the children's education within the school culture, and hopefully will continue to do so, there is more to be educationally exploited in using Logo. **For the teachers, an increasing awareness of powerful programming and mathematical ideas embedded in the language, will no doubt enable them to develop strategies of intervention and to design child activities which would catalyse the enhancement of children's understandings of such ideas.**

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Appendix I : Examples (in relation to the project of C. Kynigos)

So far, what has been presented is a rather top-level account of the Psychico College Logo programme, emphasizing the program's development and the teacher's progress. It would be really hard, however, to communicate what actually went on in the classrooms without some concrete examples of the program's content and of the activities of the children and their teachers.

The following example is a presentation of an investigation carried out by a group of three children, as explained in the previous text. Furthermore, all the teacher's written comments have been left on the presentation. The teachers' comments and the work of the children themselves, illustrate the ideas communicated in the Logo classroom, and the teachers' developing strategies to achieve the programme's educational objectives : active thinking, initiative and cooperation. Furthermore, by giving examples of mathematical and programming ideas used by the children, the current objectives in the training of the teachers is exemplified : to detect such ideas and encourage the children to reflect on, generalize and use them in different contexts.

Examples such as these are now being used to communicate ideas in all the teacher seminars, since they provide the most powerful means to link educational objectives to everyday events and to build on common experiences. The example given here is from the preliminary year of the programme's application. Examples from the following years are being processed and will be used in future publications.

Investigation (teachers' comments between brackets)

In our investigation we didn't cooperate very well : 1. we shouted; 2. we argued about who would use the keyboard, we even had a fist fight; 3. a member of our team was telling us things we couldn't understand and this made us tired.
[You did well by resisting things you didn't understand.]

TOPICS THAT WE MADE.
1. First we made a rectangle.
2. Then we made a flag but it took us two periods because we wouldn't cooperate and wouldn't stick to the topic. In the end we managed to make it. I would like to say that our main topic continued to be the rectangle.
3. Afterwards, on my initiative, we decided to make an oven but we didn't have time to finish this.

All of us believe that in our next investigation we will do much better in all the areas.
Alexandros, Chrisos, Alexandros

[Your report is satisfactory. You could have been more specific about the difficulties you encountered and how you dealt with them.]

Writers' comments

Notice the relatively high degree of the children's awareness of cooperation difficulties. This could be related to how the teacher seemed to have asked the children to structure their essay, i.e. have a special section on cooperation, under a heading. The problem of children having computers at home or copying programs from friends was quite widespread. Notice how the teacher has grasped the concept of investigative work by refusing to accept non - group results in his comment.

Chapter 4
TEACHER EDUCATION IN LOGO-BASED ENVIRONMENTS

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1. Background Information

The Primary School System

In Ireland there are approximately 20,000 primary teachers catering for the education of approximately 550,000 children, aged 4 to 12 years, in 3,400 national primary schools. Most of these schools are small rural or town schools with from 2 to 8 teachers, while a small number of city and town schools have 16 or more teachers. Primary schools are mostly state-aided and denominational, and there is a national curriculum in operation in these schools. Due to demographic trends the number of children attending primary schools is declining and will probably continue to decline over the next few years. The average class size is 30 pupils. Compulsory education is from 6 to 15 years of age.

Although there are no official statistics on the number and distribution of microcomputers in primary schools, it would appear from sales figures and from estimates from school inspectors that about 30 % of primary schools have at least one microcomputer, generally a BBC computer, while a few of the larger primary schools have from 2 to 15 computers. Seven years ago the figure was only 2 %. Logo is used widely in these schools.

The Government Department of Education has no official policy on N.I.C.T. in primary education but the inspectorate encourages and supports its use in the schools. A major review of primary education has been carried out over the past two years by a special committee appointed by the Minister for Education and it is expected that the report of this committee, to be released in 1990, will contain recommendations relating to N.I.C.T. in primary schools.

St. Patrick's College - Dublin

St. Patrick's College of Education is the largest of five educational institutions in Ireland which are concerned with the education of primary school teachers. At present, St. Patrick's College has about 450 student teachers engaged in a three-year programme leading to the award of a Bachelor of Education, (B.Ed) Degree which is validated by The National University of Ireland. The B.Ed. programme is divided more or less equally between the study of an academic subject (e.g. Mathematics, French, History) to degree level and the study of Education (including Foundations of Education, Curriculum and Teaching, and some practice teaching).

St. Patrick's College also provides in-service courses for practicing primary teachers, including a fulltime diploma course for special education teachers and an evening B.Ed. degree course for two-year trained (pre-1974) teachers. There are 175 teachers involved in these courses at present.
The college also provides short courses (including N.I.C.T. in education) for teachers in association with the Teachers Centre which is housed on the college campus. The emphasis, though, is on pre-service programmes.

The present college computer facility for teaching purposes consists of 35 computers, 25 BBC Master Compact and 10 Apple IIe. A small number of MS-DOS computers are available for use by academic staff only. The 25 Master Compact computers are available to students for word-processing in connection with the preparation of term papers, and minor theses.

2. Pre-Service Courses involving Logo-based Environments

2.1 Elective Course on Computers in Education

Aims

In the third year of their B.Ed. degree programme students can choose a course from about 10-15 special topics in education e.g. media studies, health education, education of handicapped children. One of these courses concerns computers in primary education. About 25 students (i.e. about 10% of all the Third Year students) normally opt for this course. The aims of the course are to :

- **introduce students to the role of computers in primary education;**
- **enable students to operate a micro-computer with confidence and to use it to run and evaluate a variety of educational software;**
- **programme a microcomputer in Logo and to design and explore a number of Logo microworlds which can be used in the primary school curriculum.**

Content

The content of this course is listed in Appendix I. The emphasis is on Logo-based learning environments with some time given over to more traditional content. The course covers about 45 contact hours (25 x 1.75 hour sessions) most of which involves Logo-based work. The course which has been running since 1982, is normally taught by two lecturers, one from the Education Department, and one from either the Mathematics or Science Department. The students work in a large room containing 25 micro-computers. The version of Logo used is L.C.S.I..

Methodology

The methodology normally followed for each Logo-workshop uses a problem-solving format. The students are presented with a programming problem or series of problems and encouraged to discover the inherent concepts or principles They are provided with help only when they cannot make any further progress themselves. It is hoped that by working in a learning environment where the students construct ideas and solutions they see the power and value of this learning process and are motivated to implement it in their own classrooms when they commence teaching.

To further illustrate the methodology here is a brief example of its use in introducing 3-D Logo microworlds (Session 8).

a. The students are asked if they can construct a cube on the graphics screen using the 2-D Logo commands FD/BK and RT/LT. A large box is placed on the table in front of the students to aid visualization.
b. Investigations lead to the general conclusion that it can only be done using a procedure which does not reflect the mathematical properties of a cube and which is quite awkward to construct.
c. The need for additional turning commands is suggested by some students and subsequently the PITCH, ROLL and VEER (yaw) commands are clarified and illustrated with a model of some sort (e.g. toy spaceship).
d. Students are asked to write a procedure which will construct a cube on the screen using the D Logo commands.
e. The questions of the use of the REPEAT command and of the number of faces which should be drawn arise. (How do you define a cube ?). Much trial and error activity takes place at this stage.
f. Eventually a number of the students arrive at a solution using a variety of procedures, some more efficient than others, e.g.

```
SOLUTION 1

TO FACE :S
REPEAT 4 [GFD :S VRT 90]
END

TO CUBE :S
REPEAT 4 [FACE :S GFD :S PDO 90]
END

Note:
GFD= go forward
VRT= veer right
PDO= pitch down
RLT= roll left
PUP= pitch up
```

```
SOLUTION 2

TO FACE :S
REPEAT 4 [GFD :S VRT 90]
END

TO CUBE :S
FACE :S
RLT 90 PDO 90 GFD :S PUP 90
FACE :S
RLT 90 PDO 90 GFD :S PUP 90
FACE :S
RLT 90 PDO 90 GFD :S PUP 90
FACE  :S
PDO 90
FACE :S
PUP 90 GFD :S PDO 90
FACE :S
END
```

g. Following some discussion about efficiency and state-transparency students "play" with their cubes, tilting them, constructing stacks and lattices, nesting cubes, etc. on the screen.
h. Some discussion takes place about the use of activities, such as the above, in the primary school mathematics curriculum. At what stage could the 3-D commands be introduced ? What kind of 'help' procedures would be needed? How could it be extended to explore other 3-D shapes? A video tape of children working on such activities is viewed by the students outside of classtime. As the course progresses during the year efforts are made to enable the students realise the value of Logo-based learning environments; i.e. (i) as a problem-solving approach to learning; (ii) as a 'window' on their own learning and problem-solving processes (and of children's in a classroom situation) and (iii) as a powerful method for acquiring domain specific knowledge. Problems of transfer of knowledge acquired in Logo environments to other contexts are also discussed towards the end of the course.

Materials

Students participating in the course are expected to read a selection of journal articles, textbook chapters, and resource booklets which are concerned with Logo as a tool for learning. Some of these materials are listed in Appendix II. Most of this material comes from countries other than Ireland but efforts are being made to produce more local material on Logo.

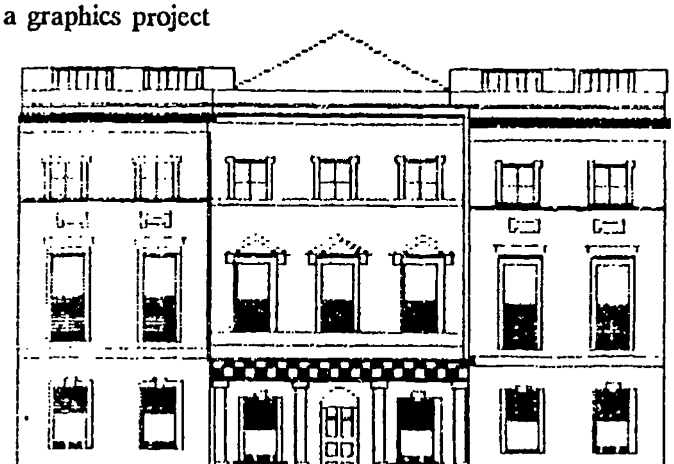
Organizational Considerations

Each session continues for 1.75 hours with each of the 25 students working at his/her own machine and the two tutors moving around the room and providing help as needed. Work is saved on a personal disk so that it can be continued after class. The computer room is available on a limited basis to students for project work outside of classtime. On average each student spends about 100 hours working at the computer on problems and projects in addition to the 45 hours of classtime.

Assessment of Student Knowledge

Students are required to submit, for assessment, Logo programming projects as part of the course requirements. One of these is a graphics project (e.g. building) and the other is a list-processing project (e.g. adventure game or database). Examples are shown down here. In addition, students sit a final examination of the essay type in which they answer questions relating to the use of Logo in the classroom (Cf. Appendix III for a sample examination paper).

Ill. 5 : Examples of a graphics project



Course Evaluation

The reaction of students to the course has been very positive. They enjoy it and perceive it as being relevant. Attendance at the workshop sessions has been almost 100 %. There has been little feedback from schools relating to graduates who have taken the course. However, it seems from informal observations, that teachers are not integrating Logo-based learning activities, into the existing curriculum, to any great degree. This is partly due to the fact that teachers often have only one or two computers available to them and for a very limited amount of time. It may also be due to the fact that teachers have not yet sufficient knowledge or support materials to integrate Logo into the curriculum, and so they continue to use it in isolation from curriculum subjects.
It is hoped to develop the Elective course in such a way that students will be motivated to and be able to use Logo as a learning tool more directly in the subject areas of the curriculum. It would also seem desirable to provide greater guidance in the use of Logo in teaching of specific curriculum subjects.

2.2 Introductory Course on Computers in Education

Aims

With the rapid growth in the number of computers in primary schools over the past five years the College authorities decided that all student-teachers should be provided with an introductory course on computers in primary education from 1988 onwards. As a result of this decision a short non-credit, introductory course has been included in the First Year B.Ed. programme.

The aim of the course is to introduce student-teachers to the use of the computer in the primary school classroom using a variety of software with a particular emphasis on Logo.
The course is taught by a group of lecturers, from several departments who have volunteered to take the courses in addition to their normal workload. The course involves 6 x 1.75 hour workshop sessions over 6 weeks.

Content and Methodology

The content of the course is listed in Appendix IV. As it is very much an experimental course the content will probably be changed quite a bit from year to year. The emphasis of the course is more on reducing students fear of computers and on highlighting the computers as a tool for learning than on ensuring student competence in using the computer for a variety of objectives in the classroom.

The format of the course is mainly workshop with the minimum of lecturing. Help is provided on an individual basis as the need arises. There are normally about 25 students in a class. There is no assessment of student outcomes of the course. Attendance tends to fall off somewhat during the second half of the courses.

Course Evaluation

Although there are no credits awarded, student response to the course, in terms of participation and interest levels, has been satisfactory. However, it is very much a preliminary course and is not sufficient to prepare student teachers to make full use of Logo and the computer in the primary school classroom. A significant benefit is the opportunity provided to lecturers, who teach the courses, to reflect on the value of the computer as an educational tool. (6-8 lecturers from a variety of disciplines give the courses).

2.3 Logo-based Mathematics Course

Aims

About 10 to 15 % of the student-teachers in St. Patrick's College elect to take mathematics as their academic subject. As a step towards integrating computers into the teaching and learning of mathematics the Mathematics Department of the College introduced in 1980 a computer based module, involving a number of topics in discrete mathematics, into the Second Year of their B.Ed. course in Mathematics.

The aims of the module are :

- **to introduce student teachers to the use of computers in education by requiring them to use Logo (particularly its list-processing facility) as a tool for learning mathematics;**
- **to develop the mathematical knowledge of the student teachers in specified areas.**

The duration of the course is approximately 20 weeks with 2 1/2 hours per week.

Contents and Methodology

Pascal was used initially as the language for creating environments in a number of topics including number theory, set theory, combinatorics, numerical methods, and probability and statistics. Later in 1984, Pascal was replaced by Logo as students experienced much difficulty in learning it and also because Logo was becoming increasingly popular in schools. The correspondence between Logo programming concepts such as procedure, recursion, list, and mathematical such as function, induction and set, facilitated acquisition of mathematical knowledge in a Logo-based problem-solving environment.

This course tends to be somewhat more didactic than the two courses mentioned above. This is mainly due to the amount and difficulty of the material and the need to cover the course in the time allocated. The format is workshop, with a clarification of concepts to be investigated and provision of 'help' procedures at the beginning.

Assessment

The student outcomes of the course are assessed by means of a 3 hour written examination carried out in accordance with university regulations. There is no provision for the inclusion of project work in the assessment. An example of an examination paper is given in Appendix V.

Evaluation

Informal observations indicate that many of the student-teachers who took this course and who subsequently took posts as primary teachers were actively involved in introducing Logo in classrooms where a microcomputer was available.

3. In-service Courses involving Logo-based Environments

St. Patrick's College runs a part-time Bachelor of Education degree programme for primary teachers who qualified in the pre-1976 two-year Diploma in Education programme (about 50% of all serving teachers fall into this category). The programme is equivalent to the programme of the last two years of the pre-service B.Ed. This programme has been in operation since 1984 and there are approximately 150 teachers enrolled in it at present. In the final year of the programme a Logo-based course on computers in education similar to the one-year Elective Course described in 2.1. above, is offered to the teachers and about 10% of them elect to take this course. The content and methodology is also similar to that described in Appendix I.
In addition to the above course a number of short courses, similar in content and objectives to the Introductory Course, described in 2.2. above, are organized by the Teachers' Centre which is attached to the College. The courses generally run for one term and are paid for by the participants. These Logo-based courses compete with a variety of introductory courses on computers in education which are being run in schools and colleges around the city and country. There is little coordination or control of these courses and the content and methodology can vary considerably from one course to the next. Many are simply introductory courses in BASIC.

4. Curriculum Development Work

Over the past five years a number of small projects relating to computers in education have been initiated in the College with a view to producing materials and information for use in pre-service and in-service courses and in the classroom. Following is a brief outline of two of these projects.

4.1 Development of a Logo Resource Pack for Teachers

With the implementation of Logo on small computers and its general acceptance as the most suitable language for primary education, the need for a Logo resource pack for Irish teachers had developed. Since 1985 a team of 2 College lecturers and 2 teachers have collaborated to produce a resource pack consisting of a teachers' manual, pupils' workbooks and supporting software. The initial pack, recently completed, deals with Logo graphics (including direct drawing, simple procedures and structured procedures) and mathematics related activities. Each chapter in the teacher's manual is divided into five sections, introductory comments, Logo theory, teaching strategies, class projects, and extension activities. The manual can be used as an independent resource or in conjunction with the pupil books and software. It can be used independently by teachers or as a manual for an introductory course on using Logo in the classroom.
It is proposed to use this manual in the Introductory Courses mentioned above. An example of a page in the manual, relating to the use of one of the Logo utilities accompanying the Resource Pack, is given in Appendix VI. The Resource Pack has been tested in two primary schools.

