

# Mathematics curriculum and development

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This paper explores curriculum development issues in nine regions in five federal countries. The focus is on the curriculum contents, the development process, and the role of teachers in development. The study explores alternatives that others may consider when reviewing their curriculum.

## Introduction

In 1997 I compared curriculum in five federal countries—Australia, Canada, Germany, Switzerland, and the United States of America, where I looked at nine regional case studies. In these five countries curriculum development is a regional responsibility and the regions are comparable to New Zealand with respect to population and area. In three of the countries—Canada, Switzerland and the USA, the curriculum decisions are expected to be modified further at sub-regional levels.

This studies was motivated by my concern about the curriculum development process in New Zealand. In 1989 this process was restructured but consideration needs to be given to further changes within the new system. My focus is to provide alternatives for regions to consider when they are planning development priorities or processes.

I had a limited time in each of the countries and was concerned with official policies and the intentions of curriculum developers. I had informal interviews with curriculum developers in each of the nine regions using an open-ended interview schedule then I followed this up by talking with colleagues who were involved either the curriculum process or in teacher education that took cognizance of the emerging curricula.

Some details about the five countries and nine regions are in table 1.

Table 1: Details of nine regional case studies.

Confederation	(Notes)	Regional Case Study	Population	Area (km <sup>2</sup> )
Australia	(6 States and 2 Territories)	Queensland	3.3 m	1 730 000
		Victoria	4.5 m	230 000
Canada	(10 Provinces & 2 Territories)	Manitoba	1.1 m	550 000
		Ontario	11.0 m	920 000
Germany	(16 Länder or States)	Berlin	3.5 m	890
		Nordrhein-Westfalia	17.8 m	34 075
Switzerland	(24 Cantons)	Geneva	0.4 m	246
		Zürich	1.2 m	1 660
USA	(50 States and Num. Territories)	Massachusetts	6.0 m	7 800
cf New Zealand	(1 Nation)	(No regional units)	3.5 m	270 000

(Notes: 1. Decisions are made at school district and individual school level; 2. Decisions are made at commune level, (3029 communes); 3. Decisions are made at local school board level)

In talking about curriculum one needs to define one's terms. I was thinking of a regional curriculum as being a curriculum document together with associated teacher guide material, any compulsory assessment initiatives, and any regulations that influence what teachers do. I acknowledge that there are many other levels of curriculum such as the school curriculum, lesson plans and the implemented curriculum that all more directly rely on the teacher as curriculum developer.

## National Coordination

Although my study was of nine regions in federal countries, most regions were influenced by some forms of national coordination.

In Australia state initiatives are partly coordinated by the Curriculum Corporation which was funded by the Commonwealth to assist in the coordination of curriculum development, and with the preparation of curriculum materials. They published "A National Statement on Mathematics for Australian Schools" for the Australian Education Council (1991) which is equivalent to a national curriculum and although it has no legal status it influences what each state does. At Ministerial level the Australian Ministers of Education meet regularly and this also has a coordinating effect.

In the USA the 'Standards' (NCTM, 1989) are the equivalent to a non-official curriculum and have influenced all the states. Apart from the Standards which were partly funded by federal funds, the federal government also influences regional initiatives by providing funds for research and exerting an influence on education through regulations.

In Canada the responsibility for education rests with each province (or territory) except that the federal government provides funds for education of some groups including aboriginal people. In Canada too there is a national council of Ministers of Education and they organise some joint projects. In mathematics there has been a Western provinces consortium and an Atlantic provinces consortium working on 'guides' and these are influencing the work in the respective provinces.

In Germany education is the responsibility of each of the sixteen länder but the Ministers of Education meet regularly and decide on common thrusts for development. This is viewed by some as having a conservative influence on development because the smaller and less populated regions which tend to be less liberal dictate policies to some of the larger länder.

