1251: What do the Doorknobs tell us about the Mansion? A Report of a Mathematics Curriculum Change Longitudinal Investigation

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Abstract

The lack of full evaluations of curriculum change in NZ has prompted a project to establish a basis for future evaluations. A longitudinal study of the curriculum is being done so that the interrelationships between parts of the curriculum can be identified., and the effect of change in any part can be monitored and/or predicted. Methodological problems of undertaking the project with limited resources is discussed. A new technique of 'icon development' using video material of students is described.

Introduction

New Zealand has, like many other English-speaking countries, undergone a recent, radical curriculum change in school mathematics at all levels (Ministry of Education, 1992) Also like other countries, this has taken place in an environment of organisational reorganisation and modified assessment. These significant changes have not been accompanied by coherent statements of the theory of how these will improve mathematics education, nor by any overall evaluation of their effect. It might be added that neither did this occur at times of earlier curriculum change, e.g. during the New Math changes of the 1960's.

One reason for the lack of such evaluation is the absence of any base from which to make a comparison. Measures of educational achievement (e.g. national examinations or IEA studies) are often looked to for evidence of improved curricula, however this practice has two problems. The validity of this evidence is reduced because what is being tested is different from one time period to the next. More importantly, however, there is no evidence to link any changes in achievement to any specific aspect of the curriculum, let alone to a specific curriculum change.

Thus any base-line information about the curriculum intended for an evaluation of purposeful changes must be able to describe or quantify changes (in educational outcomes and in other aspects of the curriculum). It must also be able to link these changes to the purposeful change. Such evaluation is not just descriptive. It also has a predictive and developmental role which contributes to better planning. Establishing such base-line information is the aim of a project which has been initiated in the Mathematics Education Unit of The University of Auckland (see earlier Report of Work in Progress, Ellis et al, 1994).

The research team has faced two major challenges. Any longitudinal study has the problem of comparing situations which are widely separated in time. This means that the context of education is going to be very different: the requirements of school leavers, public opinion of a good education, financial resources allocated to education, and so on. Thus a longitudinal study must find some way of comparing like with like.

The other challenge is that the mathematics curriculum, however it is conceived, is a large and complex system. In this particular study, there are severe restrictions on the resources available to the researchers. The study has been undertaken with four main researchers, none of whom are full-time on this study. Furthermore there was no guaranteed funding, although applications to date have met with reasonable success. How can such a large system be effectively described in such a small project?

This paper describes the approach taken by the research team to overcome these twin difficulties. The overall design of the study is related to the type of data required as a base-line and to the resource limitations. There follows a description (from one small part of the study) of an innovative technique which has been designed so that qualitative information from several informants can be combined while it is being collected.

Filming a Mansion: The Design of the Project

The research team have used the metaphor of a building to think about the problem of describing a large and complex system. How is it possible to take a series of photographic records of a large mansion, say, so that the changes over time can be seen? Further, how is it possible to do this where:

a) there is a limited amount of film available (corresponding to the few resources of the research group); and

b) the photographic record must also show how changes to one part of the building have affected (and have been affected by) the other parts of the building (corresponding to the interrelationships between aspects of the curriculum)?

When little film is available, the tendency is to stand back from the building so that as much of it as possible is included in the shot. Any attempt to include details will lose an opportunity to see the overall picture. Thus the record will consist of shots of the whole building from several different angles. Over the years the major structural changes in the nature of the building will be clearly seen. The disadvantage of such a method is that any interrelationships between parts of the building are lost. A macro-picture can only tell you about the whole object. In the context of mathematics curriculum, the syllabus changes will be visible, but it may not be obvious which ones were caused by the introduction of technology, or which ones were caused by changing workforce requirements.

An alternative approach is to choose a small number of aspects of the building, and to take several shots of those details only. For example, take a series of shots of the doorknobs, the floor coverings, the lighting system, and of the people using the building. Over the years each of these detailed records will exhibit changes, both subtle and obvious. The disadvantage of such a method is that a view of the whole building will be lost. Thus a detailed study of the mathematics curriculum will give much information about, say, assessment practices, but it still might not be possible to characterise NZ mathematics assessment in a few phrases.

However, there are some ameliorating factors in the detailed approach. In any detailed shot there is always some background, so that other aspects of the building are captured, whereas a wide shot never captures detail. Thus a view of the bigger picture may still be available. Furthermore, other people will often take wide shots which can be used (for example the IEA studies can be seen as existing wide shots of the mathematics curriculum). It is almost certain that a picture of the whole building at about the same time will be available from another source. It may well serve the purpose of getting an overview.

But, on the positive side, the detail is more likely to show how and why changes took place. In particular, if it is assumed that the structure of interrelationships in any aspect of detail is in parallel with the interrelationships existing in the whole, then the detail will give information about the whole picture. For example a time of refurbishment is likely to be reflected in each aspect of detail: doorknobs, floor-coverings, lighting, and possibly in the people who inhabit the building. A new owner, or a new use for the building (home to hotel) is also likely to be so reflected. The reasons for the change (e.g. underuse of a section of the house, change in age or needs of the owners) is much more likely to be seen in one or more of these detailed records than it is in a wide view.