4.2 Experimental Project with Talented Children 8 - 14 Years

This project, which was started in 1984, uses Logo-based learning environments to provide additional work of a challenging and enriching nature for mathematically able boys and girls, (aged 8 to 14 years) outside regular school hours. The project provides the opportunity to test a wide range of Logo microworlds in a setting which hopefully may prevail in the primary schools in the not-too-distant future, that is, when teachers will have access to a relatively large number of microcomputers (20-30 machines) for substantial periods of time. About 400 children now take the courses at 10-12 centres around the country. Children are assessed for the courses using Raven's Matrices and the Drumcondra Attainment Tests (Mathematics). Each course runs for about 10 weeks (2.5 hours per week) and many pupils return to successive courses to work on increasingly more advanced topics.

Topics covered include 2-D and 3-D graphics work in local and co-ordinate geometry systems; writing adventure games, quizzes, poetry; coding and decoding messages; creating databases; and many enrichment mathematics and science topics. The children work on a variety of projects and compete in local, national and international Logo contests.

Videotapes have been made of some of these children working on Logo programming tasks and are available for use in the teacher education courses on Logo-based learning environments. Some preliminary research has also been carried out to examine the effects of the Logo problem-solving courses on the children's mathematical development and problem-solving behaviour.

An example of the results of an analysis of a pupil's problem-solving behaviour is shown in Appendix VII. From a teacher-education perspective, a feature of the courses has been the regular seminars at which the approximately 20 course tutors and organizers meet to discuss and exchange ideas and material on Logo microworlds. Student-teachers are also provided with the opportunity to observe these children at work and record their observations.

The philosophy of the project has been very much in keeping with a constructivist approach to learning and teaching and this is reflected to a substantial degree in the approaches of the course tutors in teaching the courses.

5. Future Directions

In St. Patrick's College we hope to continue, for the next few years, with the Logo-based courses described in the preceding pages. In addition, next year, we propose to introduce, into the Mathematics Education courses, a module involving the teaching of specific curriculum objectives in mathematics using Logo-based activities and microworlds. Such a module will provide student teachers with experiences which will enable them to see more clearly and directly the way in which Logo-based learning environments can be integrated in the mathematics curriculum.

Logowriter looks very promising for integrating Logo into the language area but no version exists yet for the BBC microcomputer, the most common computer in Irish primary schools. Music and Art Education are also areas where Logo-based learning environments can be generated and some attention is given to these in the general courses.

The shortage of curriculum materials for implemented Logo-based environments in the classroom is a serious problem and will have to be solved if the benefits from the education courses are to be realized in terms of classroom practice. There is also a need for some sort of formal assessment to examine the impact and usefulness of the pre-service and in-service courses.

Appendix I : Elective Course : Content and Activities

1. Introduction to Logo 2-D graphics commands, One-key Logo and special keyboards. Direct draw activities.
2. Writing procedures. Editing procedures. Use of colour. Curriculum activities.
3. Writing structured procedures. Problem-solving strategies. Curriculum activities. Saving, loading and printing procedures/files.
4. Writing procedures with variables. Use of 'help'/tool procedures. Curriculum activities.
5. Graphics Project assignment e.g. Dublin Buildings.
6. Using tail recursion and conditionals in 2-D graphics. Curriculum activities. Use of random command. Curriculum activities.
7. Using embedded recursion in 2-D graphics. Curriculum activities.
8. Introduction to 3-D graphics commands. Writing 3-D graphics procedures. Curriculum activities.
9. Using Logo graphics in the mathematics classroom. Videotape of children working in Logo-based learning environments. Examples of graphics microworlds.
10. Introduction to words and lists commands. Simple activities to clarify principal words and lists commands.
11. Generating sentences and poems. Curriculum activities.
12. Interactive procedures. Generating quizzes, maths, history, geography, science.
13. Introduction to Music Logo. Curriculum activities.
14. Project assignment. Adventure games. Help procedures. Good programming and problem-solving strategies.
15. Lists as input and output. Coding and decoding messages. Simple sorting of lists.
16. Logo databases. Thesaurus. Records.
17. Word-processing in the primary classroom, e.g. Folio, Prompt- writer.
18. Databases in the primary classroom, e.g. Our Facts, Mini- Office.
19. Architecture of PC's. Operating Systems. Networks. Setting up and using directories of files.
20. Review of CAI/CAL S/W. Content free vs content specific S/W. Using CAL S/W in the classroom.
21. Philosophy and psychology of Logo and CAL/CAI. Implications for classroom practice. What to do with only one or two computers in the classroom.

Appendix II : Sample Journals & Books

Journals :
1. Educational Computing : Redwood Publishing, London.
2. Logos : British Logo User Group, Leicestershire.
3. Micromath : Association of Teachers of Mathematics, Basil Blackwell Ltd. Oxford.
4. Riomhiris na Scol : Computer Education Society of Ireland

Books :

1. BORK, A. (1985). Personal Computers for Education. New York, Harper and Row.
2. FRIENDY, M. (1988). Advanced Logo. New York, LEA.
3. JONES, R. (1984). Micros in the Primary Classroom. Edward Arnold.
4. MARTIN, A. (1986). Teaching and Learning with Logo. London, Croom Helm.
5. PAPERT, S. (1980). Mindstorms: Children, Computers and Powerful Ideas. London, Basic Book Inc.

Appendix III : Sample Examination Paper

COMPUTERS IN PRIMARY EDUCATION ELECTIVE

Instructions : Answer any six questions

1. (a) How can Logo foster co-operation in the classroom ?
   (b) In what ways does experience with Logo help to promote a healthy attitude toward mistakes ?
2. (a) What strategies might a teacher adopt in introducing the Logo turtle to children :
   (i) in second class;
   (ii) in sixth class ?
   (b) (i) What are the advantages of defining procedures rather than using the direct draw mode of Logo ?
   (ii) How can procedures be explained to children ?
3. (a) (i) What is meant by the "modular design" of procedures ?
   Why is this an important problem-solving principle ?
   (ii) How can a teacher introduce the idea of modular design to children ?
   (b) What is recursion ? Give examples of recursion :
   (i) in everyday life;
   (ii) in the traditional primary curriculum.
4. (a) What features should a teacher look for in choosing educational software for classroom use ?
   (b) How can a teacher use adventure games with children ? What can children learn from them ?
5. How can computers be used in teaching children :
   (i) geometry ;
   (ii) fractions ;
   (iii) geography ;
   (iv) reading ;
   (v) science ?
6. (a) Define a procedure FD1 (using TO FD1 : DISTANCE), which moves the turtle forward the specified :DISTANCE but draws the following simple design rather than a straight line.
   (b) Explain how children might make use of FD1 in their own procedures.
   (c) Show how a teacher might use FD1 to introduce the notion of recursion.
7. (a) Create a version of One Key Logo in which :
   F moves the turtle forward 10 steps with pen down;
   R turns the turtle right 30 degrees;
   H makes the turtle hop forward 10 steps without drawing;
   C clears the screen;
   and all other keys are dead.
   (b) What are the advantages of such a procedure over standard Logo in introducing the turtle to very small children ?
8. (a) Show how it is possible to create a database of plurals in Logo by pairing singular nouns with their plural forms, i.e., CAT with CATS, MAN with MEN, BOX with BOXES, etc.
   (b) Define a procedure PLURAL (using TO PLURAL :NOUN) which finds the plural of any given :NOUN in the database. If CAT appears in the database, for instance, PLURAL "CAT should give CATS. If CAT is not in the database, PLURAL "CAT should produce the message NOT FOUND.

Appendix IV : Content of the Introductory Course on Computers in Education

Logo workshops discussion topics:
1. Using Logo with children.
2. The relationship of Logo to the primary curriculum.
3. The role of computers in education: computer microworlds.
4. Future developments in educational computing.

Logo computer work:
1. Introduction: direct draw Logo, sprites, music.
2. Procedures: teaching with turtle (polygons, house).
3. Using defined procedures (box, block, hopfd, spikfd).
4. Projects.

Software workshops discussion topics:
1. Basic parts of a computer system: printer, disk, drive, computer, monitor.
2. Software media: disk, tape, chip, cartridge.
3. Software types: simulation/adventure games, drill, tutorial, word processing, data base, etc.
4. Software evaluation: characteristics of good educational software.

Appendix V : Sample Problems from the Logo-based Mathematics Course

1. (a) Sets in mathematics are similar in many ways to lists in LOGO. However, repetition of elements, which is allowed in lists is not meaningful for sets. Define a Logo operation REDUCE (using TO REDUCE :LIST) which outputs a list in which, whenever elements in the give :LIST are repeated, only a single copy is retained. For example:

```
FPRINT REDUCE [1 3 3 2 3]
[1 2 3]
FPRINT REDUCE [4 5 6]
[4 5 6]
```

   (b) Define operations UNION (using UNION :SET1 :SET2) and INTERSECTION (using INTERSECTION :SET1 :SET2) which output lists of elements obtained from the union and intersection of :SET1 and :SET2 respectively. Assume :SET1 and :SET2 are given in the form of REDUCED lists of elements.

2. Prime numbers of the form 2k + 1 where k is a positive integer, are known as FERMAT numbers. Five, for example, is a FERMAT number, since it is prime and has the above form with k = 2. Write a Logo procedure TO FERMAT :LOW :HIGH which prints out all FERMAT numbers between the given positive integers :LOW and :HIGH inclusive.

3. Write a Logo procedure SINGLEDIGITS, using TO SINGLEDIGITS :LIST, which counts the number of single digit numbers (integers between 0 and 9 inclusive) which occur in the given :LIST of non-negative integers. Also define TO EVENDIGITS :LIST, which counts the number of even single digit numbers in the :LIST. For example :

```
PR SINGLEDIGITS [12 7 8 63 6]
3
PR EVENDIGITS [ 12 7 8 63 6]
2
```

Appendix VI : Logo Resource Pack - an Example

FIGURES

The figures files on the Utilities Disk are designed for use in conjunction with worksheets and the handbook. However, they can also be introduced as part of the standard Logo environment to enable children to draw elaborate pictures easily and quickly.

The following thirteen figures are provided : MAN, WOMAN, BOY, GIRL, DOG, CAR, HOUSE, MANSION, SUN, CLOUD, TREE, and FLOWER. These figures can each be loaded seperately from the Utilities Disk. For instance, with the Utilities Disk in the drive, the commands:
LOAD "BOY
LOAD "GIRL
will load the BOY and GIRL procedure into the Logo workspace (but will not draw on the screen). WARNING : Some computers may not be able to accomodate more than 5 or 6 of these procedures in the workspace at any time.

Once these procedures have been loaded into the workspace, they may be used like FD, RT or any other Logo commands. All figures procedures return the turtle to the position and heading it started from.

Each figures procedure requires a number, which specifies roughly the size of the figure in turtle steps. Thus GIRL 100 draws a girl about 100 steps tall; while girl 300 draws a girl three times this height. Note that the command GIRL alone will not work; a number must always be provided. If the turtle starts out pointing upwards, the girl will be standing upright; but if the turtle starts out pointing downwards, the girl will be drawn upside down.

The turtle takes a relatively long time to draw some figures. To speed up the drawing process, hide the turtle (with HT) first.

Children should be encouraged to experiment with these procedures. What does GIRL 200 look like if the turtle starts out tilted to the right ? What does GIRL -200 draw ? How can you fill the screen with boys and girls of different sizes ?

To clear the figures procedures from the Logo workspace, use the command ERALL.

Appendix VII : Summary of Kevin's Protocol for Solving the Problem of the 'Folding Chair'

1. Problem assimilated
2. Problem subdivided into parts
3. RECTANGLE procedure constructed (two variables)
4. RECTANGLE procedure tested
5. CHAIR (no legs) procedure constructed (1 variable :angle)
6. CHAIR procedure tested
7. CHAIR procedure examined for bugs
8. CHAIR procedure debugged (clerical bug)
9. (repaired) CHAIR procedure tested
10. LEGS procedure constructed (1 variable :angle)
11. LEGS procedure tested
12. LEGS procedure examined for bugs
13. LEGS procedure debugged (conceptual bug)
14. LEGS procedure incorporated into CHAIR procedure
15. CHAIR procedure tested
16. CHAIR procedure examined for bugs
17. CHAIR procedure debugged (clerical bug)
18. CHAIR procedure tested for folding
19. CHAIR procedure modified to allow size to be variable (redundants commands deleted)
20. Modified CHAIR procedure tested
21. Modified CHAIR procedure examined for bugs
22. Modified CHAIR procedure debugged (conceptual bug)
23. CHAIR procedure tested
24. CHAIR procedure examined for bugs
25. CHAIR procedure debugged (conceptual bug)
26. CHAIR procedure tested

Total time : 31 minutes.

Chapter 5
TEACHER EDUCATION COURSES IN LOGO-BASED ENVIRONMENTS IN THE NETHERLANDS

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1. The National Educational System

Ideology

In addition to education organized by the Dutch government, three religious-ideological groups are responsible for the organization of public education in the Dutch educational system : roman-catholic education, protestant-christian and neutral education.
These groups influence decision-making policy in Dutch education. For example, it is a tradition that, in working groups or steering committees, representatives of the three groups are equally represented.

Primary and Secondary Education

There are about 8,000 primary schools in the Netherlands. In 1988-89, about 1.428.577 pupils attended these schools. Their structure is regulated by law and is therefore the same in every primary school. Each primary school organizes an eight year course for children 4 to 12 years of age. Education is compulsory from 5 to 17.
Primary education gives access to many types of secondary education. About 747.119 pupils attended secondary schools in 1988-89. Pupils can choose from a selection ranging from technical education to science-oriented secondary education. The number of years (between 4 and 6) depends on the type of education.

Teacher Education

Teacher education for secondary school teachers is given at polytechnical schools or at universities. Training courses for primary school teachers are organized in a PABO (Pedagogische Academie voor BasisOnderwijs : Training College for Primary Education). PABO's are either independent schools or belong to a polytechnic institution.

2. N.I.C.T. in the Dutch Educational System

Initiatives of the Ministry of Education

During the last few years, the Ministry of Education adopted a policy to promote the use of computers in primary and secondary education.
At first, every secondary school was provided with computer equipment. Nearly every secondary school now owns about 20 MS-DOS compatible computers.

In relation to primary education, some 'in-depth-projects' with Macintosh computers have been set up. In addition to this initiative, governmental policy focused especially on developing the expertise of primary school teachers.
Due to this policy, the equipment, available in primary schools is rather varied in type and in number. In order to attain compatibility of the hardware, a project starts in 1990 that will provide every primary school with MS-DOS compatible computers (ratio 1 computer/60 pupils). This project will run for at least 3 years. In parallel to this project, there is a great need for both software and teacher education courses.
It is in this perspective that the question about the role of Logo-based environments is important to primary education in the Netherlands.

Organization of 'Working Groups on Computer Technology'

In order to support the use of computers in primary education, the government invited experts in the field of teacher education as members of project groups (1982). These project groups planned and organized courses for primary school teachers. This approach continued to exist until 1987.
An important part of this article presents a description of the experiences and the conclusions of one particular sub-working group, that focused on teacher education and Logo-based environments : the 'Logo and mathematical activities' working group. The author of this chapter is a member of this working group. The two other teacher educators involved were W.H.L. Faes & H.J.M. van der Schaar. This working group had set up a variety of teacher education courses, up to 1987. The 'history' of these projects is described in part 3 of this chapter. Next to these initiatives, the members of the group have elaborated their ideas to develop a complete package for children aged 10 to 13. This package, written for MSX-DOS computers, has been published and is called 'Midgetlogo' (Cf. Booy, Faes & van der Schaar, 1988).

The Involvement of the Institute DE DRIESTAR

Each year, the institute gives a number of primary schools the opportunity to attend a range of teacher education courses for the following year. These schools include local primary schools and schools which are - e.g. ideologically - connected with the institute. Depending on the number of courses and the number of teachers attending the courses, the Ministry gives the institute a grant. The fee of the course-members only covers administrative costs.
Since the government grant depends on the number of course-members, courses last about 40 hours and are attended by at least 20 trainees.

3. The 'History' of the Teacher Education Courses in Relation to the Use of Logo-based Environments

The teacher education courses, set up by the 'Logo and mathematical activities' working group are the result of a long term process. Infra, we present the three main steps in the 'history' of the courses. Reading this history can help to understand the basic ideas that have influenced the development of a specific teacher education support package : 'Logo and mathematical activities'. We discuss these basic ideas in part 4 of this chapter.