In Switzerland there is no Federal Minister of Education, there are 24 cantons (seven French-speaking, one Italian-speaking, and the others German-speaking) and each is responsible for their own educational system. Cantons that use the same language coordinate curriculum activities to some extent and two institutions for research and development have been founded, each serving more than one länder.

While broad cross-regional initiatives have been argued for in terms of consistency and cost-efficiency, they have been recognised, in Canada and Germany, as limiting experimentation, limiting teacher involvement in the early aspects of development, and limiting the development of the initial ownership of a project which is recognized as being a factor contributing to the success of a project.

## Timing

During 1997 the nine regions were at different stages of mathematics curriculum development. In Berlin the primary school curriculum was being revised but the high school one which dates back to the new maths of the seventies was not seen as needing revision because it was not written in terms of detailed operational objectives, it was very general, and it was seen as a guide rather than as a restrictive statement. Westfalia aims to revise its curricula about every ten years or so although this is becoming more difficult and the upper secondary mathematics curriculum has not been revised since 1980. In Westfalia there are seven mathematics curricula written for the different levels of and types of school, and while these are theoretically all coherent, in practice each is revised as part of a response to an expressed need. Queensland and Geneva had revised their curricula in the 80s and had no immediate plans for reviews. In 1993 Zürich had brought out a new curriculum for all subjects, in 1995 Victoria had published its new mathematics curriculum while Massachusetts had been working from 1993 to 1997 on its first ever state math curriculum. Manitoba and Ontario had reviews in progress during 1997.

## Influences

In most of the regions reviews were initiated by political pressures (back to basics, accountability, standards, and cost efficiencies) although where standing committees exist these were able to create political pressure. Curricula have been influenced by others in the same language and by neighbouring regional initiatives. The non-European regions were influenced by or expecting to be influenced by region-wide high-stakes assessment, while in the non-compulsory school years assessment for university entrance influenced most curricula (although it was often controlled by a different authority).

No regions suggested that curriculum development in mathematics was research driven although consideration was given to what occurs overseas, to comparative studies such as TIMSS, and to the informal research of reflective teachers who provide ideas of good practice and are asked to provide feedback on drafts. No regions had an evaluation of implementation although Massachusetts intended to evaluate its new curriculum to inform future changes—such evaluation was expected to include feedback from teachers and Universities. Some regions assumed that results from the planned testing of cohorts or samples of students at numerous grades may inform future reviews.

Another influence on curriculum is school systems and tracking. In Germany and Switzerland after four (or six) years of primary education, most students go to a three tiered high school system that focuses on academic, general, and practical programmes. In these regions there are a number of curricula written. The equivalent to this in other regions occurs in the last years of high school when students have a choice about the type of mathematics they study. In all countries multiple courses seem to be slowly being abandoned as the choice has been a school one rather than being made by the student.

## Curriculum administration

The administration of curriculum and development varies, it is sometimes with the Ministry, and sometimes in a quasi-Government body (Curriculum Council or Board of Studies) or an institution. In some regions more than one authority shares responsibility and examples of this occur where the syllabus for University entrance is not determined by those who control the school curriculum. Most countries have independent schools and whether these have to fit with state curriculum depends on local decisions.

In Berlin, Manitoba, and Massachusetts an 'umbrella' document that outlines the aims of schooling and put mathematics into broad context alongside other subjects has been developed. Ontario is developing such a document and Queensland has recognised the need for one. In Zürich an alternative was used to coordinate subjects, they were grouped together into five learning areas and one school curriculum produced. The areas were: Man & the environment (Religion, Life skills or civics, Science, Home economics from yr 7), Language (German, Writing, French from yr 5, English or Italian from yr 8 or 9), Arts & music (Handicrafts, Art, Music, Textiles or Materials in yr 9), Mathematics (Mathematics, Technical drawing in yr 9), and Sport. This curriculum is intended to be taught in a cross-disciplinary way and give teachers more freedom.

