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Learners as designers: computers as cognitive tools inarchitecture education

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Learners as Designers: Computers as Cognitive Tools in Architecture Education

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DECLARATION

Except where stated in the text, and in the list of acknowledgments, this thesis represents the original work of the author, and the material has not been submitted for a degree to any other university.

Final corrections have been made to the text in accordance with the examiners' reports.

Ian Hart

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SUMMARY

In a problem-based, computer-intensive learning environment, what is the nature of the interaction between student characteristics, computers and cognition? The question is examined in the context of an intensive study of 19 students of Architecture undertaking a 6 month problem-based course in which they were required to work collaboratively on the design and construction of interactive 3D models using a range of software in a Silicon Graphics laboratory. The research method was predominantly naturalistic and data-driven, employing video observation, interviewing, mind mapping and mental modelling. The computer tool used to organize, search and report on the data was NUD•IST (Non-numeric Unstructured Data – Indexing, Searching & Theorizing). The research strongly supported the constructivist paradigm of learning and isolated a range of factors which are relevant to successful cognitive construction in computer-rich environments: approach to learning, as measured on the Study Process Questionnaire; declarative, procedural and contextual knowledge of computing; the ability to make connections between computing and domain concepts; metacognitive awareness, in particular the conscious use of distributed cognitions; and recognition of the "affordances" of the computer system. The highest achieving students exhibited an overall deep approach to learning (with above average scores on deep motive) and a high level of contextual computing knowledge and structural integration of domain and computing concepts. Follow-up interviews were conducted 6 and 12 months after the course and these provided some evience of what Salomon (1993) describes as "cognitive residue" or long-term effects of working with intelligent tools.

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INTRODUCTION

This Ph.D. thesis began life in 1990 at the University of Canberra as an action research project on authentic video for Chinese language learning. My appointment to the University of Hong Kong in 1992 meant losing my pool of subjects (Australian secondary students) so rather than try to reproduce the study I decided to look for a topic more relevant to the educational concerns of my new environment. The subject matter of the present study – computers as cognitive tools in Architecture – may seem a far cry from the original, but the assumptions remain the same: the importance of individual differences, a predominantly constructivist view of learning, and a methodology based on "action research" and naturalistic forms of enquiry.

In the course of trying to reinvent my Ph.D. research in a Hong Kong context I investigated a number of educational multimedia projects then under development. The most promising of these was the Faculty of Architecture's "interactive visual dictionary" of building structures, materials, regulations and methods being developed by John Bradford and his Ph.D. student Waycal Wong, using the university's first Silicon Graphics work station. In 1993 the Architecture Department received a capital grant to install a complete laboratory of SGI machines. Barry Will, the Dean, and John Bradford proposed an experiment to introduce 3D computer modelling into the graduate program (Bradford, Ng, & Will, 1992a; Bradford, Ng, & Will, 1992b). As a first step Will included some computer modelling problems in his 1993-94 Building Systems class. The experiment received such positive feedback from students that in 1994-95 the problem-based approach to 3D computer modelling was formally incorporated into the curriculum.

As accreditation of professional programs is dependent upon the approval of the local industry and professional organizations, the

Architecture department was anxious to demonstrate that such a departure from traditional teaching methods was educationally effective. They were, therefore, happy to collaborate with me on a longitudinal study of the 1994-95 cohort of students. Together we made an application for funding from the University Research Grants Council to assist with documenting the progress of the course.

One of my aims was to continue and further develop the naturalistic methods of enquiry I had been pursuing in the earlier project, so rather than devise a "conventional" educational technology research design with a hypothesis and a control group, we adopted instead the Action Research paradigm. Action research is a cyclical process of acting – observing – reflecting, in which the learners are accepted as participants in the research rather than looked upon as subjects under investigation (Carr & Kemmis, 1986; Stringer, 1996); the antithesis of what Biggs (1995) has described as: "the whistle-clean, four-square symmetry of the psycho-lab." (p.50)

The action research project provided an ideal setting for my own research on the role of computers in education, not as delivery vehicles for information (e.g. through CAI), but as cognitive tools with which students construct their own learning.

I posed the following question:

In a problem-based, computer-intensive learning environment, what is the nature of the interaction between student characteristics, computers and cognition?