3.1 The Teacher Education Courses of the Project Group 'Computer Science PABO'S'

The Project Group 'Computer Science PABO'S'

Above, the initiative of the Dutch government was described to set up working groups. One of the 5 institutions, selected to participate in these working groups and to set up teacher education courses for primary education, was DE DRIESTAR. At the same time, a central 'project group computer science PABO'S' was founded.
Its general aims were :

a. **drawing up a general framework for introductory courses in computer technology;**
b. **setting up a try-out of a jointly-compiled introductory course;**
c. **drawing up a final plan for this introductory course;**
d. **supervising and offering this introductory course to all training colleges in the Netherlands.**

Aims of the 'Introductory Course'

The aims are threefold :

a. developing the skills of primary school teachers to work with computers;
b. informing teachers about the possibilities of computer technology in education;
c. acquiring experience with N.I.C.T. in classroom situations.

Contents of the 'Introductory Course'

It is important to indicate that this course dealt with many aspects of education and computer. Only one fifth of the course was related to Logo (turtle graphics).

Equipment Changes

The equipment used for the course has changed over the past 6 years, due to technical evolutions and decreasing costs :

1983 - 1985	Philips P2000 (32K) and Commodore C64
1985 - 1987	MSX-DOS (128-256) and Commodore (64-128K)
> 1987	MS-DOS compatible computers (256K-20 megabyte).

Organization of the Course

Taking into account the variety of computer hardware in primary schools, the organization of the course was not easy. To overcome this problem, courses are organized, taking particular hardware types as a criterion.

Evaluative Details

Over the past 6 years the introductory course has been very successful. Thousands of primary school teachers have attended it. DE DRIESTAR organized this type of course e.g. up to 60 times. But, evaluation revealed that this course is not a sufficient incentive to prompt the actual use of N.I.C.T. by the teachers in classroom situations. This requires more advanced courses.

3.2 'Platform Computer Science PABO'S' Working Group

Composition and Purpose of the Group

In 1984, the original working group was enlarged. More PABO institutions became involved and the name of the group was slightly altered : 'Platform Computer Science PABO 's.

The aims of the group included :

- drawing up a general framework for three advanced level N.I.C.T. courses;
- planning advanced courses and setting up try-outs; ... .

Three advanced level courses were organized :

a. computer-aided education;
b. aspects of computer technology in the scope of world-orientation;
c. Logo.

Infra, we only focus on the third advanced level course.

Aims of the 'Logo'-Course

In 1984-85, the Dutch government described in its 'Computer Stimulation Plan' the educational use of Logo as follows : "Stimulating interactive use of computers to make children discover things for themselves and develop their own learning process, by means of Logo-applications." (Cf. Logo Werkgroep, 1986, p. 1).

Consequently, the advanced 'Logo'-course included the following topics :

a. Logo as an educational philosophy;
b. Logo and school subjects;
c. Logo as a computer programming language.

Contents of the 'Logo'-Course

The course contents were focused on the development of the programming skills of the teachers. It was the intention that teachers, at the end of the course, could design Logo-environments. This intention is reflected in the timetable for this course :

- turtle graphics (12 hrs)
- sprites (4 hrs)
- list processing (6 hrs)
- music (3 hrs)

- input equipment for children : joystick, buttonbox, concept-keyboard (3 hrs)
- designing Logo-based environments (12 hrs).

The course package offers many tailor-made procedures to design Logo-environments. Course-members can choose from pre-structured possibilities; e.g. Labyrinths; the Young Children (4-6) and Logo; List Processing; etc.

Equipment

The course, which was designed in 1985-86, was implemented on the Commodore C64 computer, which at that time was being used extensively in Dutch schools.

Organization

The course was organized in a very flexible way and was adapted mostly to local needs or constraints. A session was organized following this structure :

- discussion of a subject and discussion of solutions for home tasks;
- computer training;
- brief review and evaluation;
- discussion of a new home task ; home tasks could consist of reading articles, but can also include try-outs with children.

At the end of a course, the teachers focused on the elaboration of projects in smaller groups. Projects were tried out in real-life contexts. Therefore, part of the course could be given in primary schools.

Evaluation

There was but little interest for the advanced-level courses, and this in contrast to the success of the introductory course. Only 10 to 15 % of the course-members of the previous year showed an interest in these courses. The 'Logo' continuation course was taught about 40 times throughout the country.

There were two main reasons for this lack of interest :

- Primary school teachers did not have access to a sufficient number of computers, neither at home nor at school. The course content could not be linked to teaching practice.
- A large number of primary school teachers take a personal interest in N.I.C.T.. This personal interest is not linked to their professional interests.

Assessment revealed some basic points, which proved to be helpful in setting up future courses :

- After 12 hours of programming and turtle graphics training, it is not recommended to continue with sprites and/or music.
- Course-members found it difficult to develop Logo-projects. They claimed they neither had the time nor the equipment to work with children. Moreover they lacked the skill to develop Logo-courseware themselves. Even at the end of the advanced course, their programming expertise was insufficient.
- There were basic objections against the amount of Logo-primitives needed to elaborate a project or programme. In addition, knowing so many primitives was considered to be useless for future classroom practice.

The above situation reflects mainly the experiences of the 'Gouda-team. Results obtained in Eindhoven were more promising. The quality of the programming skill of the teachers, for instance, improved sufficiently to start working on small-scale Logo-projects with children. But, right from the start, the participants of this course had a sufficient number of computers at their disposal. The Eindhoven results were also favourably influenced by the fact that the trainers were skilled Logo-users.

3.3 'Second-year Module' Working Groups

Structure and Aim of the Working Groups

In 1986-87, the Ministry of Education decided to organize teacher education courses in a different way. The courses were considered to be too long and had to be organized at a broader scale. The duration of the courses was restricted to 20 hours. Longer courses (e.g. 40-hours) could consist of 2 x 20 hours.
In relation to Logo, three new courses were developed. Designing microworlds was central in the last two courses :

- An advanced-level 'Logo-Programming' course.
  This is a reduced version of the Logo-course, discussed supra.
- 'Logo-environments and young children'.
- 'Logo and mathematical activities'.

The 'Logo-environments and young children' course was hardly organized, because of its explicit link with the Commodore C64 computer, which became less used in education. Infra, especially the 'Logo and mathematical activities' course will be discussed.

Aims of the 'Logo and Mathematical Activities' Course

The 'Logo and mathematical activities' course was influenced by the following facts :

a. Evaluation of teacher education courses reveals that primary school teachers are interested in computer applications that are immediately relevant for their classroom context. They wish to explore these programmes and to discuss their didactical and organizational features. Primary school teachers need programmes with an explicit link with the existing curriculum.
b. Logo can be considered as a toolbox to make all sorts of things. A set of tools can be useful in a particular microworld, whereas another set is better suited in another microworld. It is also possible to create new tools. The number of primitives in a toolbox has to be limited, taking into account the possibilities of the children.
c. Logo and mathematics are closely linked. In the Netherlands, mathematics education is heavily influenced by the notion of 'context'. Microworlds can present or represent such 'contexts' to learn mathematics (cfr. 4.3).

The Content of the 'Logo and Mathematical Activities' Course

The course was built on a specific microworld : 'MidgetLogo'. This microworld had the following characteristics :

- it is based on midget golf;
- for Dutch children, this is a well-known game. Nearly every child has played midget golf at one time or another;
- it is an open microworld and next to specific MidgetLogo primitives, also other Logo-primitives remain available;
- the children have to find their own way in solving problems;

- this microworld was designed with certain mathematical concepts in mind : length, angles, aspects of scale and planning.

The course participants were expected to have a good Logo-background. They were expected to know about procedures, recursion, analysis of complex problems, etc. The course, described in 3.2, was a good preparation to this new course.

Seven programmes are connected to the 'MidgetLogo'-microworld. They are written in MSX LCSI-Logo. Each of the programmes is accompanied by a worksheet for the pupils. The course had the following content structure :

- introduction on the course (1 hr)
- Logo-backgrounds, microworlds, tools, 'MidgetLogo' (2 hrs)
- introduction on MSX LCSI-Logo (2 hrs)
- exploring the possibilities of the 'MidgetLogo' microworld (3 hrs)
- the role of the teacher in the classroom situation and the use of worksheets (3 hrs)
- arithmetics/mathematics backgrounds. What is 'mathematizing' ? What is 'context' in arithmethics/mathematics methods (2 hrs)
- programme construction (2 hrs)
- personal adaptations of the microworld or development of a new programme and related worksheets (5 hrs)

Next to theoretical work (e.g. reading articles), the participants were also expected to work with children using some of the 'MidgetLogo'-programmes.

Equipment

The programmes are written in MSX LCSI-Logo.

Organization

Since the institute (DE DRIESTAR) has a mobile set of 16 MSX Philips computers, the course can be organized in flexible way (time and place).

Evaluation of the 'Logo and Mathematical Activities' Course

Until now, the course has been organized only twice.
Evaluative details have been collected from (future) course-lecturers who commented on the contents of the course. Furthermore, there is also some experience with children, who have used the programmes.
The findings reveal the following ideas.

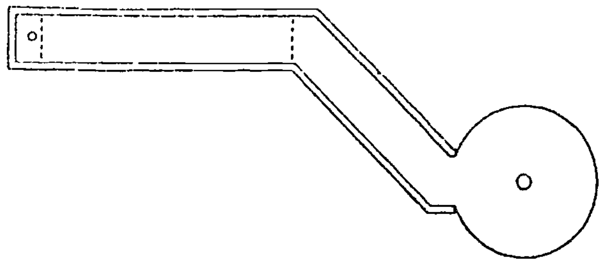
- Experience gained with a group of 30 children shows that the MidgetLogo microworld has sufficient appeal for children, aged 10 to 14. Moreover, depending on the quality of the programmes and the worksheets, a teacher is able to set up relevant learning experiences.
- MidgetLogo has been presented during workshops on conferences in relation to computers and mathematics. The responses of maths lecturers from training colleges indicate that the microworlds-idea deserves further development.
- About 200 third-year training college students worked with the programmes. Their response was very positive.

The positive experiences have prompted the authors of this course to elaborate the course-ideas. In the period 1988-89, the set of worksheets was extended to a new set of 37 programmes and sheets. This set has been published.

An Example from the 'Logo and Mathematical Activities' Course

The following example is based on worksheet no. 3 of 'MidgetLogo' :
On the screen of the computer, a golf problem is presented :