Let us jump out of the metaphor and expand on this point. The mathematics curriculum (interpreted widely) has many aspects to it. It is almost impossible to step back from it enough to be able to take it all in at once, although IEA surveys, national examinations, and Review Office audits attempt to do that. Even in a small country like New Zealand, such a macro-curricular study will not be possible because of the enormous resources it would require to complete. However it is possible to investigate any particular aspect in considerable detail. A micro-curricular study could be attempted on, for example, Assessment Procedures, or The Use of Technology. Each of these aspects will display development and change which (this is the assumption) reflect changes in the system as a whole. Because of the detail of the investigation, it will be possible to hypothesise reasons for any changes that are found. Furthermore it will be possible to identify connections between that aspect and other aspects of the curriculum. The Use of Technology will change if it is promoted (or discouraged) in a new curriculum, and it will be possible to see how this change is connected to Assessment: for example, does the relaxation of restrictions on calculators in examinations affect their use in class?

Note that a rather large assumption is being made: that changes in one detailed aspect reflect changes in the structure of the curriculum as a whole. The validity of this assumption can be tested by investigating more than one aspect. If two aspects reflect the same change or relationship, then the assumption is stronger. If, for example, investigations into The Use of Technology, Assessment, and Students' Perceptions of Mathematics all came up with a strong indication of the power of parents to influence school practice, then it is likely that such a relationship would also be found in other aspects of the curriculum.

Thus the design of the 1251 project involves four separate studies. (Available national statistics on the whole curriculum will also be gathered, but not generated). Each of the main researchers is investigating one of: Assessment, The Use of Technology, Students' Perceptions of Mathematics Classes, and Teachers' Philosophies & Practices. Each of these four aspects is to be 'captured' and archived for comparison with subsequent years. In addition, each of these aspects will be analysed using Nudist data analysis software for relationships which exist within the data, and with other aspects of the curriculum. These four analyses will then be merged and parallelisms identified. Thus some conclusions about the mechanisms for change within the whole of the mathematics curriculum will be drawn.

This design is possible with the resources currently available, and will provide some information about the internal structure of the whole curriculum.

Moving Targets: Comparability in Longitudinal Research

When measuring anything, including change, it is necessary to have a benchmark against which any differences can be assessed. The problem with longitudinal research in particular is that there is no benchmark, since the basis is also changing - the bench is moving.

For example, how can you measure whether teachers are doing their job better now than they were 20 years ago, when the job they are being asked to do now is different from in 1975? Again, how can you measure whether students have learnt more mathematics, or whether they understand it better, now compared with 1984 when the maths they were supposed to learn was different?

Stepping Back from the Problem

One way to resolve this difficulty is to move back one level, and to measure change against a construct which does not change so much. If that is not good enough, then you move back another level, and so on, until you have reached a concept which is relatively unchanging over the time-period being contemplated.

For example, consider trying to evaluate student performance over a period of 50 years by considering their performance on a national examination, say, School Certificate.

It is clear that simply looking at the national averages and grade distributions over the years will not tell us very much, because national distributions are manipulated politically (both by scaling and by examination setting), and because there have been changes to the syllabus over such a period.

The first level back is to look, instead, at School Certificate itself. By documenting the examinable content and the type of questions, and by analysing the level of difficulty of the examination, we could say something about student performance. And we could compare it over 10-year intervals.

However the context of School Certificate itself is changing: the proportion of students in a year-group taking the examination, the number of years of mathematics study they have had, the technology which is available to them, and so on, have all changed. So the second level is the context of School Certificate.

However even here there is a moving target: the role of School Certificate as an assessment procedure is not the same now as in the 1960's. Changing characteristics at this third level include the gate-keeping role of the examination, its use as a qualification for further study and employment, and the control of the setting and marking processes. Thus a further level is assessment. A longitudinal study which maps the nature of assessment will be less susceptible to criticism over subjectivity of analysis than one which looks at the annual School Certificate pass-rates.

The 1251 project looks (as its main task) at the nature of the curriculum, broadly conceived, and tries to map the changes in this concept. The team uses the phrase "gradient of change" to remind them to attempt to collect data which will show the direction of changes going on in the present, rather than a static picture. It is a 'video-clip' rather than a 'snapshot' which is being sought. This is a third level task at least.

Looking from the Inside Out

Another component of the problem of comparability over long time-periods is that the researchers are likely to be different and therefore have different agendas. Furthermore, each set of researchers is liable to be involved in the mathematics curriculum at that particular time - they are biased observers.

