

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

MASSEY UNIVERSITY

**LOGO PROGRAMMING:
INSTRUCTIONAL METHODS AND
PROBLEM SOLVING**

by

WING KEE AU

A THESIS

PRESENTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

IN

EDUCATION

FACULTY OF EDUCATION

MASSEY UNIVERSITY

PALMERSTON NORTH

NEW ZEALAND

DECEMBER, 1992

© WING KEE AU, 1992

Abstract

This study was conducted to examine the effects of the learning of programming on the problem solving abilities of primary school children. Two programming languages were used: LOGO and BASIC. The aim of the study was threefold. First, the study compared the two programming languages in the development of problem solving skills. Second, this study compared the effectiveness of two different instructional methods in the teaching of LOGO programming: process-oriented and content-oriented approaches. The third aim of this study was to examine the social interactions among the learners who engaged in LOGO and BASIC programming.

The sample for the study comprised 73 subjects drawn from a primary school in Palmerston North, New Zealand. Subjects were screened initially on their background knowledge in programming to ensure that they did not possess any substantial knowledge in programming before participating in the study. The subjects were then randomly assigned to four groups: LOGO process-oriented, LOGO content-oriented, BASIC, and control. These groups of subjects were then pre-tested on a number of problem solving measures: Rule-naming task, Tower of Hanoi, Torrance Test of Creative Thinking, Object Assembly, Block Design, Picture Assembly, and PAT Mathematics. The intervention phase in the form of learning programming of either LOGO or BASIC then took place for the three experimental groups. During the intervention, observations on the social interactions of teachers and students in the learning environment were also made. At the end of the 20 week intervention, subjects were then post-tested on their problem solving skills.

The findings revealed that students who learned LOGO programming were able to demonstrate transfer of problem solving skills to a near-transfer context but not to a far-transfer context when compared to students who learned BASIC. Also, students who learned LOGO programming using a process-oriented approach demonstrated better transfer of problem solving skills to a near-transfer context with complicated problems than did students who learned LOGO programming using a content-oriented approach. Classroom observation during the intervention phase also showed that there were more substantive verbal and non-verbal interactions among

students who learned LOGO compared with students who learned BASIC. Also, students in the process-oriented group were involved in more classroom interactions than students in the content-oriented group.

The main conclusion from this study is that LOGO programming could be used to facilitate the development of problem solving skills among students. In particular, the process-oriented approach, which focuses on the processes of problem solving, could be used to assist students further in the development and transfer of problem solving skills. As well, LOGO programming could also facilitate more social interactions among the students, especially if the instructional method provides such an emphasis.

This dissertation is dedicated to
my parents and my wife, Ching Hung,
whose understanding and support provided me with
the encouragement and determination to complete this work.

Acknowledgments

This thesis has been accomplished through the assistance of a number of mentors, colleagues, and friends. They cannot be held accountable for its deficiencies, but if merit resides in its pages much is undoubtedly due to them.

Thanks must go to my chief supervisor, Dr Kenneth Ryba, who provided me with excellent professional supervision and inspiration throughout the duration of this research. I am especially grateful to Professor Ray Adams, who has continued to supervise my thesis even after his retirement, for his wise counsel and critical appraisal of this dissertation. Special thanks must go to Associate Professor Don McAlpine, whose support during Dr Ryba's sabbatical leave has been invaluable. Over the years, these three mentors have provided me with excellent models of critical and logical analysis, as well as meticulous scholarship, examples which I have striven vainly to emulate. I am particularly indebted to Associate Professor Lorna Chan of University of Newcastle, Australia, who has given me much appreciated advice and guidance regarding statistical analyses. Professor David Battersby of Charles Sturt University, Australia, has offered valuable critical and constructive comments in the final editing of this thesis. Thanks must also be offered to Dr. Kerry Chamberlain of Massey University, who assisted in the initial stages of this investigation.

In addition, a number of colleagues in Australia, Canada, Hong Kong, New Zealand and the United States responded with information and encouragement regarding this study. I extend my gratitude for their efforts, interests and support to the following: Dr Patricia Babbs, Dr John Borkowski, Dr John Burton, Dr James Chapman, Dr Douglas Clements, Dr Geoff Cumming, Dr Diane Cuneo, Ms Teresa Doyle, Dr Catherine Emihovich, Dr Greta Fein, Dr Joan Gallini, Dr Henry Gorman Jr, Dr Mark Grabe, Dr Kay Irwin, Dr Judith Kull, Dr Kwok Wing Lai, Dr David Lancy, Dr John Leung, Dr Marcia Linn, Dr Allan McAllister, Dr Anne McDougall, Dr Annemarie Palincsar, Professor Seymour Papert, Dr Robert Seidman, Mr Chris Watson, Dr Peter Williamson, Dr Sylvia Weir, Ms Sandra Wills, and Dr Susan Zelman.

I am extremely grateful to the principal, Mr. Richard Bullock, and the staff of the Hokowhitu Primary School for their assistance and support during the course of this investigation. My sincere thanks must also go to the students who participated in this research, and to their parents who provided so much support during this study.