Ill. 6 : A typical 'Midgetgolf' problem



The game player (teacher or pupil) has to bring the ball from the tee (dot on the left) into the hole (dot on the right). Some new Logo-primitives are added to the microworld to play the game (e.g. STROKE, DIRECTION). No lines are drawn when the turtle moves after a stroke.
In this particular problem, the aim is to make the pupil aware of the strategies he/she can use to reach the hole. An example to solve the problem is in-built, but more efficient strategies can be designed. The pupils are asked to find such more efficient strategies. An expert strategy is e.g. :

```
S O  SLAG 100     ('slag' = 'stroke')
S O  SLAG 10
S ZO SLAG 60
S ZO SLAG 20
S O  SLAG 40
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The S procedure puts a dot on the actual position of the ball. In this way, the pupil/teacher can retrace the consecutive positions of the ball.
The heading of the ball can be controlled with a set of additional commands, based on the use of a compass-card with eight wind-directions (O stands for East and ZO stands for South-East). The SLAG-procedure (STROKE) requires a numerical input, controlling the distance covered by the ball.

In teacher education courses, the participants are urged to change the above procedures (based on didactical arguments); for example :

- change the programme in such a way that there is no collision effect when the ball hits the side;
- children need more precise headings than the eight offered by the compass-card available. Intermediate directions have to be developed; i.e. ZZO (South-Southeast), ZZW (South-Southwest), ...;
- develop a procedure that controls the number of strokes. If this number exceeds 4, than the ball is put back at the tee.

The above example is especially related to Logo-programming. In another worksheet, the same activity is used to explore mathematically rich activities : when, for instance, the pupils realize that the numerical input for a STROKE is not related to the measurement unit mm or cm, they are asked to make a Logo-ruler. This ruler must respect the size of the screen. A stroke of 100 units is shorter on a small screen than on a large screen.
Part of the course can also be devoted to a discussion about 'discovery learning in a context'; the structure (sequence) of learning processes to learn about measuring; the interdependence between the SLAG-procedure and the screen-size; ... .
In connection to these activities and discussions, assignments for further classroom activities can be given.

4. Ideas behind the 'Logo and Mathematical Activities' Course

The 'Logo and mathematical activities' course is heavily influenced by some basic ideas, premisses and hypotheses, related to the link between Logo and mathematics.

4.1. Logo and Microworlds

Microworlds and 'Schemes'

A Logo-microworld offers the pupils a set of possibilities to explore a particular idea. Turtle graphics, for instance, helps to explore 'maths land'. Exploring implies the use of the available primitives or the construction of new procedures.
Microworlds are highly interactive. Making progress requires discovering the logic/rules. In this way, pupils construct 'schemes'.
It is typical that 'objects' in a microworld are not real objects but 'representations of objects'. These objects are not constrained by physical limitations and are surprisingly consistent. As a consequence, a course of events can be predicted more easily than in reality. With a computer and a consistent microworld, pupils can construct complex schemes.
Playing real midget golf is influenced by uncontrolled intervening factors. Planning a series of strokes - beforehand - is therefore not always efficient. In MidgetLogo, planning does improve the game efficiency because of the nature of the microworld.

Logo as a Toolbox

In a real context, children use toolboxes in a very open way. They can examine what certain tools are for and play with them. Later on, the same tools can be used to create new things or to mend what no longer works. And most important, tools can be used to make new tools. Logo can be used in exactly the same way : exploring, playing, problem-solving and designing new tools (procedures). To use the toolbox in an effective and efficient way, it is necessary that the user (a teacher or a pupil) knows the content of the toolbox and the functions of the tools. Exploring the toolbox (Logo or a Logo-microworld) is therefore an objective of prime importance.

4.1.3 'Environment Logo'

Logo - as a computer language - has been expanded with a growing set of possibilities/primitives. Some of these new primitives are linked to colour control : e.g. VUL and KLEURONDER (fill & colour.under). These primitives help to colour closed areas or to check the colour under the turtle.

These new primitives offer possibilities to move a sprite across the screen and/or to make it react, depending on the colour of the background. By linking rules to each colour, all kinds of activities can be set up when a sprite moves accross the coloured areas. Such a Logo-microworld has been developed and is called 'Environment Logo' by the members of the working group. In MidgetLogo, 'Environment Logo' is implemented to a very high extent. An example is the way the golfball bumps back when it touches the edge of a course. The colour of the edge determines the way the ball will run back. Certain procedures have been connected to the colour of the edge.

4.2. Teachers and Logo

If primary school teachers are interested in a computer language, they opt for Logo.
In addition to this, nearly every teacher in the Netherlands is acquainted - to a certain extent - with Logo (and this in contrast with other languages). Since 1984, Logo is also part of the pre-service course.
As a consequence, Logo is the evident choice to set up a teacher education course for primary school teachers. It gives them the opportunity to explore and design things and to work towards classroom practice. The Logo computer language is easy to use by children and by teachers. It is relevant at the personal level of the teachers and at the pupil-level. Both levels can be taken into account at the same time.

4.3. Mathematics and 'Contexts'

The concept 'context' is an important one in the Dutch approach to the teaching of mathematics (Gravenmeyer, 1981-82): "A context is a (well-defined) situation in which pupils can realize mathematical activities and in which they can carry out exercises and applications." .
In Dutch textbooks for mathematics, the presence of 'contexts' is a didactical prerequisite. Such a context not only gives opportunities for relevant mathematical activities, but also enlarges and widens the variety of applications. It helps to present a 'rich problem' and a 'rich context'. A 'rich problem' can be defined as follows (Goffree, 1983, p. 104).

1. A rich problem inspires many ***mathematical activities***. Because of the open character of the problems raised, different approaches are possible. Often the pupil is required to create new mathematical conceptions. This we call 'horizontal mathematization'.
2. A rich problem ***motivates the pupil***. This means that his interest is invoked. He experiences a lack of knowledge and he is motivated to search actively for solutions. Moreover, there has to be a possibility for the pupil to make a start. This stage is called 'boarding' the problem.
3. In a rich problem, ***the context*** is of vital importance. The context goes beyond the text, it is not embodied in the text. This means that an opportunity is created to put forward personal, often very individual, ideas. The fact that this input may be irrelevant to solve the problem, makes the situation even more realistic.

4. When solving a rich problem, the ***attitude towards mathematics*** is influenced in a positive way. The pupil is given an opportunity to explore, his input is stimulated and valued. There is also room to reflect on one's own thinking. This can help to learn from his/her own and other people's problem-solving approach.
5. Rich problems invoke ***cooperative behaviour*** in smaller or larger groups. The pupils learn to listen to one another and they also develop strategies to deal with constructive proposals from fellow-pupils.
6. A rich problem **promotes cross-curricular integration**, thus creating an understanding of the wide applicability of mathematics.
7. A rich problem is ***not isolated.*** If it is a good problem, it can be a ***point of reference*** in a subject field.

The designers of the 'Logo and mathematical activities' course are convinced that the topics, mentioned above, have been operationalized when implementing Midget-Logo.
For pupils, who have explored Midget-Logo activities, this experience can become a 'determining context', a context that is a model for future mathematical activities.

5. Future Directions

In 1990, the initiatives of DE DRIESTAR are heavily influenced by the new COMENIUS project. This project provides the systematic introduction of computer use in the primary schools. Collaborators of DE DRIESTAR are active in many subparts of this national project. They have taken e.g. the initiative to set up a 'speerproject' (spear-head project). In this project, the use of open-ended learning environments is central. As a consequence, the use of microworlds and Logo is again of high importance.

6. Summary and Conclusion

During recent years, the Dutch government has put special emphasis on Computer Assisted Instruction and on Computer Managed Instruction in its N.I.C.T. policy . This policy has influenced the way the most recently designed Logo teacher education course is integrated into current school subjects, in this case mathematics.

Next to this external influence, it is clear that the 'Logo and mathematical activities' course tried to combine :

a. Logo as a language, to be used in microworlds and to design microworlds.
b. Logo, as a programming language, most primary school teachers are familiar with, for programming purposes and 'turtle graphics'.
c. The understanding of 'contexts' in mathematics.

Combining these three aspects helps to clarify the specific approach adopted in this chapter to use Logo-based environments in teacher education courses.

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Chapter 6
TEACHER EDUCATION IN LOGO-BASED ENVIRONMENTS IN PORTUGAL

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1. Background Information

1.1 The Schoolsystem in Portugal

Table 3 represents the Portuguese school system. In Portugal there are approximately 39,000 primary school teachers, responsible for the education of ± 750,000 children, aged 6 - 10, in 9,800 national primary schools. Most of these schools are small rural schools with only 1 or 2 teachers. Only a small number of city schools have 15 or more teachers. There are ± 25,000 middle school teachers, involved in the education of ± 370,000 children, aged 10 -12, in 450 schools.
In primary schools, only one teacher is responsible for the teaching of all subjects, while in middle schools, there is a teacher for each subject. Most schools are state schools. There is a national curriculum in operation.
There are approximately 450 secondary schools, which are attended by ± 650,000 students, aged 12 - 18, and where ± 43,000 teachers work.

Table 3 : The Portugese Schoolsystem

Age	Grade	Current	Future	
3 4 5		Pre-school	Pre-school	
6 7 8 9	1 2 3 4	Primary school	1st Cycle	COMPULSORY SCHOOL
10 11	5 6	Middle school	2nd Cycle	
12 13 14	7 8 9	Secondary	3rd Cycle	
15 16 17	10 5 11 Areas 12	school	Secondary School	
18 .		Higher Education		

1.2 The Minerva Project

In relation to New Information and Communication Technologies in Education (N.I.C.T.), there is a national project supported by the Ministry of Education, called the **Minerva Project**. Its main pedagogical goals, till 1992, are :

a. to provide every middle and secondary school with computers;
b. to provide 20 % of the primary schools with computers;
c. to educate teachers (in-service education) to work with computers as a tool.

The Minerva Project started in 1985-86 with a first experimental phase. This schoolyear (1989-90), the expansion phase started. Up to now, ± 50 % of the secondary and middle schools are involved in the Minerva Project and are provided with some (3-6) computers in a computer room.
At primary level, there are only computers in 250 (about 2,5 %) state schools. Usually, there is one computer in the classroom.
The Minerva Project is based in 'teacher education schools'. The 'teacher education schools' (Universities and Colleges of Education) are in charge of the teacher education in N.I.C.T. and the implementation of the Minerva Project in their area. So, there are several nodes of the Minerva Project at Universities and Colleges of Education. Those nodes work independently. The Project is co-ordinated by a team, appointed by the Ministry of Education. There are 23 nodes throughout the country.
If a group of teachers wants to work with computers, the school board can ask to get involved in the Minerva Project. But, teachers use computers on a voluntary basis.
In primary schools, the computer is usually used as 'a tool' in the classroom, next to other pedagogical tools ; there is a computer available in the classroom. The students work in small groups (two pupils) and elaborate their own projects.
At middle and secondary schools, there is a computer room where lessons can be given or where a computer club or extra-curricular activities can be set up.

As said before, teachers work with computers on a voluntary basis. In middle and secondary schools, teachers usually have some time free of class. During this time, they can work with students, and elaborate a project as an extra-curricular activity.

In every node of the Minerva Project, there is a special group of primary, middle or secondary school teachers who have teaching responsibility and are based at the Universities or in the College of Education. This group collaborates with teachers from Universities or Colleges of Education. The team is in charge of the implementation of the Minerva Project and the teacher education process in their area.
There is no tradition in Portugal, for teachers at different educational levels to co-operate with one another. However, in the Minerva Project this is done for the first time.
Teachers of different levels work together and develop projects, in order to find the best way to use computers in schools and to improve the current teaching-learning process.

The different nodes of the Minerva Project, although adopting different approaches to the introduction of computers in education, work with the Logo-language. This is especially true at the primary level. For the past three years, there has been an annual Logo-meeting where teachers and researchers from all over the country exchange their experiences and discuss their approaches and educational uses of the Logo-language.

Besides Logo, schools involved in the Minerva Project, work with a variety of software tools, such as wordprocessors, databases, spreadsheets, drawing programs, etc.
The different nodes adopt different approaches and put different emphasis on specific areas. Some of them put special emphasis on the use of tools, others on the use of programming languages. Some nodes work mainly in collaboration with secondary schools, others rather with primary and/or middle schools.

1.3 Escola Superior de Educaçao de Lisboa

The 'Escola Superior de Educaçao de Lisboa' is a College of Education in Lisbon and is part of a polytechnic school. Polytechnic schools and Universities constitute Higher Education in Portugal.
At present, about 230 student teachers follow several programmes in the Escola Superior de Educaçao de Lisboa :

a. a three year programme leading to the Bachelor of Education degree for pre-school teachers;
b. a three year programme leading to the Bachelor of Education degree for primary school teachers;
c. a four year programme leading to a Higher Degree in Education for middle school teachers.

The students who have a Higher Degree in Education can also teach as a primary school teacher. The typical entrant to the College is a 18 year old female (ratio 1 ♀ / 18 ♂).

The 'Escola Superior de Educaçao de Lisboa' also provides in-service courses for pre-school and primary school teachers. The courses include a two year full-time diploma course for special education teachers. At present, about 60 teachers are involved in this type of in-service course.
As a node of the Minerva Project, the College also provides in-service courses in relation to 'N.I.C.T. and education'. Approximately 120 teachers are involved in this type of courses, 50 from 12 primary schools and 70 from 20 middle schools.
The present computer hardware for training purposes is MS-DOS compatible.

Five teachers of the College are involved in the Minerva Project. This team has been enlarged with 5 primary school teachers and 7 middle school teachers. The teachers from primary and middle schools possess an important pedagogical background. They have attended a special training course concerning pedagogical and technical aspects, related to the introduction of N.I.C.T. in education.

2. Pre-service Courses involving Logo-based Environments

2.1 Logo and the Mathematics Curriculum

Aims

During the second year of their B. Ed. degree programme, students have an introduction into the Logo-language, integrated into the mathematics curriculum.
The objectives are :
- to give initial experiences with the language;
- to think about the relationship between the Logo-language and mathematics learning, especially in relation to geometry;
- to reflect about the use of computers in elementary education.

This 30-hour course is integrated into the mathematics curriculum and is taught by a mathematics teacher. Especially turtle geometry and its relation to geometry learning is discussed :

Table 4 : Contents of the course

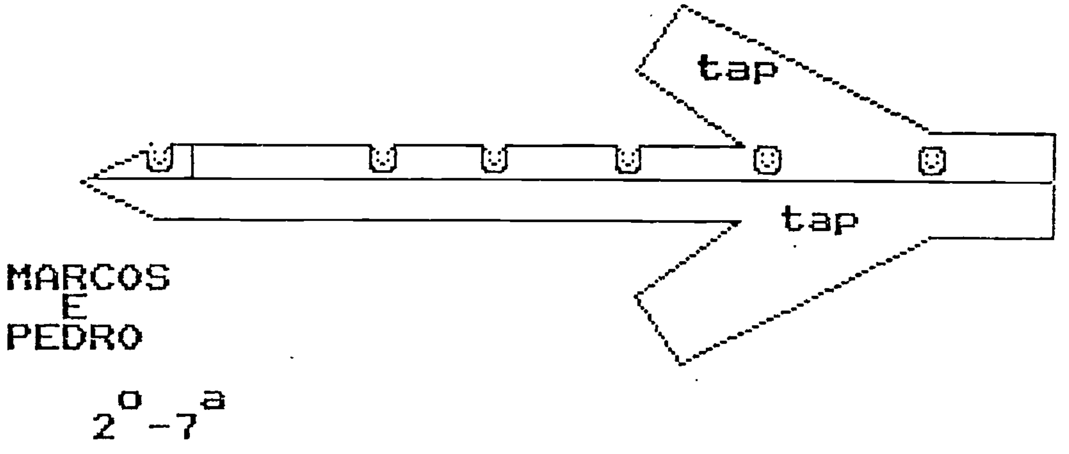
Turtle Geometry :	**Arithmetic Applications :**
Procedures	Operations
Variables	Lists
Recursive Procedures	Recursion
Animation :	**Word Processing**
Multiple Turtles	
Sprites	

Methodology and Organization

Guided discovery is the main didactic method, adopted during this course. The students work in groups of two to three, and work at their computers for about 95 % of the time. They also spend many hours outside class hours, working on Logo-problems and trying to develop Logo-projects. Appropriate problem solving strategies are introduced when this is necessary. The students enjoy learning by problem solving with Logo; this justifies the hours they spend working in Logo outside class time.
Logowriter is used, which is a combination of the Logo-language and a wordprocessing environment. It allows to develop interdisciplinary projects.

Students are expected to read a selection of articles, concerning Logo as a tool for learning. Some articles are reports of experiences made in primary schools, integrated in the Minerva Project. Students are also invited to visit schools where experiences with computers are running.
Each group of students has a disk on which they save their work. The computer room is also accessible, for project work, outside of classtime.

Ill. 7 : Project work



Assessment and Evaluation

As part of their mathematics curriculum, students are required to submit, Logo programming projects for assessment. The students reaction to the course format and content has been very positive. Students enjoy Logo and enjoy discussing about Logo use in the classroom. Students want to acquire more knowledge about 'computers in education' and some of them take an elective course (Cfr. 2.2), during the third year of their B. Ed. degree programme.

2.2 Elective Course on Computers in Education

Aims and Organization

In the third year of their B. Ed. degree programme, students can opt for a course concerning 'computers in education'. About 50 % of all third year students have opted for this course. Its aims are to :

- **discuss the role of computers in education (especially primary education);**
- **enable students to work confidently with a computer;**
- **programme a computer in Logo, to design and explore a number of projects in Logo and to discuss their use in the primary school curriculum.**

The emphasis is on Logo-based environments, with some time devoted to other programmes (e.g. a wordprocessor). The 30-hour course (10 x 3 hours) is mostly devoted to Logo-based work. The course is taught by a mathematician.

The format of the course is mainly a workshop, with some discussion about the different projects and classroom experiences in primary schools. The content of the course is an extension of what was presented in the pre-service course, with more emphasis on list processing.

Assessment and Evaluation

The students have to submit, as a basis for assessment, a Logo-project and a project using the wordprocessor. Students ask for more time to work with the Logo-language, because they want to discuss the implications of Logo use in terms of curriculum management and of Logo as a learning tool.

3. In-service Teacher Education involving Logo-based Environments

3.1 Introduction

The in-service teacher education programme, described below, is part of a global programme concerning teacher education in N.I.C.T., which is the research object of a study, carried out by one of the authors.

Our challenge is to use the computer facilities in a way that :

- justifies expenses;
- helps to realize its true potential;
- helps to make learning more interesting and stimulating;
- and helps to get the students more involved.

Traditionally, teaching in Portugal is teacher-centered and the authors want to change this towards a rather student-centered teaching. Computers can offer a good way to sustain this.

The new technology can change the relationship between the students and the teacher. But, in itself, technology is simply technology. According to Beswick "for any movement to succeed in education, it must perform the difficult task of enthusing its supporters while

at the same time tackling the doubts and criticisms of its detractors and the cautions misgiving of everyone else. It must 'show results' while at the same time recognizing that the most important results are untestable and unquantifiable" (Beswick, 1987, p. 116).
We have to consider that "in any teacher education model, the learning of the Logo language cannot be the exclusive component, neither the most important.

If it is desirable that teachers have a strong training in Logo, especially the pedagogical component is indispensable." (Matos, 1987, p. 145). As Leron (1986) mentioned, teachers are essential for any serious learning to occur, but, "the problem is not so much with the programming part but, again with the educational philosophy and the deeper ideas behind the turtle and the programming language" (Leron, 1986, p. 226). According to Matos (1987) teacher education in N.I.C.T. must pay more attention to the pedagogical perspective and this by :

- discussion and follow-up of experiences;
- reflection in small groups on the role of the teacher as the facilitator of learning;
- and thinking about the activities with children.

Infra, we present the general objectives and the pedagogical foundations of the in-service courses in the use of N.I.C.T..

3.2 Specific Objectives

The following are the main objectives of the in-service courses:

- to involve teachers in their own learning process, promoting the development of the capacity of planning, implementing and evaluating their educational activities;
- to develop a scientific attitude by investigation and the integration of theoretical knowledge into their daily teaching practice;
- to develop the ability to work in a team by sharing knowledge, experiences and by producing materials;
- to foster acquisition of and integration of scientific, technical and pedagogical knowledge;
- to promote awareness of the importance of motivation in knowledge acquisition;
- to stimulate self-confidence and personal initiative of teachers.

3.3 Pedagogical Principles

The structure and content of the courses are influenced bij the following principles.