Investigating the question involved observing the Building Systems class as they came to terms with working in a demanding, production-oriented computing environment over a period of 5 months (with follow-ups 6 and 12 months later). The methodology was qualitative and data-driven, utilizing a variety of research tools and an approach which owes a great deal to the "grounded theory" of Anselm Strauss (1987; 1990). The

aim of this project was not to produce a new theory nor to prove or disprove a hypothesis, even a null hypothesis, but to seek for what Guba (1982; 1988) and Richards (1993; 1992) see as the real goals of qualitative research: "perceptions", "insights" and "coherence".

1. **Chapter 1** situates the question within the context of historical and current research on learning and research methodology.
2. **Chapter 2** situates *the problem-based computer-intensive learning environment* within the narrower context of architectural education at the University of Hong Kong and describes the Building Systems curriculum and the computing facilities.
3. **Chapter 3** describes the heterogeneous and unstructured data which was collected over the 18 months of the study.
4. The classification of *student characteristics* is the subject of **Chapter 4** and includes both qualitative measures based on normed scales and a number of less conventional, qualitative indicators. The resulting individual student profiles have been compiled in **Appendix A**.
5. The students' *interactions* with computers and the Building Systems course are collected, classified and analyzed in **Chapter 5**, using the NUD•IST™ indexing system.
6. **Chapter 6** is a narrative treatment of the interaction derived from Chapter 5's indexing structure and consists of case studies of the four student projects. **Appendix B** contains off-line documents relating to the projects.
7. **Chapter 7** examines two types of *cognition*: which emerged from the data as particularly significant: metacognition and distributed cognitions.
8. Finally, **Chapter 8** returns to the original question and considers what the study has provided in terms of perceptions or insights into the

interaction of student characteristics, computers and cognition and suggests a hypothesis which can be tested using the data.

A journal article and a book chapter relating to my original research work on educational technology and language learning have been published (Hart, 1992; Hart, 1995b) and a number of refereed conference papers and reports have been produced as part of the Action Research Project (Bradford, Hart, & Will, 1995; Hart, 1995a; Hart, 1996; Will, 1995). Three of these papers are reprinted in **Appendix C**.

Names

Names can be a source of confusion for people unfamiliar with Hong Kong forms of address as most students have both a European Christian name and a three-syllable chinese name. In this thesis I have employed the names which the students prefer to be called by: e.g. Michael Yew Koon-wai prefers to be called Wai; Alice Teng Yiu-wai prefers Alice. Following is a reference list of the names which appear in this thesis.

Alice	*female*	Temple Base group
Bonita	*female*	Temple Dau-gung group
Christina	*female*	Curtain Wall group
Desmond	*male*	Temple Dau-gung group
Fai	*male*	Curtain Wall group
Frankie	*male*	Curtain Wall group
Han	*female*	Morphing group
Howard	*male*	Morphing group
Joan	*female*	Maintenance group
Leung	*male*	Temple Base group
Matchy	*male*	Ph.D. student (teaching assistant)
Mo	*male*	Maintenance group
Ronald	*male*	Temple Base group
Shirley	*female*	Maintenance group
Yat-man (aka Man)	*male*	Maintenance group
Yin (aka Ho-yin)	*male*	Temple Dau-gung group
William	*male*	Temple Base group
Wai (aka Michael)	*male*	Curtain Wall group
Wai-man	*female*	Morphing group
Wai-ling	*female*	Research Assistant
Waycal	*male*	Ph.D. student (teaching assistant)

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In December 1994 the Department of Architecture and Centre for Media Resources were awarded a 12 month grant under the Action Learning Project (funded by the University Grants Commission) to evaluate the introduction of computer-based teaching in the Architecture degree programme. The funds provided for the employment of a Research Assistant in the Architecture Department, Miss Yung Wai-ling. Her duties included assisting the lecturer with course organization, and documenting the progress of the course. She also assisted me with setting up and operating equipment, filing, translation from Cantonese to English and some preliminary indexing. Her assistance is gratefully acknowledged.

Twenty students contributed to this study and I would like to record my thanks to all of them for their generous and unreserved cooperation at all stages of the project.

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Ian Hart

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