This research would not have been possible without support and funding from a number of organizations, and appreciation must be extended to them. Firstly, IBM (NZ) Corporation supplied all the computing equipment and software for this study as well as funding for the employment of the necessary personnel. Special thanks must go to Ms Pamela Yates, the Education and Marketing Manager of IBM (NZ), and the technical staff who were always there to overcome various crises during this study. Secondly, the Education Department of Massey University provided the funds for the purchase of necessary testing instruments. Thirdly, Brightway Ltd donated some of the testing equipment for this study.

I am indebted to Bill Anderson, Ron Henderson, and Jane Horton, who helped to teach the children in this study, and provided constructive suggestions about the design of the teaching modules used in this investigation. A number of graduate students at Massey University helped to conduct the testing of students with much cheerful competency. I am beholden to: Teresa Ball, Karolle Galtema, Ron Henderson, Bev Hong, and Lois Wilkinson.

Appreciation is also due to Associate Professor Phil Moore, who has allowed me time to complete writing this thesis at the University of Newcastle in Australia, as well as for his support and friendship.

Finally, to my parents and my wife are due my acknowledgment and gratitude for the emotional support, encouragement, and understanding through the inevitable stresses associated with this doctoral investigation.

Table of Contents

Chapter	Page
I INTRODUCTION AND OVERVIEW	1
II REVIEW OF COMPUTER APPLICATIONS IN EDUCATION	8
III LOGO: CHARACTERISTICS, THEORETICAL FOUNDATION AND CLAIMS	25
IV REVIEW OF RESEARCH ON LOGO PROGRAMMING	42
V PROBLEM SOLVING AND COMPUTER PROGRAMMING: INSTRUCTIONAL IMPLICATIONS	83
VI RESEARCH DESIGN AND METHODOLOGY	110
VII RESULTS	143
VIII DISCUSSION	208
BIBLIOGRAPHY	236
APPENDICES	
1. Summary of LOGO research	269
2. Examples of teaching modules	291
3. Rule Naming Test - instructions for administration	346
4. Rule Naming Test - scoring sheet	349
5. Tower of Hanoi - instructions for administration	351

6.	Tower of Hanoi - scoring sheet	354
7.	Tower of Hanoi - calculation of solving sub-problems	356
8.	Questionnaire to all subjects in the main study	358
9.	Schedule for observation of teachers	361
10.	Schedule for observation of individual students	363
11.	Schedule for observation of groups	365
12.	A typical LOGO lesson	367

LIST OF TABLES

Table	Page
5.1 List of learning strategies	84
5.2 Comparison between process-oriented and content-oriented approaches	108
6.1 Schematic representation of the experimental design	111
6.2 Processes and exemplars of the process-oriented approach	135
7.1 Age and sex distribution of subjects	144
7.2 Listening Comprehension and Reading Comprehension Score Distribution of Subjects	144
7.3 ANOVA Summary Data for Mathematics Achievement: Pre- Versus Post- Test Comparison	146
7.4 Means and Standard Deviations for Mathematics Achievement: Pre- Versus Post- Test Comparison	146
7.5 ANOVA Summary Data for Raven's Standard Progressive Matrices: Pre- Versus Post- Test Comparison	148
7.6 Means and Standard Deviations for Raven's Standard Progressive Matrices: Pre- Versus Post- Test Comprehension	148
7.7 ANOVA Summary Data for WISC-R Picture Arrangement: Pre- Versus Post- Test Comparison	150
7.8 Means and Standard Deviations for WISC-R Picture Arrangement: Pre- Versus Post- Test Comparison	150
7.9 ANOVA Summary Data for WISC-R Block Design: Pre- Versus Post- Test Comparison	151
7.10 Means and Standard Deviations for WISC-R Block Design: Pre- Versus Post- Test Comparison	151
7.11 ANOVA Summary Data for WISC-R Object Assembly: Pre- Versus Post- Test Comparison	152
7.12 Means and Standard Deviations for WISC-R Object Assembly: Pre- Versus Post- Test Comparison	152

7.13	ANOVA Summary Data for Rule Naming Task - Number of errors: Pre- Versus Post- Test Comparison	154
7.14	Means and Standard Deviations for Rule Naming Task - Number of errors: Pre- Versus Post- Test Comparison	154
7.15	ANOVA Summary Data for Rule Naming Task - Number of Trials to Criterion: Pre- Versus Post- Test Comparison	155
7.16	Means and Standard Deviations for Rule Naming Task - Number of Trials to Criterion: Pre- Versus Post- Test Comparison	155
7.17	ANOVA Summary Data for Torrance Test of Creative Thinking - Fluency: Pre- Versus Post- Test Comparison	157
7.18	Means and Standard Deviations for Torrance Test Creative Thinking - Fluency: Pre- Versus Post- Test Comparison	157
7.19	ANOVA Summary Data for Torrance Test of Creative Thinking - Flexibility: Pre- Versus Post- Test Comparison	158
7.20	Means and Standard Deviations for Torrance Test of Creative Thinking - Flexibility: Pre- Versus Post- Test Comparison	158
7.21	ANOVA Summary Data for Torrance Test of Creative Thinking - Originality: Pre- Versus Post- Test Comparison	159
7.22	Means and Standard Deviations for Torrance Test of Creative Thinking - Originality: Pre- Versus Post- Test Comparison	159
7.23	ANOVA Summary Data for Torrance Test of Creative Thinking - Elaboration: Pre- Versus Post- Test Comparison	160
7.24	Means and Standard Deviations for Torrance Test of Creative Thinking - Elaboration: Pre- Versus Post- Test Comparison	160
7.25	ANOVA Summary Data for Torrance Test of Creative Thinking - Total: Pre- Versus Post- Test Comparison	161
7.26	Means and Standard Deviations for Torrance Test of Creative Thinking - Total: Pre- Versus Post- Test Comparison	161
7.27	ANOVA Summary Data for Tower of Hanoi - Three-disk Problem - Number of Moves: Pre- Versus Post- Test Comparison	164