- The teacher education process must be a continuous one, if we want teachers to integrate concepts and to change their attitudes. Any teacher education process should provide continuous support.
- It is important to educate teachers according to the methods which they are expected to use with their students.
- Teachers should have an investigative attitude towards the teaching-learning process, to acquire a reflective and critical approach towards their own teaching practice.
- The interconnection between scientific, technical and pedagogical teacher education is fundamental.
- Teachers should be considered as active agents of their own learning process. Teacher education initiatives must be organized in a way that allows teachers to work with colleagues in a group setting, sharing responsibilities, exchanging experiences and elaborating educational materials.
- Knowledge and knowledge acquisition is a dynamic process in which both students and teachers are important in discovering knowledge.

3.4 Structure of the In-service Course

The teacher education is organized in several phases, each phase with specific aims.

Introductory Phase

The aims of this phase are : to provide teachers with an elementary technical knowledge and a general view about the educational possibilities of computers and to acquire the necessary knowledge to work with their students.

Table 5 : Contents of Introductory Phase of the Course
(module 3 is not for primary school teachers)

Module 1: Turtle Geometry Procedures Variables Recursive Procedure	**Module 2: Animation** Multiple Turtles Sprites Word Processing
Module 3: Arithmetic Applications Operations Lists Recursion	**Module 4: Other Applications** Text Manipulation Illustrated Stories
Module 5: Project Work	

We believe that the teachers will adopt the same teaching approach with their students as was used during the teacher education process. The methodology of the course therefore focused on learning by discovery and problem solving learning.
On activity cards, the teachers can find some suggestions. They work in small groups and discuss how to solve the problems. The atmosphere is informal during every training session. This is illustrated by the following example :

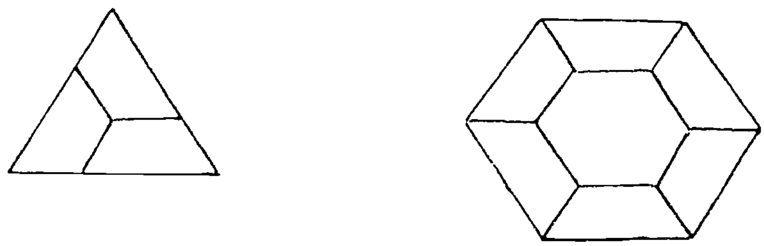
It was a session with a group of middle school mathematics teachers, starting to learn Logo. After a small introduction on the educational philosophy of Logo, the trainees started with some tasks in turtle geometry.
As usual, the very first tasks were to draw some geometric shapes, such as a square, a triangle, ...; after a while regular convex polygons, star polygons, spirals, ... were elaborated. During this hands-on phase, a teacher, who preferred to work alone, stopped her work and stayed seated with her arms folded, as if she had nothing to do. When the teacher educator asked her what had happened she answered :
I have already understood how "this" works, so I do not have to do the other tasks (she had made a square). The very first moment, her attitude was surprising to the teacher educator, but immediately she tried to take the position of this teacher and decided to talk with her. Without criticizing her point of view, he put forward the task to write a procedure for any star or polygon. With little interest, the teacher started the proposed task and said "if it is this you want me to do, that's O.K.".
The teacher educator left her alone but kept an eye on her. She did not stop working and, at lunch time, she was so involved in her work that she proposed to exchange opinions and to discuss the different mathematical questions that emerged from the solutions to the problem. She considered the task is uncompleted and asked for reference materials. She wanted to look for other strategies and to think about the different mathematical ideas behind the problem and the solutions.

This teacher discovered the relationship between Logo and mathematics and some implications for the teaching-learning process.

An example of the activities, proposed during a teacher education course is :

Make a procedure to draw the trapezium ABCD, where AB = BC = DA and CD = 2 AB.

Using the latter procedure, make a new procedure to draw the following shapes :



Teachers try to solve these problems in small groups. Afterwards, they discuss the different strategies used and the usefulness of them for mathematics education.

In parallel, some seminars are organized where a theoretical reflection on approaches to teaching/learning is presented.

3.4.2 Second Phase of the In-service Course

After the introductory phase, the approach is different for primary and middle school teachers since they work in different situations. At primary level, there are some difficulties because of staff constraints. Teachers cannot get easily free during school time. In middle schools, the teachers involved in Minerva Project, have each week a day without courses to teach, so they can participate more easily in the teacher education activities.

Primary School Teachers

Periodically, a teacher educator visits the school, in order to :
- support the teachers involved in the project;
- discuss with the teachers questions arising;
- discuss and plan with the teachers activities for the next period.

This school-based support is very important because the teachers can exchange opinions with the teacher educators. The latter can at the same time observe the child's reactions to the proposed activities (possibly reformulate training strategies).

Once a month, teachers from different schools, involved in the Project, conduct a meeting to exchange experiences with other teachers, to discuss pedagogical issues related with student activities and think about or to discuss different problems arising during the teaching-learning process.

Middle School Teachers

Regularly, middle school teachers work together with a teacher educator to develop a learning context based on a problem solving approach. These contexts can comprise :

a. the construction of mathematical concepts, emerging from Logo projects;
b. learning of specific mathematical topics where the Logo-language is used either by teachers or by students;
c. designing projects (possibly interdisciplinary ones) in Logo, where mathematical contents appear as a tool.

During those meetings, the teachers develop lessons to use in their own classrooms, such as :

Make as many rectangles, you can, whith an area of 2500 (consider the turtle step as the unit). Add information to the following table, while solving the problem :

Length	Width	Perimeter

How many different rectangles can you make with the given area measure ? Observe the table and add the information for other cases you discover.

When the teachers return for the next training session, after one week in their school setting, they are asked to discuss the following issues, related to the students' use of Logo and their experiences with the activities suggested :

a. practical problems associated with the suggested activities;
b. issues concerning the role of the teacher;
c. other approaches for dealing with the same problem, without the use of Logo.

The teacher educator listens and co-ordinates the discussion. The following can arise from these discussions.

- The role of intervention.
  At the beginning, many teachers reported that they felt anxious to help their students and wanted to interfere too much.
- The appropriateness of the activities.
  The teachers said that the activities suggested, are important to discover the difference between area and perimeter. This is a topic with which many children have difficulties.
- The use of other materials.
  Teachers are concerned about and discuss the use of other materials (such as geoboard). They think of activities where others materials are used.
- Organization.
  Teachers are concerned about how they can organize the computer activities, taking into account the limited computer resources. They also tackle issues in relation to the fact that part of the class is in the computer room and part of the class is doing other activities.

In general, these sessions are important to discuss crucial issues, raised by the teachers themselves. After a discussion of these issues, the activities for the next week are planned.

Throughout the schoolyear, topics are discussed in relation to other aspects of the mathematics curriculum : e.g. rational number, geometry, the interrelation between area and perimeter; aspects related with Logo-language (e.g. the use of variables in Logo, mathematical investigations in Logo, Logo and the role of the teacher, projectwork and Logo, etc.).

There are - each year - at least three meetings where all the teachers (middle and primary teachers) exchange their experiences. These meetings are very important since teachers from primary level find out what is done at the middle school level and vice-versa.

3.5 Implementation and Organization

As mentioned before, there are some difficulties **at primary level**. These are mainly related to the lack of free time for the teachers, during which they could work together. To solve this problem, whenever possible, **a one week workshop** was set up. During this workshop the content of the introductory phase was discussed. Another solution was to split up the content of the course into two blocks : modules 1-2 and modules 3-4. After an introduction on the first block, the teachers started working with their own students. At the end of the first school term, the other block was presented to them. Meanwhile, the second phase of the training started.

Weekly, **middle school teachers** have, a day free of class, so it is easier to organize the training. The introductory phase is set up at the beginning of the schoolyear. This can be done during a one week workshop or 5 single days during the first five weeks of the schoolyear. Both approaches have their advantages and disadvantages. One of the advantages of the second approach is that the teachers can already bring into practice what they learned during the last module. But, sometimes, teachers do not possess sufficient knowledge after a single module to solve the problems that can arise during classroom practice.

3.6 Assessment and Evaluation

The introductory phase of the teacher education has in general been successful. This phase is of prime importance before teachers start to work with their students. It is important that teachers get opportunities to exercise in-between training sessions. As a consequence, we prefer to organize the training during four training sessions (2 days). After this initial part of the training, the teachers can explore the new possibilities in their own school context or start to work with students. During weekly meetings these experiences can be discussed. In primary schools these meetings are organized in their own schools; in middle schools, this is done in the teacher education centre.

The second phase of teacher education is relevant because it allows :
- to promote the discussion about different strategies to work with students;
- to exchange the experiences between the teachers involved;
- to encourage the elaboration and organization, in small groups, of support materials;
- to organize work sessions to explore some aspects of Logo-language, especially issues related to the projects in progress;
- to facilitate the use of reference materials.

Evaluation of the teacher education initiatives is based on the reactions of the teachers and by observation of their projects and activities (possibly in their own school context). Usually, middle school teachers start working with students during extra-curricular activities, called 'computer clubs' or 'informatics clubs'. Only when they feel confident, they start using the computer during classtime. This depends on individual characteristics of the teacher; some need more time than others. But, they all need to learn through real-life experiences with students, before starting to work during classtime. They also need to co-operate and discuss with other teachers the kind of activities they propose to the children.

The main differences between the work in computer clubs and in the classroom lies in the lack of curriculum limitations and time restrictions in the computer club context.

At primary school level, the teacher starts to use computers during classtime. The computer is put in the classroom and the students develop projects (group projects or class projects).
Usually, computer use at the primary level is easier to organize because there is only one classroom teacher and there are less time limitations. While a group works at the computer, other students do other activities. Such use of computers compels teachers to think about classroom organization.

The teacher education process usually takes a long time. Teacher attitudes are not easily changed. We can conclude that the following guidelines will sustain in-service education :
- teacher education has to incorporate college and school based work;
- teachers have to take part in the development of materials for use with students;
- course organizers have to be both familiar with the Logo-language and be experienced in its educational use; moreover, they need to know the curriculum content;
- teachers have to be motivated; motivated teachers who want to invest in their own teacher education are needed;
- support teachers are important; teachers need to know that in the college there is someone to whom they can talk and with whom they can discuss their problems.

4. Future Directions

As mentioned before, this schoolyear sees the start of the expansion phase of the Minerva Project.
As a consequence, there are many more schools to support and teachers to educate. At the same time, a new teacher training centre is set up to decentralize the initiatives, but co-ordinated by a centre in the college of education. It is the intention to maintain the scheme of teacher education as sketched above, but, training has to be set up during the free time of the teachers. Too many teachers now are involved in teacher education and they cannot get extra free time. Attempts are made to adapt the model to the new conditions.
But the conviction remains the same : the two phases of teacher education are essential and teacher involvement in discussing and designing materials for use with their students, is of prime importance.
Teacher education cannot be set up during restricted courses. It has to be a continuous process. The use of computers by teachers should not be compulsory. Teachers should understand and discover by themselves the advantages of computer use in education.

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Ill. 8 : Project work

Chapter 7
TEACHER EDUCATION IN THE ATENEA PROJECT OF THE SPANISH MINISTRY OF EDUCATION AND SCIENCE

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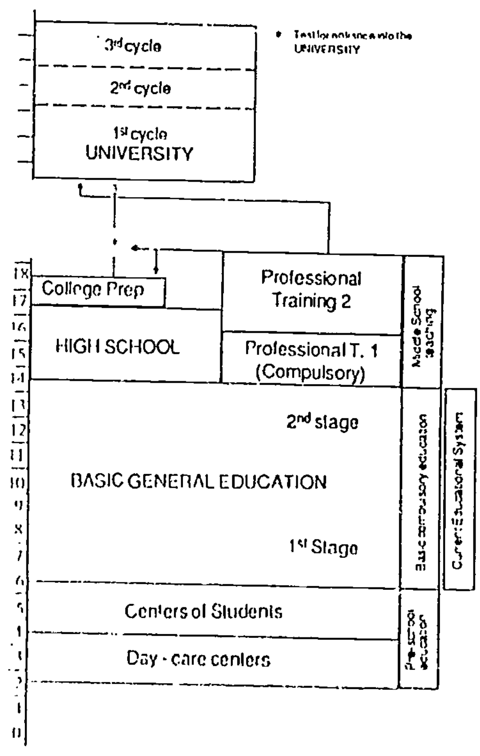
1. The Spanish Educational System.

The Spanish educational system is undergoing a major transformation as a result of the implementation of a plan for reform which is going to effect a considerable modification of the curricula in the next years. Among other changes, the shift of the school-leaving age from 14 to 16, with the elongation of the period of compulsory primary education that it involves, should be remarked.

This circumstance, together with the need to adapt the school curriculum to the demands of the future society, has motivated a deep reorganization of all its elements.

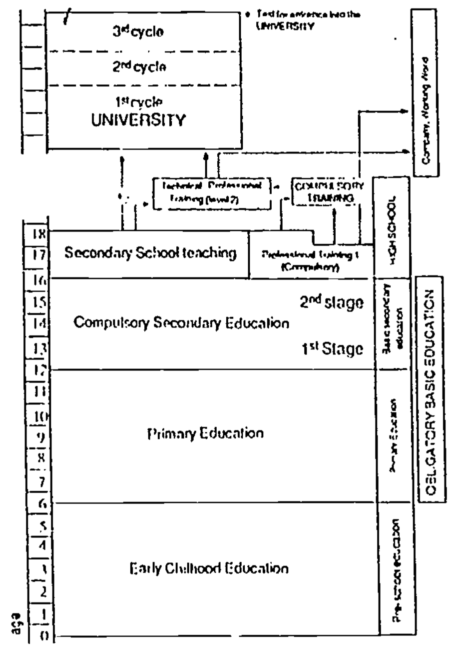
Nowadays, the school system is organized as follows :

Table 4 : The actual school system



The new school system proposed by the Ministry of Education and Science is as follows :

Table 5 : the Future School System



2. The "Programa de Nuevas Tecnologias de la Informacion y la Comunicacion" (P.N.T.I.C.) in relation to the Spanish Educational System.

2.1 Structure of the Educational System in Spain.

The Spanish territory is organized into seventeen Comunidades Autónomas (self-governing regions) which are, in turn, subdivided into provinces. In eleven of these Comunidades Autónomas (which incorporate a total of twenty eight provinces), educational affairs are under the direct administration of the Central Government's Ministry of Education, whereas each of the other six Comunidades has its own educational administration, although all of them adjust to the same educational pattern.

There is a Dirección Provincial (local representative office of the Ministry) in each of the twenty eight provinces where the Ministry is directly in charge of education. Each Dirección Provincial is in charge of the educational organization in the corresponding province; a certain number of Centros de Profesores (Teacher Centers, hereafter, C.E.P.s) are subordinated to each Dirección Provincial. There is a total of a hundred and six C.E.P.s in these provinces. The purpose of these Centros de Profesores (hereafter, C.E.P.) is to provide training as well as scientific and pedagogical updating to the teachers in each local area. The training is carried out through courses, seminars, meetings for the exchange of information on relevant experiences, work groups, workshops and other activities. The C.E.P. are meeting places where primary and secondary teachers can discuss the professional issues that concern them.

Under the jurisdiction of the "Programa de nuevas tecnologias de la informacion y la comunicacion" (henceforth P.N.T.I.C.) is the Secretaría de Estado de Educación of the Ministry of Education and its headquarters is in Madrid. It has set up a network of Teacher Trainers specialized in information and communication technologies who work in the C.E.P.s all over the territory under the direct administration of the Ministry of Education.

The P.N.T.I.C. is only concerned with in-service training, since pre-service training is the responsibility of the Universities.

The six Comunidades Autónomas, where educational affairs are not under the administration of the Ministry of Education, have their own projects for the introduction of computers in schools. A Coordinating Committee is in charge of keeping all the different projects in contact, setting technological standards for the education and establishing strategies for development. It also acts as consulting board for projects concerning new information technologies in the European Economic Community.

2.2 The Programa de Nuevas Tecnologias de la Información y la Comunicación (New Information and Communication Technologies Program).

The Programa de Nuevas Tecnologías de la Información y la Comunicación was created by the Ministry of Education and Science in 1987 in order to unify the lines of action of the pre-existing projects Atenea and Mercurio. These projects were launched in 1985, on an experimental basis, with the aim of carrying out a gradual and systematic introduction of computers and audiovisual technologies, respectively, in schools. The final evaluation of these projects will be carried out during the school year 1990-91.

The objectives of the Atenea Project are :

- to stimulate teachers to reflect upon the curricula of the different subject matters and to contribute to their revision from the perspective of the new information technologies;
- to define paths for the integration of the new information technologies in the different areas of the curriculum;
- to develop and experiment applications of the new information technologies in education, exploring the opportunities they offer as well as their social and cultural impact. To use the new information technologies as tools for improving the quality of education in each specific area of knowledge as well as in its interdisciplinary aspects;
- to support the use of computers for generating new environments for autonomous (individual and group-work-based) learning, for the development of cognitive skills, creativity, and self-esteem;
- to explore the possibilities opened by the new information technologies as regards the teaching-learning process;
- to analyze the impact of the integration of the new information technologies on the organization, management and every day functioning of schools, with special attention to architectural and ergonomic matters.

3. The focus on the Education of the Teacher Trainer

3.1 General Aim

In accordance with the existing educational structures, it was considered necessary for the achievement of the objectives of the Atenea Project to have a Teacher Trainer for new information technologies (computers) working in each C.E.P. with the teachers of the pedagogic teams from the experimental schools of the Atenea Project.

3.2 References of the People Involved in the Teacher Education Courses

Trainees

Until the present schoolyear, the Atenea Project has carried out the training of four groups of Teacher Trainers. They are teachers of primary and secondary education, specialists in different subjects, mainly in mathematics (approximately 50% of them). Most of them are males (90%).
The numbers of trainers trained each schoolyear are : 1985-86 (54); 1986-87 (32); 1987-88 (32); 1988-89 (22).

Trainers

The training of the Teacher Trainers is designed and carried out at the P.N.T.I.C. Headquarters and, as far as Logo is concerned, the ten teachers who took part in the elaboration of the microworlds and the applications contained in the resource package are usually in charge of the training. They are primary and secondary level teachers.

3.3 Functions of the Teacher Trainers

The functions these Teacher Trainers must carry out in the C.E.P. are :

- train the teachers from the pedagogic teams of the schools integrated in the Atenea Project in the use of new information technologies;
- help the pedagogical teams to plan and experiment curriculum-integrated applications of the new information technologies;
- Atenea being an experimental project, Teacher Trainers have also been required to take part in the follow-up and evaluation of the project;
- the plan for training the Teacher Trainers was designed in accordance with the objectives of the Atenea Project, and all the different functions that the Teacher Trainers have to carry out were taken into account.

The paramount importance attached to teacher education also sustained the process of improving the quality of education.
Since the Atenea Project was conceived as a project for educational innovation, strategies for the implementation of innovation in the classroom were included as part of the training of Teacher Trainers. This involves providing examples of good practice in order to show the application of technological media in real teaching-learning situations.

Consequently, the contents of the plan for training teacher trainers include technical and pedagogical aspects of the New Information Technologies in education as well as matters concerning its rationale and purpose.

3.4 Resources

Because of its peculiar features and the opportunities it offers for education, Logo is thought to be a computer tool which deserves to be regarded in a special way.

An adequate use of Logo may create favourable conditions for significant learning and for the development of problem solving strategies. It can help teachers to reflect upon their role in the classroom and the possible strategies for teaching. Finally, as its creators suggest, it may turn into a Trojan Horse which may cause a global re-thinking of the whole school curriculum.

In view of all this, the role of Logo in the teacher education programme of the Atenea Project has been fundamental. In this respect, the first important decision was to reach an agreement upon a standard to name the primitives of the language in Spanish.

On the other hand, the need was felt to have at hand enough Logo-based materials integrated into the school curriculum. This motivated the production of the resource package **"Logo. Metodología y Recursos Educativos"** (Methodology and Educational Resources).