One technique being used to minimise the influence of different, involved researchers is that of research documentation. An integral part of the research is to document the steps that are taken in gathering this particular set of data, so that parallel steps may be taken in subsequent years. This involves, not just the recording of what is done, but also recording what decisions are made, and why, with respect to any research event. Why were these four aspects of the curriculum chosen? How was the methodology in each study selected, and how was it modified as the study proceeded? What was the thinking behind each questionnaire question?

It so happens that the approach of examining one aspect in detail is less likely to be biased than an approach which tries to take an overview. The more detailed the investigation, the more it is possible to get a complete picture, a 'factual' picture, a picture from which each reader can make up their own mind. General overviews are more likely to contain biases due to the orientation of the researcher towards the object under study.

In some cases the researchers are using colleagues from other parts of the country. This means less travel and expense, and also reduces the influence of a single researcher. Another hedge against researcher bias is that the four aspects will be brought together, and only those relationships found in more than one analysis will be considered representative of the curriculum as a whole.

It can be seen, therefore, that the project has found a methodology which is possible on its limited resources, which minimises the subjectivity of a small research team, and which has a good chance of mapping components of the dynamics of change in the complex system of mathematics education. The next section describes an innovative technique within one aspect of the project.

Student Icons

One part of the project is to gather a "video-clip" of students' perceptions of mathematics, the mathematics classroom, and mathematics learning. The problem, therefore, was to gather perceptions from a big enough sample of students to be representative, but to end up with a small enough archive that it could realistically be used.

There has been little research of this type in the past. An overview article on Students' Experience of the Curriculum in all areas of education in the 1992 *Handbook of Research on Curriculum* states (Erickson, 1992, 465-466):

> *...[Student] experience of curriculum has not received much attention recently from educators. Neither in conceptual work, nor in empirical research, nor in the conventional wisdom and discourse of practice does the subjective experience of students as they are engaged in learning figure in any central way.*

Erickson presents arguments for the importance of such research from the point of view of the psychology and sociology of the classroom. The idea that this may be useful in curriculum evaluation does not appear to be mentioned at all. Only one research study in mathematics education is cited (Lampert, 1990).

The difficulty in collecting nationally representative student perspectives is to condense the data into a manageable form without losing its richness. On the one hand there could be the raw data from each student (in whatever form it was gathered) which is very rich, but which cannot be easily read in its entirety. On the other hand there could be a summary report of the questionnaires/interviews/etc of 300+ students. Such a report may be accessible, but it is bound to lose individual insights as well as the range and depth of response.

The development of icons is an attempt to have a middle level of data which retains the best of both worlds. An icon takes the form of a mythical student who represents the collective experience of a small group of students.

Developing the Icon

A group of eight students are gathered in a room with the facilitator for a session lasting about 2 hours. The session has three stages: individual experiences, icon formation, and icon interrogation. Initially students are given the opportunity to talk about anything they like concerning their own experiences in mathematics education. This discussion is largely undirected, but prompted if necessary. Second, a deliberate attempt is made to gather the experiences together into one mythical persona. This is not an exaggerated caricature, nor an "average" student, but rather a collected experience of the particular students in the group. (It may be that a group will wish to create more than one icon. This will be acceptable, but it did not occur in the Pilot Study). Finally, having described and agreed on the icon(s), the facilitator will ask hypothetical questions about its past and future.

In the pilot study a group of Form 6 students (age 16) developed an icon called Bobby who, for example, had had about 50% good maths teachers during their school years; who used a computer at home, but not for maths; who would take maths until the end of school, but not beyond; who did maths homework, even liked it; and who generally worked on maths problems alone.

In the 1251 Project, the icon is recorded on video-tape. Experience has shown that students are willing and able to develop the icon, exhibiting a surprising degree of unanimity about his/her characteristics. The process of describing and interrogating the icon takes about one hour and pilot studies have been completed with 7 year olds and 17 year olds. The project will edit each tape to about ten minutes. Thus the experiences of 320 students will be condensed to 40 ten-minute tapes (less than seven hours viewing). That quantity will be archived, but, because sampling is taking place at five levels, the eight tapes at each level will be merged into a single 20-30 minute segment for summary viewing.

The technique of icon development has an additional spin-off in the ethics of the research. Keeping video-tape of students is problematic, but if it is a tape of students talking about an hypothetical person (not about themselves), this is less problematic.

Summary

An ambitious research project to map the dynamics of change in the New Zealand mathematics curriculum over a long time-scale is being undertaken at The University of Auckland. The type of data required for evaluating the curriculum and informing future changes is much more complex than a catalogue of test results. This task, combined with the restricted resources of the project in its early stages, has led to the development of an innovative longitudinal methodology. The design involves the study of a limited number of aspects of the curriculum, describing these in detail, and undertaking parallel analyses.

New techniques are also being forged in the gathering of qualitative data from a large sample of students. An icon representing a group of students is formed by the students themselves, and interrogated about past experiences and future reactions. Pilot studies have shown the method to be effective.

The study is presently in the data-gathering stage of the base-line phase.

Results will be reported at future conferences.

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