Interactive decision support systems and activity theory: a population projection flow model for strategic planning in education

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INTERACTIVE DECISION SUPPORT SYSTEMS AND ACTIVITY THEORY: A POPULATION PROJECTION FLOW MODEL FOR STRATEGIC PLANNING IN EDUCATION

A thesis submitted in fulfilment of the requirements for the award of the degree

DOCTOR OF PHILOSOPHY

from

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by

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DECLARATION

This is to certify that the work presented in this thesis was carried out by the author in the Department of Business Systems at the University of Wollongong, Australia and is the result of original research and has not been submitted for a degree at any other university or institution.

Edward Gould
ABSTRACT

Population modelling is an important component in educational decision support systems. This thesis describes how a problem faced by demographers in predicting school based populations can be solved by the use of a decision support system based on a model which balances micro based population values derived at school levels against more accurate nationally derived figures. The approach taken is to use an interactive human-centred computerised solution so that demographers can make full use of their local knowledge, intuition and experience. Because of the interactive nature of the model, concentration is focused on the active position of the user. To achieve this the cultural-historical tradition in psychology and activity theory were used as a basis for the approach and involved the concepts of mediation of activity with a tool, exteriorisation/materialisation and goal formation.
PUBLICATIONS ARISING FROM THE THESIS


PREFACE

0.1 Introduction

The work covered in this thesis forms part of a decision support system to assist senior education administrators in strategic planning, a process requiring precise long term information. The accurate prediction of school population figures forms the crucial first step in modelling the education system. From these population figures other variables such as the demand for teachers, classrooms/buildings and finances are calculated and hence population projections form the basis for the whole decision support system. However, education planners not only need gross population figures at the national level but also at an individual school level for micro planning in particular districts. Nationally derived population numbers produced by the relevant Statistics Bureau and based only on macro statistics of population growth, redistribution, immigration and mobility are of limited use for school level planning because of the difficulties inherent in disaggregating data accurately.

An alternate approach is to use school level enrolment data and 'flow' it through the school grade system. Obtaining this data presents no special problems as it is collected
periodically from schools by relevant authorities usually in a standard format and with dependable integrity. Predicting the number of entrants to the first grade is dependent on the availability of data relating to the age distribution of pre-school children in the feeder areas for each school. Once these two sets of data have been obtained the flow of pupils through the whole or part of the school education system can be modelled.

A characteristic of populations in small geographical areas is that they are extremely sensitive to local conditions. For example the opening of a new housing estate or a large construction project can cause local fluctuations in the number of school age children. This means that the projection model must allow for manual intervention so that planners can manipulate the figures and take full advantage of local knowledge and intuition regarding population changes which affect individual schools. One problem faced by planners using a school based micro-level approach is that the effects of national population trends such as birth rates, immigration, mobility and redistribution are unavailable for such small areas. This means that aggregating separate school populations will yield inaccurate results for the nation as a whole, the opposite effect to that of disaggregation. The outcome is that two sets of figures need to be produced, one based on national (or regional) data and the other based on the individual school data.

0.2 Statement of the Problem

Given the two sets of population data (micro and macro) as outlined above, the problem is to find the most expedient and efficient method for ‘balancing’ the two populations so
that accurate school projections can be obtained which aggregate to the same value as the more accurate national (macro) population values. A system for producing school based population figures is described but given the sheer amount of data output by this computerised system a unique interface was required which took into account psychological characteristics of human operators and their interaction with complex data sets. A technique was needed which was based both on an appropriate psychological theory and the principles of visual interactive data modelling.

0.3 Rationale and Scope

A number of different approaches to the balancing of the macro and micro population figures are possible; one is to solve the balance by mathematical or operations research based techniques, another is to use an expert system to mimic the performance of a demographer under given conditions and the third approach is to design an interface which allows individual demographers to interact with the flow model and provide a balance manually. It is the third option that is the subject of this thesis.

The ideas in the thesis arose from work carried out in demographics information systems for the Australian state of NSW Department of Education where the author worked as a Senior Education Officer on the development of a projection system for school enrolments. Further refinements of the concept came form a period of study leave taken at UNESCO's Office of Statistics (Division of Statistics on Education) in Paris. Both these experiences made it clear that there was a need for such a projection system.
The scope of the study is the projection of population figures for school children during the first 7 years of their schooling, known in NSW as kindergarten through years 1 to 6. This covers ages 5 to 11 in the normal pattern of enrolment.

0.4 Contribution of the Thesis

This thesis makes a unique contribution in two ways:

- An interactive school-based flow model is developed showing how anomalies can be overcome by the use of nationally derived data as a control over aggregated school based data provided good local demographic knowledge is available and can be utilised by the appropriate interface.

- The background philosophy for the choice of this human centred approach to a solution and the design of the interactive interface is based on the Russian developed cultural historical psychology known as activity theory.

0.5 Synopsis

Chapter one contains much of the theoretical background to the thesis with sections on decision making, computerised decision support systems, educational strategic planning and two branches of psychology. The first is cognitive psychology based on the
information processing model of human cognition. The second branch of psychology is the lesser known Russian developed cultural-historical activity theory with its emphasis on the development of the human mind as an organ of socio-cultural determination. This background theory forms the basis of the choice of model outlined in the second chapter.

Chapter two is primarily devoted to the development of a flow model solution to the ‘balance’ problem outlined in Section 0.1. Following a description of flow models in general, the details of a model in use by the Australian state of New South Wales is presented. This is followed by alternate solutions to the balance problem and reasons for the choice of a solution based on activity theory rather than the information processing model of cognitive psychology.

Chapter three contains the design of an interface to support the model developed in the previous chapter. It begins by relating the concept of mediation of activity by tools and introduces techniques for interactive modelling. A working prototype interface is constructed which is based on the previous theory and on the basis of an experiment on the use of colour in relation to various notions of variation in population. This can be considered the main contribution of the thesis and proves the feasibility of this approach.

Chapter four contains the concluding remarks and discusses the possible application of this approach to other areas of decision support for strategic planning such as budgeting.
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