This resource package, as the rest of the packages published by the P.N.T.I.C., has a double aim. On the one hand, it provides instances of applications in concrete teaching-learning situations which will stimulate discussion among teachers and provide them with ideas for planning their own activities, either using the materials as they are or adapting them to the needs of their students. On the other hand, they are used as resources for the training of teachers, so that the technical aspects remain subordinate to the pedagogic applications.

The training in Logo aims at providing the Teacher Trainers with grounds for decision making upon whether or not a given Logo learning environment is adequate for a given teaching-learning situation. It also tries to enable them to carry out applications based upon Logo or upon microworlds and other tools developed in Logo. And, finally, it also tries to enable them to teach the courses mentioned before.

4. Contents of the Teacher Education.

As it was mentioned before, the training in Logo is part of a much wider training. Before we discuss the contents related to Logo, it would be convenient to place this part of the training within the framework of the global contents of the plan, which are the following :

The P.N.T.I.C.. The Atenea Project Training Plan

Basis for the use of the new information and communication technologies in education :
- social, cultural, cognitive, affective perspectives;
- technological and pedagogical purpose of their role in the curriculum.

Teacher education :
- organization of the training : seminars, workshops, courses, etc.;
- training resources : audiovisual media, computer tools, forms etc.

Role of the new information technologies **in the curricula** of the different areas and in their interdisciplinary elements.

Innovation projects, their follow-up and evaluation :
- strategies to support innovation;
- technical and resource support;
- follow-up of innovation plans : tools, quantitative and qualitative research, observation techniques, analysis and gathering of data, evaluation of processes and results, analysis and dissemination of experiences.

Use of computer programs **in education** :
- computer aided instruction : games, simulations, programs for children with special needs, word processing, databases, desktop edition, computer aided design, spreadsheets, Logo : problem solving, tool kits, microworlds.

Other **technological matters** :
- hardware and peripherals: the Operating System MS-DOS, utilities;
- long distance network connections: CD-ROM, Robotics and process control, Artificial intelligence.

Contents of the Training of Teacher Trainers in Logo.

Logo and education
Areas of application of Logo
Pedagogical implications of Logo
Methods for the design of applications in Logo
Methods for the use of Logo applications in the classroom

Logo as a computer language

Features	Primitive procedures	The editor of procedures.
Turtle graphics	Cartesian geometry	Arithmetic expressions and functions
Control structures	Interactivity	Words and Lists
Programming techniques	Recursiveness	Functional programming
Files		Problem solving strategies
Modularization	Lists of properties	Three-dimensional graphics

Educational applications

Microworlds	Tool kits	Pedagogical applications
Analysis of applications		Design of applications

5. Methods and Materials used in Teacher Education

5.1 Methods

The four groups of Teacher Trainers were heterogeneous as far as the initial knowledge of the different computer tools, but especially Logo, was concerned. To solve this problem, different activities for the different levels of knowledge were planned in some training sessions.

The learning of those primitive procedures connected with the turtle and the lists was carried out through hands-on practical work where the Teacher Trainers explored the functioning of the different commands and wrote simple procedures.

Recursion is one of the aspects of Logo that is most difficult to understand and handle, and therefore one of the most difficult to explain, too. The study of recursiveness in the Logo courses begins with the analysis of recursive graphic procedures and then goes on to compare them with recursive list procedures. The latter are analyzed by means of different media such as diagrams, videos and demo pieces of software. Once the functioning of recursiveness has been understood, the teachers practice building recursive tools which manipulate graphics and lists.

One of the features of Logo that makes it more powerful is modularization. In order to help teachers to grasp its meaning, a session based upon Papert and Solomon's experience with the 'game of NIM' is organized in the following way. After the teachers have practized with simple projects, which admit a small amount of break down, the development of a few games with Logo is proposed.
Groups of six or seven teachers are formed and each group chooses one of the games. All the proposed games have something in common.
They can be subdivided into three basic parts. Setting the initial conditions and rules of the game, controlling of the functioning of the game and creating the different elements which are used in it (figures, movement of the turtle, etc.).
Once the group has analyzed the problem, three subgroups of two or three persons are formed; each one of them takes charge of one of the modules. Each subgroup builds up the procedures of its module, which involves a new modularization task. Once the three modules are working independently, the task of joining them begins. After that, the display or the game's functioning can be improved, or the team can try to make it "more intelligent". In this way, the advantages of modularization for correction can be observed.

The fact that teachers tend to reproduce the patterns of the same type of teaching that was imparted to them when they were students, is taken into account in the training sessions with Logo and with the other computer tools. Consequently, the teachers' learning process is intended to be as similar as possible to that of the students they have to teach. For example, the learning of the microworlds is approached through the pedagogical applications that have been developed in the P.N.T.I.C., where a set of activities, tests, observations and exploration tasks are proposed. In this way, a fundamental aspect of the Logo method such as the method for working with the students is dealt with.

5.2 Materials

Following the lines proposed by Papert, different microworlds and tool kits have been developed in order to generate new learning environments for individual and group work that stimulate the development of cognitive skills, problem solving strategies, creativity and self-esteem.

The purpose was to enlarge the field of application of Logo and, above all, to make profitable use of this powerful tool and to integrate it into the curriculum of certain subjects, mainly Mathematics for students between twelve and sixteen years of age.
A certain type of exploratory work is proposed in these microworlds in order to make the students build and test their own theories, set and solve problems, and, all in all, build up their cognitive processes in an active way, as Piaget suggested.

The microworlds and tool kits are complemented by instances of application which show the sort of activities that can be carried out with Logo-based environments and the objectives that can be achieved.

The resource package "Logo : Metodología y Aplicaciones didácticas" (Logo : Method and Pedagogical Applications) consists of three volumes with approximately a thousand pages and two disks containing all the programs mentioned in the books.

The first volume presents a general overview of Logo from a double perspective : Logo as a programming language and as an educational tool, with an analysis of the opportunities it offers for the development of problem solving skills and formal thought, for "learning how to learn", and its possible cognitive effects.
The other two volumes include most of the applications directly based on the Logo language and the developed microworlds and tool kits. Among the applications based upon the primitives of the Logo language the following can be mentioned : "An Approach to the Concepts of Function and Variable", "Polygons, Perimeters and Areas", "Computer Simulations", "Montecarlo's Method", "Trapeziums", "The Number Ò", "Solving Problems of Maximum", "The Turtle with Memory".

The microworlds and toolkits contained in the package are described in the following sections.

GEOPLANA

The development of mathematics curricula in different countries, during the last decades, has brought back classical geometry in primary and secondary education, without giving up the study of analytic methods, which poses problems for the majority of the students when used on their own. It is being found that in teaching, it is beneficial and even necessary to have available visual representations in order to obtain the geometrical concepts.
Geoplana is a toolkit which allows the solutions to geometrical problems which can be accomplished with rulers, T-squares, compasses and protractors. With the computer, these problems become dynamic. For example, one can see how the position of the barycentre in a triangle changes if we move a vertex along a straight line.

A variety of new commands are presented in this toolkit :
- to help teachers decide which commands to offer to their students to work with;
- which commands the students can build upon;
- and which ones are not suitable for them at a particular point.

For example the package "straight lines", which comes in the toolkit, can be used independently for the study of the relation between points and straight lines and their different expressions.

The development of the capacity for making and testing hypotheses and for associating synthetic and analytic thought, through the parallelism between graphic and algebraic methods is highlighted as one of the goals in the applications that come with this toolkit. A set of problems solved with the help of GEOPLANA is also included.

The Shapes Microworld

The motions of the plane is another topic that practically disappeared from the mathematics curriculum, being reduced to its analytical study in some cases. The reason for that could be related to the lack of appropriate means. If geometry is a privileged context for posing problems and providing situations for study, the topic of motions, in particular, helps the development of positive attitudes, the taste for the beauty and for the composition of shapes, and other more creative activities.

"Shapes" is a graphic microworld which allows students to manipulate shapes by means of a set of commands which produce the plane motions : translation, rotation, symmetry and other transformations such as homothety. The shapes can be defined by either the teacher or the students.

A user's interface is provided, with a syntax similar to natural language, which facilitates applications for 8 to 10 year old students. The students improve their aesthetic composition abilities and those related to laterality.

A proposal for the study of the motion of the plane is made in this microworld, as well as other applications such as, "Tangram Game", building up a landscape, etc.

This in an example in which computers bring something essential to the geometrical study implied in the movement of shapes on the screen. This, along with the interactivity and the characteristics of this microworld, allows the students to observe the effects of the motion, to test the properties of motion composition, and in fact, to learn in an active way.

Graphic Representation of Functions

The understanding of natural and social phenomena is sometimes determined by the interpretation of the information presented in a graphic way. Hence, the importance of developing skills for the graphic representation of functions in such a way that interpretation of this sort of treatment, so often used in common life, can be attained.

This microworld presents a model, that can be enlarged, which permits the representation of functions in an explicit way, approaching the curriculum of mathematics in a new perspective. It takes advantage of the facilities provided by Logo for the treatment of functions.

The representation can be done in three ways half-automatic, manual and formal. The first one requires that the conditions of the representation, that is : the intervals, the area on the screen, the number of points in the graph and the function among others are defined, and the representation is carried out through a command. The manual one permits the representation of the graph point to point according to the advance of the cursor keys. The increment of the absciss can be modified at any time, you can also go forwards or backwards and show the coordinates of the calculated points of the function.

The formal representation studies the function in the specified interval keeping the graph, which allows the study of increasing and decreasing intervals, the bounding local maxima and minima and the indication of possible assimptotes. A good approximation of the derivate function can be obtained without calculating its expression.

It works with windows so we can have several representations on the same screen. A net grid can be drawn to any scale and you can zoom over an area of the plane and change the scale relation of the axis. It allows the students to study function families.

Vectors in the Plane

Free vectors in the plane can be a graphic example which draws up to the knowledge of such a productive structure as real vector space. The problems detected in the study of this specific point do not come up when operating with vectors and their application but when acquiring the basic concepts.

The microworld that has been created for the study of vectors makes the acquisition of the following basic concepts easier : equipolence, free vector, properties of the operations, real vector space, linear vector space and basis of a vector space.
The usual nomenclature with the different ways of notation is used and besides its graphic representation, the vectors' coordinates can also be shown if required. The representation scale can be changed so that the length of the vectors fits in the screen's dimensions.

The application proposed here for the mathematics curriculum takes advantage of the possibilities offered by the microworld so that the students can investigate, discover and test properties, contrast hypotheses and solve problems that, without the computer's help would be very difficult to achieve.

Coordinate Systems, Cartesian Coordinates and Polar Coordinates

The use of the cartesian coordinate system is not difficult for the students. It can also be convenient that they understand the meaning of such coordinate system. By doing this, they can compare it with a different one, sus as the polar coordinate system. The use of the latter brings in the necessity of representing angles with accuracy such which implies difficulties for the students.
This toolkit is based upon two new commands which represent given points in polar or in cartesian systems. There are other accessory commands to draw the coordinates axis, to determine the representation of points to be done with or without the projections and to change the coordinates from one system into the other.
An exploratory work with the students is suggested. They try to represent points and, while analyzing the value of the coordinates and observing their representation, they verify that under certain conditions the known plane lines (straight lines, circles, spirals) are generated. They discover how a representation system allows to name the elements in the plane (points, lines, etc) and therefore they can relate geometry and algebra. In short, they get themselves into the study of analytic geometry.

This application can be an example of how media can determine the contents of the curriculum, in this case, how computers can help in the study of topics such as polar coordinates that is not usually approached.

The 3-D turtle

The development of the spatial orientation is an important objective in the first educational levels. Its fulfilment can imply some difficulties. On the other hand the representation of shapes in the three dimensional space with a definite perspective implies the application of the projection laws. These laws are complex enough to require a certain level of knowledge.

This microworld is based upon Abelson's and diSessa's ideas. It simulates the turtle's movement in a three dimensional space and it gives a conic perspective projection on the screen. This microworld allows the student to draw geometrical shapes in the space without the need to know the laws of representation in perspective. The shapes are created according to the movements the turtle makes. In that way, the student is pushed to discover the inherent properties of those shapes and to develop the sense of spatial orientation.

Different activities for exploring the geometrical shapes are proposed as well as open projects. For example, when working with pyramides if you get unexpected results, due to concept errors, you can discover the notion of diedric angle which is obtained in a totally experimental way as a result of the correction of that error after a deep analysis of it.

Spherical Geometry

It is a microworld which allows the exploration of a non Euclidean geometry, to acquire or reinforce geographical concepts such as meridian, parallel, length, latitude and to work with geographical coordinates, and spherical triangles.
Some of the activities proposed to be carried out with this microworld are : to determine some places in the globe, to locate the geographical coordinates for some cities, to determine distances, and to move on to the globe.

Logo and Mechanics

It provides a working environment in which the student can experiment with the laws of mechanics, which in another way would be very difficult to fulfil. This experiment consists in making several forces, in different directions, interact over a physical object defined by its position, mass and speed. The student can observe the produced effects.
Besides the commands that change the object's state, the performing forces and the friction, there are other commands that make easier working with the microworld and that allow to draw the vectors representing each force, to draw a reference system, etc.
The applications of this microworld can develop the capacity of observing and predicting in order to establish relationships between the physic magnitudes that define the state of a figure.
If the students know some Logo, as it happens with the other microworlds, a set of activities can be proposed to enlarge the microworld, for example, to create procedures to stop a figure, to give a certain speed or to compose forces.

Story Maker

Organizing ideas, writing, revising, correcting, publishing are some of the main activities of the writing process. It can be difficult when only pen and paper are available and students are forced to erase, or re-write the same text in order to get a neat copy.

GENHIS is a programme that takes advantage of the possibilities of the Logo Editor in order to plan, write and publish stories with a tree-like structure, particularly stories of the type "Choose Your Own Adventure", and, of course, linear ones. It also allows the processing of any information which can be organized in a tree-structure, for example any animal, plant taxonomy, etc.
Most of the commands of the turtle microworld are available through an INSTANT-LOGO, so that the student can make drawings to illustrate the stories. When you are making the drawings there is also the possibility to use any other Logo command by activating a key. It also takes advantage of all the possibilities provided by computers for text processing, such as saving different versions of a story, retrieving them for further corrections, printing them on paper, etc.

'Music' Microworld

Music as a subject, is an effective element of general education which benefits the whole formation of the human being, has enough entity to play a more important role than it usually does in the curriculum. The reason for that might be the scarcity of specialised teachers and appropriate materials.

The musical microworld is a large set of procedures which can be used at different levels. The first level does not require any previous knowledge. By using it, you acquire the basic concepts such as the notes and their values, height relation between different sounds, prolongation signs, alterations, basic rhythm formulas, air or movement, repetition signs, tonal and modal orders. In the second level scores could be read and coded provided that the student had a slight knowledge of music theory. The third level could be of help for composition and it allows more creative composing activities.

Some notions about sound physics and the mathematical relations which rule music could also be undertaken.

Logic Programming in Logo = Prologo

PROLOGO is a working environment which shows the possibilities of the Logo-language to carry out developments of artificial intelligence and to get a better knowledge of the processes of search of solutions in declarative languages and expert systems.
It is a tool for the learning of formal logic and of reasoning through declarative programming. It also allows the management of relational databases integrated in the different areas or in a multi-disciplinary way. Programming in this environment, Prolog like, consists of defining the knowledge database (facts and rules of production) and enquiring it.

Some specific didactic applications are included together with the user's technical information and characteristics of the environment : for history, a data base of family relations of the members of the "Austrias" royal family; a bird study; a key for determining minerals for Natural Sciences; a logic study to be used in mathematics as well as in philosophy; and an application on reasoning which could go with any subject.

6. Implementation and Organization of the Teacher Education

The training of Teacher Trainers is organized in eight phases, five with a duration of two weeks each (three hundred and fifty hours) and three with a duration of one week each (one hundred and five hours).
The first five phases are carried out at regular intervals during their first year in the Atenea Project, interspersed with periods of self-training when the trainees carry out tasks such as the development of pedagogical applications. All the contents mentioned in section five are dealt with in these five phases, except those related to the follow-up and evaluation of innovation projects, which are dealt with during the other three phases.
The functions that the Teacher Trainers have to carry out make it necessary for them to have a full time dedication to the Atenea Project. This allows them, on the other hand, to receive their full training, which, as can be concluded from what has been mentioned before, is sufficient. That is why these teachers are relieved from their normal teaching duties and their commitment to the Atenea Programme is renewed each year.

7. Assessment and Evaluation of the Training

The data for the evaluation of the Teacher Trainers' training are obtained by different means. Every day, a few of the teachers attending the training course are asked to write a report on what they think about any aspect of the course. Most of these reports reflect not only personal opinions, but the opinions of the group.
This allows the course coordinator to have inmediate information on how things are going in the course and which problems appear.

At the end of each phase, every trainee fills in a questionnaire. Later on, there is an oral, global evaluation in which the questions covered in the questionnaire, as well as others which were not included in it, are discussed and commented upon in group.
At the end of the first schoolyear, the basic training is finished and each trainee submits a report on the training received. This is an open report, where all sort of comments can be included, although trainees are given a guiding list of aspects of the training about which they can make comments and suggestions for improvement.