To coordinate developments within mathematics some regions had a permanent subject committee with a rotating membership which was able to provide advice and guidelines for developments. In most regions the convenor of the development project was a full time curriculum officer or consultant/adviser who was a development expert, but in the other regions a seconded inspector, a university mathematics educator, or someone seconded as a curriculum officer headed the project.

All the regions had set up development committee(s) with a balance of teachers, consultants/advisers, university mathematicians, and mathematics educators participating and in all cases teachers were in the majority. The teachers in some regions applied to be on committees, in others they were nominated. The number of committees in the regions varied considerably from only one central committee in one region to a number so that different aspects would be considered and so that all school districts were represented.

The time involved from deciding to review a curriculum to complete implementation with resources in place seemed to vary up to ten years. Now the trend is towards months rather than years with three years being regarded as usual. This variation is influenced by:

- the number of people involved and what consultation occurs between groups,
- whether the teachers involved are released from their teaching during the project,
- the frequency of meetings for the committee(s),
- if draft curriculum are tested as they are in some regions,
- how much consultation occurs with schools,
- how many drafts are circulated to schools for feedback,
- whether curriculum development is separated from the teacher development process,
- whether resources (teachers guides or texts) are prepared and distributed.

Curriculum status varied from being directive to being a guide depending on the autonomy teachers, schools and school districts had. The trend was towards directive curricula—Massachusetts had not had a state document before, the present developments in the Canadian provinces were more directive than in the past, and curricula in Australia were becoming linked with initiatives that would become part of the de facto curriculum.

Some relevant issues were not addressed in the curriculum development process or by the mathematics steering committees, but seemed to be decided without debate for all curriculum by a small central group of officials or politicians, these were issues such as:

- what status should a curriculum have? should it be directive or a guide?
- should the curriculum be visionary or detailed? and how much detail?
- what philosophical or theoretical underpinnings does the curriculum have?
- what opportunities are provided for the appointed personnel on curriculum development committee to debate or consider some general curriculum and development issues?

### Curriculum contents and structure

Emerging curriculum from the non-European regions emphasised the mathematical processes as well as content. These included logical reasoning, problem-solving, modelling, estimation, mental maths, communication, visualization, making connections, using contexts, applications, using technology. Where processes were emphasised it was usually in the introduction or in a strand of the curriculum, they were not embedded in the content—the integration of content and processes was left to teachers guides and texts.

Content varied across regions. In the English-language curricula there was an emphasis on patterns in algebra and on statistics and geometry in the lower grades; and on number sense and estimation (including topics such as number theory and discrete mathematics). The European curricula were more similar to English-language documents from the early 80s with even trigonometry and statistics omitted in the Zürich curriculum.

Curriculum strands (or topics) do not integrate mathematics and how the strands were linked to teaching sequences was seen as something that teachers should decide although teacher guides and textbooks often provided suggested sequences.

Ideas in the various curricula related to pedagogy included exploring, inquiring, connecting between topics and within maths, doing cooperative work, writing in maths, using open-ended and open response questions, and explaining and justifying answers. All these statements about pedagogy were only suggestions and the curricula all assumed that decisions about teaching should be made by the teachers.

Much of the curriculum content was listed in behavioural terms, but in Victoria the introductory section of the curriculum stated that the *outcomes are not to be considered as a checklist and an atomistic outcome-by-outcome approach should not dominate.*

A number of concerns about pedagogy arose in some regions, these included:

- content seemed to be based on logical rather than psychological considerations,
- teachers were seen as lacking knowledge of concept development and learning theories,
- using students' questions as a basis for teaching seemed not to be accepted,
- teachers did not seem to share experiences to improve their work, and
- discovery learning was given undue emphasis.

The way that curricula were organized varied from three-year topic groupings, yearly programs, and ability levels which were seen as spanning a number of classes. Planned teacher guides reflected these different groupings but I heard nothing to suggest that teachers had had any input into which organisational grouping they preferred. One respondent was quite critical and remarked how curriculum was defined in terms of the direct outcomes of formal education rather than recognising the complexity of schooling and the influence that school has on aspects of socialisation.