7.28	Means and Standard Deviations for Tower of Hanoi - Three-disk Problem - Number of Moves: Pre- Versus Post- Test Comparison	165
7.29	ANOVA Summary Data for Tower of Hanoi - Three-disk Problem - Two-disk Sub-problem: Pre- Versus Post- Test Comparison	167
7.30	Means and Standard Deviations for Tower of Hanoi - Three-disk Problem - Two-disk Sub-problem: Pre- Versus Post- Test Comparison	168
7.31	ANOVA Summary Data for Tower of Hanoi - Four-disk Problem - Number of Moves: Pre- Versus Post- Test Comparison	172
7.32	Means and Standard Deviations for Tower of Hanoi - Four-disk Problem - Number of Moves: Pre- Versus Post- Test Comparison	173
7.33	ANOVA Summary Data for Tower of Hanoi - Four-disk Problem - Two-disk Sub-problem: Pre- Versus Post- Test Comparison	175
7.34	Means and Standard Deviations for Tower of Hanoi - Four-disk Problem - Two-disk Sub-problem: Pre- Versus Post- Test Comparison	176
7.35	ANOVA Summary Data for Tower of Hanoi - Four-disk Problem - Three-disk Sub-problem: Pre- Versus Post- Test Comparison	178
7.36	Means and Standard Deviations for Tower of Hanoi - Four-disk Problem - Three-disk Sub-problem: Pre- Versus Post- Test Comparison	179
7.37	ANOVA Summary Data for Tower of Hanoi - Five-disk Problem - Number of Moves: Pre- Versus Post- Test Comparison	183
7.38	Means and Standard Deviations for Tower of Hanoi - Five-disk Problem - Number of Moves: Pre- Versus Post- Test Comparison	184
7.39	ANOVA Summary Data for Tower of Hanoi - Five-disk Problem - Two-disk Sub-problem: Pre- Versus Post- Test Comparison	186
7.40	Means and Standard Deviations for Tower of Hanoi - Five-disk Problem - Two-disk Sub-problem: Pre- Versus Post- Test Comparison	187
7.41	ANOVA Summary Data for Tower of Hanoi - Five-disk Problem - Three-disk Sub-problem: Pre- Versus Post- Test Comparison	189
7.42	Means and Standard Deviations for Tower of Hanoi - Five-disk Problem - Three-disk Sub-problem: Pre- Versus Post- Test Comparison	190
7.43	ANOVA Summary Data for Tower of Hanoi - Five-disk Problem - Four-disk Sub-problem: Pre- Versus Post- Test Comparison	192

- 7.44 Means and Standard Deviations for Tower of Hanoi - Five-disk Problem -
Four-disk Sub-problem: Pre- Versus Post- Test Comparison 193
- 7.45 Interaction of teachers with students 196
- 7.46 Student group interaction 199
- 7.47 ANOVA Summary Data for Substantive Verbal Interactions 203
- 7.48 Means and Standard Deviations for
Substantive Verbal Interactions 204
- 7.49 ANOVA Summary Data for Substantive Non-Verbal Interactions 205
- 7.50 Means and Standard Deviations for
Substantive Non-Verbal Interactions 205
- 7.51 ANOVA Summary Data for Non-Substantive Interactions 206
- 7.52 Means and Standard Deviations for
Non-Substantive Interactions 206

LIST OF FIGURES

Figure	Page
3.1 LOGO Turtle Graphics	29
4.1 Chain of Cognitive Accomplishment	77
5.1 A Guide to Self-management in Solving a Problem	97
7.1 Tower of Hanoi: Three disk problem - Number of moves	166
7.2 Tower of Hanoi: Three disk problem - Two-disk sub-problem	169
7.3 Tower of Hanoi: Four disk problem - Number of moves	174
7.4 Tower of Hanoi: Four disk problem - Two-disk sub-problem	177
7.5 Tower of Hanoi: Four disk problem - Three-disk sub-problem	180
7.6 Tower of Hanoi: Five disk problem - Number of moves	185
7.7 Tower of Hanoi: Five disk problem - Two-disk sub-problem	188
7.8 Tower of Hanoi: Five disk problem - Three-disk sub-problem	191
7.9 Tower of Hanoi: Five disk problem - Four-disk sub-problem	194
7.10 Student Group Interaction	200