In the phase built on Logo-applications, the evaluation of the contents, the method and the materials used is positive. Of all the objectives set for this phase, developing pedagogical applications is the most difficult to achieve, perhaps due to the difficulties inherent to the task. On the other hand, there is not enough time during the course to carry out such tasks, since the teacher trainers are only intended to experience a situation in which they have to design, and discuss in groups, the implementation of pedagogical applications. Once the training is finished, the teachers consider themselves capable of teaching, on their turn, training courses on Logo. In general they think that it would be convenient to devote more time to the training in Logo.

8. Recent Developments in the Training Initiatives of the P.N.T.I.C.

During the present schoolyear, the training of a fifth group of seventeen teacher trainers is taking place.

The objectives, and therefore also the contents, of the training imparted to this group are different from those of the previous groups, due to several reasons. On the one hand, this is the last schoolyear of the experimental plan, so these trainees will not have to take part in the follow-up and evaluation tasks of the project. That is why the contents of the training corresponding to these matters have been deleted from their training plan.

On the other hand, this group is more homogeneous than those of former years as far as previous knowledge is concerned, since most of the teachers in this group came from the pedagogical teams of schools taking part in the Atenea Project, and had already received their training at the C.E.P. from colleagues trained in previous years. This situation makes it possible to start the training on the different computer tools from a higher level and therefore reduce the number of phases of training.

This schoolyear, all the efforts are being invested in the elaboration of materials for the experimentation of curriculum-integrated computer tools and in the gathering and processing of data for the evaluation of the project. That is why the training activities of the teacher trainers at the C.E.P.s are reduced to a minimum.

9. A typical Trainer-Trainee Interaction

Our experience in training teacher-trainers has been described in this chapter. The trainees, after following this training plan, will become the trainers of those teachers who will use the LOGO-based environments with their students in real classroom situations.

It is necessary that the training plan promotes the reflection from three very different points of view: the student's, the teacher's and the teacher-trainer's point of view. In order to achieve this reflection, activities are designed in such a way that the trainees are invited to play one of these three roles, although it is very difficult to avoid the ambiguity of the three roles in most of the activities.

For example, in an exploratory work session with LOGO-primitives or LOGO-procedures, which act as primitives in some of the above mentioned microworlds, the trainees play, mainly, the role of students. In small-group sessions or in general debates, they are asked to take the stand point of teaching professionals when analyzing and evaluating the validity of the applications and microworlds, which they have been using as students.
Along the training process, the future teacher-trainers observe and evaluate how the different sessions are carried out, the dynamics arosen, the different media (written materials, videos, transparencies ...), used in the course and, in the final sessions, they discuss one of the problems which affects them more directly : the way they will plan their own LOGO courses for teachers in the future, that is to say, they assume the role of teacher-trainers.

One of the activities in which the ambiguity of these three roles appears spontaneously is the one described in 5.1. The activity about modularization, where they had to develop and improve some games, took very close to the students' point of view. As teachers they realised the power of LOGO and its facility and adequation for the construction of the thought taking advantage of LOGO possibilities of modularization for solving a problem. As teacher-trainers they carried out a more complex activity by which they had to develop learning environments based in LOGO.

One of the more comforting experiences in the final evaluation of the achievement of the objectives in a LOGO course was when a teacher, with no previous experience with computers, asseses that the LOGO course had made her understand better the way her students felt in the class when they were being taught something completely new to them, and that she would modify from then on her teaching practice. Although this had not been stated as an objective for the course we think it can be considered an important achievement.

10. Conclusions

Although the final results of the evaluation of the Atenea Project are not available yet, it can be stated that he LOGO way of working has influenced all the teacher-training process, even when using other tools.
It has also become a model for the development of new educational software. It seems that " the Troy's horse ", mentioned by Papert, has carried out his task, introducing in the teacher environment a new methodology of use of didactical media. Unlike most of the general software, which has had a great development and new versions during the last years, LOGO has not improved lately. In today's version we miss a more developed working environment, it doesn't realize the potential advantages offered by new graphic cards of great resolution and the new peripherals which are so useful in education.

For the above mentioned reasons and because we think of LOGO as a very valuable tool for teaching, the " Programa de Nuevas Tecnologias de la Informacion y la Comunicacion " is promoting the development of a new version of LOGO which will include all these improvements and which will be based on the experiences carried out along these years.

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Chapter 8
THE MICROWORLDS COURSE : AN APPROACH TO COMPUTER-BASED IN-SERVICE TEACHER EDUCATION FOR MATHEMATICS

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1. Introduction

1.1 Background Information

Considerable resources continue to be spent on equipping schools with computer hardware and to a lesser extent software. It may well be that many of the early claims concerning computer applications in the classroom were unjustified or overblown but it is our belief that unless the question of teacher education is urgently addressed the potential of computer use in schools will not be realised. In addition to the need for teacher education the question of software must be addressed. Our focus has consistently been on mathematics, and in this domain the software available has been largely based (in the U.K. at least) on usable but limited programs related to specific mathematical topics, or on simple drill-and-practice programs (often loosely disguised as games). Given the enormous development costs of powerful software and the lack of funds within education this situation is likely to continue. It is our experience that after using the microcomputer in ways which do not exploit its power, teachers tend to judge it to be an irrelevant luxury.

In England the provision of in-service training for teachers is influenced by a nationally specified strategy (DES, 1989) which is delivered at local authority level (1). Local authorities make decisions about their own particular in-service training needs. Within this framework courses of teacher education concerned with new technology fall into a national priority area. This means that local authorities can bid for national funds to support these courses. The local authorities are then to a certain extent free to choose whether these courses are based in schools, Local Authority Centres or in Institutes of Higher Education.

Given this background, one of the aims of the microworlds Course (2) was to develop, innovate and evaluate a programme of in-service teacher education concerned with the use of generic computer applications (Logo, spreadsheets, databases and graph plotting packages) within the secondary school mathematics curriculum. The aims of this course were for participants to :

. develop competence and confidence in the use of the computer as a mathematical problem solving tool;
. reflect on their own learning processes and relate these to the learning of the pupils within their classrooms;

- develop ways of structuring the computer environment within their mathematics classrooms and evaluate its role in terms of pupil's learning;
- confront the issue of the computer's influence on the role of the teacher, and to increase awareness of individual learning styles;
- disseminate their expertise amongst colleagues in schools and Local Education Authorities.

We (the three authors) were the course organisers and the teachers were recruited as a result of publicing the course within the local education authorities and the local schools. The number of teachers attending the course was 13 in Year 1 (1986-1987), and 7 in Year 2 (1987-1988). Two of these (one in each year) were part of their local education authority mathematics advisory team and the majority of the remaining teachers (3) were in positions of some responsibility within their mathematics departments (7 were heads of department, 6 were deputy heads or equivalent). In addition 5 held the position of head of computing within their school; 16 of the 20 course participants had at least five years' teaching experience and the ages of the participants ranged from late twenties to early fifties. Acceptance on the course was conditional on access to at least one computer within the teacher's mathematics classroom. The course did not provide institutionalised qualifications for the teachers and in this respect they were all intrinsically motivated to attend the course.

This chapter is concerned with the Logo components of the Microworlds course. We outline the factors affecting the design of the course before describing and discussing the role of Logo within the course.

1.2 Factors Influencing the Design of the Microworlds Course

We shall describe the underlying influences on the course design and their practical implications.

The atmosphere and pedagogical input of a course influences the ideas that teachers take away with them and ultimately use in their classrooms. We aimed within the course to create an effective teaching and learning environment, that is one in which the individual teachers take responsibility for their own learning. There was to be an emphasis on small-group work with the groups being carefully formed to foster an atmosphere of collaboration, encourage self-help units, maximise the constructive spread of ideas and minimise potentially destructive relative dominance within the groups. Materials used on the course had as far as possible been successfully used by pupils in the classroom. The course organisers saw their role as facilitators who set up mathematical activities, encouraged reflection and extensions, built in ideas related to pedagogical practice, developed didactic sequences to highlight computational ideas and worked alongside teachers to synthesize experiences - both personal and professional.

Course organisers need to share their course goals explicitly with the participants. All participants were given a booklet at the beginning of the course which gave them an overview of the aims and expectations of the course. Expectations for classroom-based work and computer-based assignments were clearly written down and the timetable for each day was given to the teachers at the beginning of each session.

The affective side of learning needs careful consideration. All too frequently the cognitive or conceptual focus of a course is all that is taken on board by course organisers to the neglect of affective considerations.

We recognised that some teachers would be anxious about and resistant to using the computer. Logo activities were used for the teacher's first introduction to the computer, as Logo has been found to be more accessible, meaningful and less threatening than other computer environments.

Achieving a balance of personal learning and a consideration of classroom issues is important. This implies an emphasis on "hands on" activities as the central means to learn new mathematical and/or computational ideas and discussion and group work as a way of focussing on classroom issues. The layout of the computer room was such that the teachers could also use the room for discussion and non computational work. All teachers were given a Logo Pack of materials for getting started in the classroom at the end of the introductory three-day block (Sutherland, Evans & Hoyles, 1986).

Teachers need time to work on Computer-based projects for themselves in order to develop competence in the use of the Logo programming language, and to feel the power that the computer can give them to express mathematical ideas, independently - initially at least - of any pedagogical considerations. Teachers worked on an extended Logo project, the focus of which was chosen by themselves.

Teachers need to develop their own ideas and classroom materials, and try them out in their classrooms (rather than be given pre-determined packages of materials) in order that they can attain a feeling of ownership of the materials, and integrate them into their classroom practice.

Teachers need support with their classroom-based work and in particular to start using the computer in the classroom. This support involved both classroom visits by course tutors and substantial course time devoted to the issue of classroom implementation.

The relevant mathematical idea within the computer-based work need to be continuously and explicitly addressed. We were influenced in this respect by the findings of the Logo Maths Project (Hoyles & Sutherland, 1989) which suggested that embedded mathematical ideas are frequently not appropriated unless highlighted by pedagogical activity.

Hardware issues must be subordinate to the issue of using the computer as an expressive medium. Many teachers are put off using the computer by attending training sessions in which the main focus is on how to use the machine (load and save programs, use the printer etc) and not on what to use the machine for. These issues of hardware were dealt with on the course as part of the on-going mathematical activities. Teachers were able to work with the same hardware at the University as they used in their schools.

2. Components of the Course

The course was substantial in terms of contact time which allowed it to focus on educational rather than technical issues. We structured the course to be 30 days over the period of one school year, with a mixture of blocks of time at the University and one-day sessions at fortnightly intervals. The blocks allowed us to focus in depth on specific issues, while the sessions at fortnightly intervals allowed time to try activities out in schools and allowed space for the course organisers to work with the teachers in the schools. The emphasis shifted in each of the three terms of the course, and this changing emphasis was reflected in the content of the termly blocks. At the beginning of the course the three-day block provided the participants with the opportunity to get to know each other and to become confident in using Logo; in the middle term, the block was devoted to microworld design and production of curricular materials; in the final term, the block was focussed on the question of dissemination and evaluation (4).

The course was structured around the following teacher activities.

"Hands on" activity : During the course sessions teachers worked on both open-ended exploratory projects and more well-defined goals chosen with specific learning aims in mind. These goals were sometimes devised by the teachers themselves and were sometimes suggested by the course organisers.

Extended projects : Teachers were asked to produce an extended Logo project, in order that they had time to develop their own expertise. The teachers chose their own project topic which greatly enhanced the level of motivation and involvement in the project. Projects were written up and presented to the rest of the group, with an emphasis being placed on reflection on their own learning and use of mathematical ideas.

Classroom-Based Work : After the first three days of each course the teachers were expected to start using the computer within one of their mathematics classrooms. During the University-based course sessions participants were asked to report on their computer-based classroom work. In addition the couse tutors made classroom visits.

Case studies : Teachers were asked to develop case studies of two pupils using Logo in their mathematics lesson throughout the year. This was to provide a focus for a discussion of teaching and learning. As part of our input, we presented case-studies of pupil's activities drawn from our previous and on-going classroom-based research work. We were particularly careful to discuss the issue of gender and how this relates to ways of interacting with the computer (Hoyles, 1988).

Microworlds : A central facet of the course involved work with the participants in designing computer-based microworlds for a specific area of the mathematics curriculum with a focus on the effect of the computer on pupils' learning. A starting point in the development of these microworlds was to ask the teachers to reflect on their own experiences of the ways in which pupils commonly hold alternative conceptions of mathematical ideas (for a more detailed description of what we mean by Microworld see Hoyles & Noss, 1987). The microworlds were evaluated by the teachers in their schools.

Dissemination : Teachers were expected to develop dissemination procedures within their school mathematics department and also within their own Local education authorities. Working in groups each teacher devised a plan related to the needs and situation within their school. The implementation of these plans was monitored by the course organisers.

2.1. The Role of Logo Within the Microworlds Course

> ***"I think it's important that we develop our confidence and competence at Logo even if it's not the sort of thing that will carry over directly into the classroom. Even if I've not introduced recursion to any of the students I'm working with...I think if it arises it's important for me to be able to do it."*** **(Microworlds course participant)**

The main computer-based elements of the course were the programming language Logo, a spreadsheet package, a graph plotting package and a database package. In addition some time was spent on 3-D Logo, Control Logo, Graphics Calculus and a number of other small computer programs. We quite intentionally spent a considerable proportion of the course on the Logo programming language as we saw Logo as a paradigm for thinking about the use of mathematical software.

We believe that Logo is a good medium for confronting teachers with their preconceptions about teaching and learning mathematics and also for providing a positive framework for introducing computer anxious teachers to the use of the computer in the classroom.

The Introductory Three-day Block

The Microworlds course started with an introductory three-day block at the University which aimed to allow the teachers to get to know each other and to begin working together as a whole group. This block also gave teachers the opportunity to have an intensive "hands-on" period of computer work with Logo which was aimed at providing them with the confidence to get started in the classroom. During the first session we tried to make explicit the distinction between the teachers' need to learn for themselves and their ultimate aim of helping pupils learn. We stressed that the first few days of the course were for them to develop their own personal competence with Logo.

Within the introductory three day block teachers started with the beginning turtle graphics commands and then worked on a range of open ended and more structured Logo tasks although they were always encouraged to both extend and deviate from the given tasks. An example of one of these tasks is provided by the SMILE task (Ill. 9) which teachers worked on during the second day of the introductory block. This task was valuable for the following reasons :

. it encouraged a mixture of group and individual work;
. it provoked the use of procedures;
. it provoked the need to attend to modularity and turtle state;
. it provoked the need to save and retrieve procedures from disc in order to communicate between members of the group;
. participants could extend the task (for example by making the procedures variable or by randomly generating different words);
. it drew attention to the range of possible solutions to a task.

Ill. 9

S M I L E

We have divided you into small groups. Each one in your group should choose one or more letters from the word SMILE. Then write a procedure to draw your chosen letter.

If you choose the letter M for example it might be helpful if you mark on your letter where the turtle starts and finishes.

When you have all written your procedures put them together in one SUPER procedure which will draw the word SMILE

Then rearrange the letters in a new SUPERPROCEDURE to draw another word.

SLIME MILES

LIMES

We had trialled and refined this task in the classroom (Hoyles & Sutherland, 1989) and it particularly excited the teachers with its potential for classroom use. This meant that the task not only had classroom credibility but that the pedagogic atmosphere created within the session could be used as a model for classroom practice, thus enabling issues of classroom organisation to be discussed.

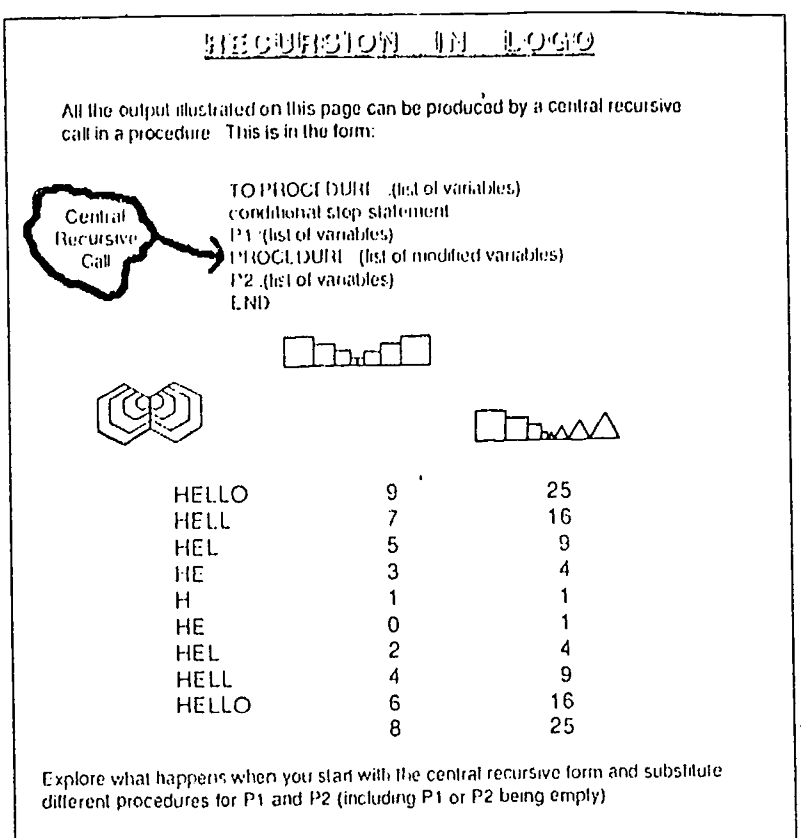
We wanted the teachers to know about the functional nature of Logo and we introduced the idea of functions, composite and inverse functions on the third day of the block. We also had the "hidden agenda" of wishing to preempt any criticisms about Logo being "only turtle geometry".

The "litle people" model (Harvey, 1985) was introduced in the introductory block to provide teachers with a model for the control structures of Logo. These "playing out" activities were evaluated very positively by the teachers as helping them begin to understand the stucture and flow of control of the Logo programming language. It was particularly important for teachers who had had experience of other programming languages with different control structures and one teacher reflected *"I wish I had never learned BASIC. I want to loosen up and not be so in control of the program".*

Aspects of the Course Related to the Idea of Recursion

Within the course considerable emphasis was placed on the idea of using recursive procedures to solve mathematical problems within the turtle graphics, list processing and arithmetic domains. We considered that the sessions related to "full" recursion would both confront the teachers with the need to learn about new and challenging mathematical ideas and provoke them to reflect on their own learning.

Ill. 10



We recognised that the idea of recursion is not trivial. The approaches we used to introduce the teachers were based on a synthesis of previous practice and research in the area (Rouchier & Samurçay, 1985; Guin, 1986; Mendelsohn, 1986). These approaches involved :

. playing out recursive procedures using the "little people model";
. investigating the effect of procedures which include recursive calls;
. constructing recursive solutions for given geometrical objects (Ill. 10).

Initially we worked on central recursion and then extended this to procedures with a number of recursive calls (e.g. to generate fractals or the Fibonnaci series). We aimed whenever possible to make the links between Logo and algebraic representations explicit by presenting the participants with the two representations simultaneously as illustrated below.

$SUM_1 = 1$
$SUM_n = n + SUM_{n-1}$