The contents of the curricula varied considerably, they all had introductions and then aims and/or purposes for studying mathematics. The introductions were followed by the general aims for each strand or section, a statement of the content for each section, and a guideline which provides some elaboration of this and includes links with other parts of the syllabi. Sometimes notes on learning activities and assessment activities were usually given. The detail in the curricula depended on whether they were seen as directive and controlling or guiding with the expectation that schools or districts would develop their own curriculum to suit their particular situations.

All the countries said that they had ethnic minorities and broad ability groupings to cope with. In Europe many of the students from these minorities went after four years schooling to the third (practical) tier of high school where it was up to teachers in those schools to cope with them, although at least in these schools the curricula did vary so the expectations of all concerned were significantly different. In some countries translations of curriculum documents were available for large language groups but not usually for smaller groups or for aboriginal people. In Canada the first nation people were seen as a federal not a provincial responsibility and in Victoria aboriginal people had been partially considered by the use of reference groups during the development of the curriculum. In general the needs of aboriginal people, of ethnic minorities, of refugees, and of the less-abled and the gifted were left for teachers to address.

### **Teachers' professional development**

Related to curriculum implementation, catering for minority groups, new content, and new teaching strategies is professional development. My belief is that curriculum and teacher development should be integrated and be mutually dependent. This was not the situation in any of the nine regions and the traditional linear model with dissemination involving teacher development following development was the prevalent view. This was most obvious in the two Australian regions where the responsibility for the development of the curriculum and the implementation were controlled by different authorities.

In Germany teachers are regarded as being very well qualified. They spend from five to seven years in preparation, they are assumed to be professional, and therefore teacher development is their own responsibility—unfortunately, and in spite of the opportunity provided by teaching each day only between 8am and 1pm, most German teachers were not involved in professional development. However in Berlin the teachers from comprehensive schools were seen as adventurous, they had developed a database of teacher-prepared units of work which they freely share with each other as they face the problems of mathematics for all. These units reflect modern ideas of mathematics and learning and emphasise applications and contexts, they also integrate social values and students interests with the mathematics when possible. Gymnasia teachers have recently started to work with this group as in Berlin the Gymnasia now take not merely the elite 1% or 2% but closer to 40% and sometimes even 60% of the age cohort and teachers are facing the problems associated with teaching students from this wider range of abilities. In Northrhine-Westfalia the institute that developed the curriculum also had responsibility for teacher inservice, but while there used to be some provision for teacher development this was being reduced due to the lack of resources for education.

Manitoba had teachers from all districts involved in curriculum development and came the nearest to the ideal with teacher and curriculum development being mutually dependent. In fact their development was based on the Western provinces protocol so the

initial involvement of teachers had not been great. Their teachers expect to participate in 10 days of inservice or administration work each year while schools are closed and schools budget \$450 per teacher for professional development. When possible inservice work related to the new curriculum involves modelling the way that teachers might work with it. The problem areas in Manitoba were seen as the new emphasis on mathematical processes and the lack of background in algebra and statistics of many elementary school teachers. Change was not expected within a year but was expected to take 4 or 5 years which did not fit well with political thinking which assumed that after the mathematics initiative there would be other subject reforms that would impact on generalist teachers. The initiative in Manitoba for professional development rests with superintendents and principals although resource people are available and the pressures of assessment and testing are making people aware of the need to make development opportunities available.

In Geneva the primary curriculum is supported by the "Didactic Services" who provide advice on teaching methods and on ways that the curriculum can be developed. For high school mathematics teachers the main foci for professional development are their professional societies and their in-school department meetings. Professional development is mainly during holidays as the expense of 'teacher relief days' is high.