```
TO SUM :n
IF :n = 1[OP 1]
OP :n + SUM :n-1
END
```

We recognise that within mathematics the main focus is on the formal global expression of recursion, but we found that some teachers (and particularly those who had previously learned to program in BASIC) had difficulty in accepting the idea of a recursive procedure without having some awareness of the process of control within such a procedure. The "playing out" activities were important in this respect. Once the teachers accepted the possibility of a recursive procedure they were more likely to be able to take the "leap of faith" (Harvey, 1985) which is necessary in order to write a recursive program of any complexity.

By the end of the course the majority (16 out of 20) of the teachers were competent at using the ideas of full recursion in Logo. Individuals varied in their evaluation of which aspect of the course was most critical in their developing understanding :

"........you can write the Logo program and then there are some ways that you learn it by looking at Logo programs and somehow I think we have needed both ways to do it..."

"I also thought that when you played out the recursion sequence ....where you had another command after the procedure was called up...that was actually the point at which the idea clicked."

Many of the teachers used ideas of recursion within their own Logo extended projects which they wrote up and presented to the rest of the group. One teacher produced a program which graphically simulated the "Tower of Hanoi" problem :

"The most exciting part of this project was when the first simple Hanoi worked. I knew beforehand that it must but couldn't believe it...I could not believe it would work - after all I had never told it what HANOI was, I had just passed instruction down the line. However with Recursion you MUST HAVE FAITH (caps in original)."

Pedagogical Issues

One aim of the course was that the teacher participants would incorporate computer-based activities into their normal mathematics teaching as set out in the aims (cfr. 1.1). The aspects of the course which supported the teachers in the use of the computer in their classroom were :

. classroom-based tasks upon which teachers were asked to report in a subsequent session;
. case studies made by the teachers of a pair of pupils working in a Logo environment;
. microworlds developed by the teachers;
. classroom visits by course tutors.

As the course progressed opportunities were found to link computer-based activities to issues of teaching and learning whenever possible, relating our own classroom-based experiences as they arose naturally within the discussion. We avoided making presentations on our classroom-based work until later in the course when the teachers had become more confident in their own ways of working with the computer. We did however include two articles Hoyles et al. (1985), Hoyles et al. (1985) in the Logo Curriculum Pack (Sutherland et al., 1986) which we had given the teachers at the end of the introductory three-day-block.

Throughout the course the teachers were given computer-based tasks to try out in their classroom and were expected to give feedback on these activities in the subsequent session. The first such classroom-based activity was the "M" task (Ill. 11) given to the teachers at the end of the introductory three-day block.

Ill. 11

CLASSROOM OBSERVATION TASK

Ask a group of pupils to draw a letter M

Try only to intervene to give support with syntax

Make the following observations.

— What commands do they use

— How do they make decisions about the distances involved

— How do they make the decision about the turtle turns.

— What interventions you feel you needed to make.

When the teachers returned to the University on Day Four after two weeks in their schools, they were organised into groups and asked to discuss the following issues related to their pupil's use of Logo and experiences with the "M" task :
. practical problems associated with starting to use the computer;
. issues associated with their role as teacher;
. reaction of other staff in the department.

As course tutors we mainly listened to and coordinated the discussion in which the following issues arose.

The appropriateness of the M Task for pupils' first Logo experience. Some of the teachers criticised the task for being too closed and this enabled us to discuss the issue of open and closed tasks and the role of exploration in Logo.

The role of intervention. Many teachers reported that they felt anxious to help their pupils and wanted to "interfere all the time". One teacher said that she was going to make a rule to never intervene unless someone asked her a question. Another said that in the past she felt she had been overdirective with her computer work.

Writing Procedures. The discussion centred on the role of procedures in Logo and when and how to introduce them to pupils. Is it acceptable for pupils to produce long strings of commands without writing a procedure ? Should the REPEAT command be introduced before or after the idea of procedure ? How should you intervene if pupils discover recursion by accident ?

Importance of written records. Should pupils be encouraged to write down their commands on paper and what are the implications of this on different planning styles ?

Relevance of the Logo work to mathematics. A minority of teachers expressed concern about how the Logo work related to their mathematics curriculum. They tended to give the reasons for their concern as pressure from the head teacher or parents.

Teacher expectation of pupils. Several reported surprise at what normally "unproductive" pupils produced when working in Logo. One teacher tried out the task with ten-year-old pupils and these pupils appeared to have performed in similar ways to the older secondary school pupils. This provoked a discussion on issues of "readiness" and more generally on what could be expected of pupils of different "abilities" and on "ability" itself.

Organisation and Pupil pairing. Teachers were concerned about how they could fairly organize the computing activity given limited computer resources. They also discussed the issue of how they should pair their pupils, whether in mixed ability or mixed sex pairs.

During this session many crucial issues were raised by the teachers themselves thus providing a framework for on-going discussions throughout the rest of the course. Many of the points raised were related to our ways of introducing Logo throughout the three day block which supports our original conjecture that "the atmosphere and pedagogical input of the course influences the ideas that teachers take away with them".

As the course progressed other classroom tasks and related feedback were concerned with :

. the use of inputs in Logo and its relationship to mathematical variable;
. mathematical investigations in Logo;
. the role of teacher intervention.

Developing Computer-Based Microworlds. As we discussed earlier a central component of the Microworlds course involved work with the participants in designing computer-based microworlds for a specific area of the mathematics curriculum. A consideration of this aspect of the course has highlighted the importance of the process of microworld design and evaluation in encouraging teachers to reflect upon pupils' conceptions, build a pedagogic sequence and evaluate the potential contribution of the computer. In addition developing the microworlds confronted the teachers with the need to make decisions about teacher/pupil control. Many teachers initially developed "CAL-like" computer based environments and then during the process of evaluating them in the classroom began to realize the limitations of this approach, subsequently modifying their microworlds to give more control in terms of mathematical problem solving to the learner.

We now see the creation of a satisfactory product (i.e. a microworld for use in the classroom) to be both more difficult and of lesser importance for the perspective of in-service education (5). The casting of teachers as curriculum developers is problematic : achieving a satisfactory product requires a vastly different range of skills of production and sequencing. In fact, the teachers were themselves highly critical of their own products and this might provide some explanation for their failure to continue to use their own microworlds in their classrooms.

Developing Case Studies. From the beginning of the course the teachers had been told that they would be expected to develop case studies of two pupils working with the computer throughout the year. These were important as a means of focusing on pupils' strategies and different learning styles, as well as sharing classroom experiences. As far as the case-studies were concerned, there was a need for careful structuring of what to observe, how to observe it, and what to report. For example after a case study observation session teachers were asked to reflect critically and report on two interventions which they made during the session, one which they considered appropriate and one which they considered to be inappropriate. Teachers were asked to observe both open-ended computer-based sessions and more structured sessions in which pupils worked on teacher-devised tasks designed for example to provoke pupils to use the idea of variable. Even so, we detected a resistance on the part of some of the teachers, to learn from others' experiences, and to synthesize other teachers' observations with their own.

3. Conclusions

> *"I think the most effective part of the course was the actual time that I had myself working at the computer on a particular task... for me that was the biggest motivating factor for doing it in school because it gave me confidence... people will still ask questions and I don't know the answer... that doesn't bother me so much because there is more of a depth of knowledge there... that I feel sort of secure..."*

When we consider the effectiveness of the Microworlds from the point of view of the teacher's learning of Logo we can conclude that the majority (16 out of 20) of the teachers were confidently able to use a range (6) of Logo programming ideas in order to solve problems of a mathematical nature. The extended Logo project was an important contributory factor in the teachers' developing confidence and the substantial time spent on the idea of recursion was an important catalyst in this development as evidenced by the evaluation interviews carried out by the teachers at the end of the course.

When we analyse the teachers' evaluation of the course (7), feeling confident and competent about using Logo for themselves was the most frequently given reason for continuing to use the computer in their classroom. There is further evidence of the importance of developing confidence and competence when we look more closely at the four teachers who have not continued to use the computer since the completion of the course. These four teachers were still relatively unconfident about their own personal use of Logo at the end of the course. They had all been less motivated to engage in the parts of the course which were predominantly related to their own learning. In particular they had all wanted to make their extended projects relevant for their classroom work and had been resistant to the idea of working on a project which was primarly for their own personal development. This suggests that one of the most critical factors influencing the development of confidence and competence in the use of the computer in the classroom is *a willingness to engage in computer-based activities which are primarly aimed at personal development.*

Teachers valued the clear structure surrounding the course and the course sessions within which they were expected to be in control of and make decisions on their own learning and their own classroom practice. It was the potential for devising or extending tasks for themselves which was the motivating factor provoking task engagement. This is consistent with our findings when working with pupils in the classroom (Hoyles & Sutherland, 1989, Noss, 1985). Participants had high expectations of what the course should offer them and clearly valued the course organisers' expertise. Course organisers having expertise is not the same as course organisers behaving as experts which tends to have a destructive influence on learner autonomy.

The importance of integrating school-based work with University course-work cannot be underestimated. This was achieved by a number of interrelated strands; microworld development, pupil case studies, reporting back on classroom-based tasks, classroom visits by course tutors, which merged throughout the course. Although it is difficult to disentangle the effect of each of these strands the "whole" was a necessary contribution to the effectiveness of the course from the point of view of transition to the classroom.

The need for course organizers to be familiar with Logo both from a personal and professional point of view was a crucial factor in influencing which computer activities continued to be used in the classroom. Course tutors need to be able to base their discussion concerning the pedagogic implications of computer-based activities on their own classroom-based work. These experiences can be informed by theoretical considerations but theoretical considerations alone are not sufficient to give credibility and support to classroom-based issues. This is also related to the need to provide teachers with "tried and tested" computer-based materials for getting started in the classroom.

There are a number of critical barriers to continuing computer use in the classroom which include a lack of computer provision, access to and control over hardware and lack of support from other members of staff, heads of department and heads of schools. It seems that teachers who are confident and competent themselves in using the hardware and software overcome these barriers, but for those who are not so confident the barriers become insurmountable.

All the course participants gave an overall positive evaluation to the course and the majority (16 out of 20) continue to use the computer in their mathematics classroom in ways which are qualitatively and quantitatively different from their use of computers before they started the course. The following quote from one of the teacher participants who at the start of the course was almost a computer-phobic sums up the feelings expressed by many of the others members of the course.

> *The course helped me to develop from a stage in which I did not know what a floppy disc was to becoming a confident computer-using maths teacher and not (thank goodness) into a computer expert.*

Footnotes

(1) England is divided into just over one hundred local authorities which have a reasonable amount of autonomy with respect to education.
(2) This course was part of the Microworlds Project funded by the ESRC (Economic and Social Research Council) 1986-1989. The In-service course itself received no additional financial support. Participants had to be recruited and the responsibility for funding them (including paying for teachers to cover them while they attended the course) lay entirely with the local authority.
(3) All teachers on the course taught in secondary schools.
(4) It is not possible to preset here all the details of the course. For a more detailed description of the Microworlds course see Sutherland, et al. , 1990.
(5) We have however as part of the Microworlds Project still addressed the issue of Microworld Design and evaluation (Hoyles, et al. , 1990).
(6) This range includes the ideas of procedure, superprocedure, variable, function and recursion.
(7) For a more detailed discussion on teacher attitudes see Noss et al. (1990).

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Chapter 9
CONCLUSIONS ARISING FROM THE PROJECT REPORTS

Children, entering primary school now, will be leaving secondary school at the beginning of the next century. In terms of their education, many new skills have to be taught and developed. They have to be acquainted with the new technologies and it must be demystified for them. They should also be given every opportunity to use the new technology.

The reports in this book have highlighted the fact that N.I.C.T. will play an increasing role in the delivery of the educational service in the compulsory education phase. The strategy to be adopted, in using N.I.C.T., will be to integrate as much as possible the technology into the total school curriculum.

The following observations have been highlighted in the various reports :

In terms of pre-service education, in some countries a major national initiative has been undertaken, while in other countries only institutional initiatives have been adopted. The same is also true for the in-service education of teachers. There is evidence to support the view that every E.C. country **should undertake a major national initiative** in this respect.

It is striking that in many initiatives, presented throughout this book, the **existing** teacher educational structures and instituations play a major role, both in pre-service and in-service education.

A **wide range of methods and strategies** have been adopted in the different countries in conducting pre-service and in-service education.

Teachers are convinced of the potential **relevance** of the use of **N.I.C.T. in education.**

In terms of pre-service and in-service education of teachers, **Logo** has been regarded as an **essential feature.**

Logo has also been seen to play a major part in **delivering curriculum integrated learning** experiences to the children.

Success in delivering an effective in-service education was due mainly in the following features :

Logo and implementation :
- the design of a structured introduction plan as part of an innovation strategy;
- the relevance of the course content to the daily practice;
- the balance between school-based and college-based work.

Logo and resource materials :
- the provision of well-documented resource materials;
- the provision of ready-to-use Logo-microworld materials.

Logo and teacher-education structures :
- the training of teacher trainers;
- building up the proficiency of teacher in a gradual way;
- ease of contact between trainers and teacher in the field;
- access to the teacher trainers by the teachers in the field.

Logo and teacher-education support :
- the provision of continuous support to the teacher;
- the founding of a resource team;
- the establishment of an adequate support structure.

Logo and teacher-attitudes :
- a high degree of personal involvement of the teachers in the teacher education process;
- the involvement of teachers in the planning and implementation of the teacher education process;
- the necessity to develop teaching materials and classroom materials, in cooperation with the teachers.

Logo and educational policy :
- the long-term nature of the courses;
- focusing on developing the 'abilities' of the teachers;
- seeing teacher education as part of curriculum development;
- the link between the use of Logo and the general teaching and learning approach of the teacher;
- the fact that Logo was considered as part of a richer - technology-supported - learning environment;
- the attention paid to the affective and social sides of teaching and learning;
- the fact that hardware issues were subordinate to the issue of using computers.

The examples of teacher education initiatives, described in this book, prove that the use of the Logo programming language can be a very effective and efficient way to support teacher education. Its value has been proved in terms of pupil and teacher outcomes. In particular the language is flexible and can be easily adapted to specific needs. The examples of microworlds, toolkits, etc. in this book, illustrate the diversity of application fields and the rich nature of learning experiences when presented to the children.

Furthermore, the use of microworlds has indicated that Logo can be more than just a powerful educational medium to support actual educational practice. It also shows that the use of Logo can help to introduce into our schools new, motivating and exciting dimensions to teaching and learning. In this respect, it is striking that most authors in this book refer to the constructivist learning approach as being very valuable in using Logo with the children.

However, evidence from the reports has indicated that in using N.I.C.T. in education, a high level of commitment and a great deal of hard work is involved.

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