In Massachusetts a recertification procedure requires all teachers to gain 120 points in each five years and these points (development hours) are divided further into 60 in general education and 60 in maths education for mathematics teachers. This pressures teachers to attend courses and workshops on the curriculum and provides a focus for courses which districts must ensure are available for teachers. The idea of compulsory professional development and recertification sounds fine but it is not all that successful in some other states, a number of educators are cynical about its effect, and concerns about the 'professional development industry' that is growing so that teachers can satisfy the requirements by attending courses but not changing their practice were voiced.

Increasingly the implementation of curriculum is seen as a school or school district responsibility because of a belief in local autonomy. In some cases this is a traditional belief, in others it is the rhetoric behind political moves which are reducing budgets and the responsibilities of regional authorities. Most regional offices were doing what they could to at least ensure people are identified as consultants and so that teachers were aware of holiday courses, university courses, subject association meetings, as well as district initiatives, and in Victoria professional development activities were also being delivered by satellite with simultaneous on-line links.

## Resources

One way to assist the implementation of curriculum is by providing teacher guides and to ensure that suitable textbooks are available. Most of the English speaking regions were developing teachers guides (in print or CD form). Ontario had decided not to do so and in Westfalia it was felt that there was a conflict of interest with publishers. The teachers guides were not legally binding but gave detailed suggestions related to teaching methods, sample programmes, essential learning, links between topics and links across subjects, assessment, ability-based outcomes, and references to other suitable resources.

Textbooks were seen in many countries as the defacto curriculum. To make the most of this some countries have approval systems. In Australia schools are free to buy whatever texts they want and the situation is the same in Massachusetts even though half of the states in the USA have approval systems. Approval is required in Ontario while in Germany approval is also required although this is usually given unless the book is actually contradictory to the curriculum or it contains errors. In Geneva texts are paid for by the state and in Zürich texts are produced and issued by the canton's own publishing house and these are seen to provide an interpretation of the curriculum for teachers.

The provision of prepared texts and worksheets produced by experts was commented upon by one interviewee as deskilling teachers, he believed that each teacher should prepare their own resources if they are to really understand the curriculum.



In contrast to these regional curriculum initiatives an alternative view was suggested for Canada by Taylor (1997) from Queen's University. He recognized the influence of textbooks in North America but sees the need for an extended problem-solving focus as used by some schools in Japan. His philosophy is summarized in his book by: *This is a collection of classroom problems; they are not meant to be simply inserted into the curriculum—they are the curriculum* (p 1).

## Conclusion

Many regions begin curriculum revision without adequate planning. They allow politicians to suggest national coordination that means that local teachers are not heard and they accept unreasonable timescales instead of considering the change process.

While research did not play a significant part in curriculum development apart from teachers informal research, I was surprised that action research projects and exploratory studies as a form of developmental research were not being fostered.

Too many questions are not asked during curriculum development, questions about status, purpose, assessment, and so on. While accepting that these relate to all subjects, there was little evidence of teacher (or public) debate in the few regions where a document provided a framework structure for subject curricula.

The idea that some variation might be possible within a curriculum seemed not to be considered although in the Czech Republic (Kotásek & Svecová, 1995), with approved curricula a 10% to 40% variation is allowed in some subjects at school level and an individual teacher can make further changes of up to 33%.

The changing emphasis on mathematical content and on the processes that are emerging as school mathematics is redefined was to be expected, but the disregard for minority groups and ideas of ethnomathematics was a surprise for me.

Teachers value practical strategies more than learning theories, but most teachers in high schools have a good knowledge of their subject and less knowledge of pedagogy. Perhaps curriculum for them should emphasise how to teach rather than what to teach.

Each region I visited had some unique contribution to this study, my hope is that mathematics educators and curriculum developers are able to reconsider the development process and look towards making changes in the future.

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I also acknowledge my data sources and thank my colleagues for their assistance. In some cases my interpretations of what was said may be erroneous—I have presented what I constructed from the data and accept total responsibility for misrepresentations.

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