

Challenging curriculum: process and product

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Abstract: Education, mathematics education, and curriculum are interrelated and by challenging education ideas my aim is to challenge curriculum. My challenges arise from the nature of knowledge, the purposes of education, the way we learn, and notions of complexity. From these some implications are presented for curriculum in terms of development and activities that influence development. I conclude with some thoughts on curriculum-as-product and -as-process, and on the future.

Historical introduction

As mathematics educators we often look at our subject in isolation rather than as part of education and alongside other subjects. When looking in this way one can identify numerous influences on our subject since the 1950s, in particular: new mathematics, the Cockcroft report, the NCTM standards, ethnomathematics, constructivism, and technology. From the broader perspective influences on education include more central control of education and curriculum, an acceptance of behaviourism with its 'analytic' way of looking at knowledge, a resulting structuring of curriculum and assessment based on objectives, and recently, concern with accountability. This conference, with its emphasis on a human renaissance, is an ideal forum to reconsider some of these influences that are now either taken for granted or have waxed and waned, and to think about possible directions for the future.

My concern is that we accept unquestionably a number of assumptions and some of these may be wrong. These assumptions should be made explicit as they underpin our views of education and curriculum. For me these assumptions concern the nature of knowledge, the purposes of education, and the way we learn. My intention here is to present alternative assumptions that seem to me to have different implications for the way we view curriculum both as a product and as a process.

The nature of knowledge

With behaviourism the ways that mathematics and other school subjects are viewed has changed. Curriculum documents written recently involve analysing the subject and topic into objectives. With the 'new maths' the ordering of these objectives was based on a logical analysis of the subject. More recently it has been based on a psychological analysis involving the order in which we believe students learn topics. In spite of the recent acceptance of constructivism both curriculum and assessment are still dominated by objectives. Even before constructivism rose to prominence there were educators (for example Stenhouse, 1975) who were unhappy with an objectives approach and offered alternatives based on their ideas about learning that preferred synthesis rather than analysis. The objectives approach seems to be reinforced by the 'information age' and the 'knowledge wave' where information/knowledge seems to be seen as the valuable commodity that we should all accrue.

When we seek answers to the question 'what is knowing?' we question this objective approach. I have been attracted by the view presented by Hart (2001), he looks at knowing and learning as a six-layered unfolding involving information, knowledge, intelligence, understanding, wisdom, and transformation. These layers involve moving from basic facts and procedures to merging this information with life experiences, and then with what we know more intuitively, this merging involving both analysis and synthesis. As we move on to understanding we need to add an emotional dimension, considering both heart and head, and see our world not only from the individual perspective but also from that of the community. Wisdom emerges when an ethical dimension is added to understanding and from this comes the possibility of personal and cultural transformation.

For me, Hart's ideas resonate. Information is not the goal of education, and we ignore this merging of information with experience, intuition, synthesis, emotion and ethics at our peril. The challenge is to incorporate these ideas into education and mathematics.

Another issue related to the nature of knowledge concerns the 'pure' and 'applied' aspects of subjects. This has been an issue in mathematics for some time and applications were given more emphasis in mathematics when 'relevance' was being sought. Now, with a reorganization of core school subjects we see science and technology being split apart in some countries, yet statistics and other applied mathematics remain integrated with pure mathematics. I prefer the integration of these aspects and argue that this is to do with 'understanding'. For me this was summarised by Aoki (1987) when he discussed some ideas from Gadamer (1982) in the context of computer applications, he wrote:

(Gadamer) confronts squarely the hermeneutic problem of application in the context of understanding, interpretation, and application, which to him, are all moments of the hermeneutic act. He states that "understanding always involves something like the application of the text to be understood to the present

situation of the interpreter” and that application is an “integral or part of the hermeneutical act as are understanding and interpretation” ... The question concerning application raises the hermeneutic problem of the relationship between the general and the particular. At the heart of the problem is the notion that the general must be understood in a different way in each new situation. Understanding is, then, a particular case of the application of something general to a particular situation.

The purposes of education

With accountability being emphasised and measured by achievement tests the aim of education has shifted to focus on information acquisition. This is a change from the 1970s and the 80s when more was said about the overall development of the child in the personal and social sense as well as in the academic sense. It is also a significant shift from when investigation and exploration were key terms to describe the educational process. Apart from education in general, what is the purpose of mathematics education. Mathematics has traditionally been in the curriculum, this question of purpose has not always been asked or taken seriously, and mathematics has usually only addressed the academic area of growth.

I see mathematics as part of a western partitioning of knowledge, and see a need for us to view it not only as a separate subject, but also as part of an overall knowledge system. I see the purpose of mathematics education as being similar to the purpose behind the teaching of all subjects. Every subject is taught to help each learner develop new ways of making sense of their world. With mathematics (and statistics) this means to be able to think of and make sense of aspects of their world quantitatively, spatially, symbolically, graphically, and in terms of relative certainty and of uncertainty. Making sense of one’s world requires thinking so mathematics education involves thinking numerically, geometrically, algebraically and statistically, and this thinking in turn involves problem solving, logical reasoning, communicating, making connections, and thinking creatively. With this in mind, I believe that the emphasis in mathematics needs to shift from the current content orientation, to a thinking orientation in which the mathematical content will arise purposefully.

The way we learn

There are many theories about how we learn. Over the years behaviourism has gradually been replaced by constructivism but behavioural objectives remain. A recent development from constructivism that interests me is enactivism that has been described in the context of mathematics teaching by Davis (1996) in his book “Teaching Mathematics: Towards a Sound Alternative”. According to Begg, Davis, & Bramald, (in progress)

Enactivism is an emerging theory about learning that draws from a number of discourses, among them phenomenology, constructivism, ecology, and systems and complexity theories. Enactivism might be considered as an elaboration of constructivist epistemologies. It views learning and knowing, as complex, emergent processes by which dynamic agents maintain fitness with one another and within dynamic contexts. Two of the key concepts within this shift in thinking are: (i) an enlargement of the notion of cognitive (or learning) systems, and (ii) the combining together of knowledge, activity, and identity.

On the first, a *learning system* is seen as any complex form that can adapt itself to changing circumstances. For the most part, such systems are dynamic and robust, able to change and adapt efficiently. Inherent in this notion is the broader definition of cognition as ‘coming to know’ which includes traditional rational thinking and other forms of learning. From such a perspective *learning* refers to transformations, those that expand the learner’s potential range of action—and it is here that the second major concept fits into place. The suggestion that learning is a *transformation* is a reference to the physical character of a learning system. Upon learning, a systems’ patterns of activity and its associations—internal and external, with and in other systems—undergo physical change. Put differently, learning affects the entire web of being, and it follows that what one knows, what one does, and who or what one is cannot be separated.

For me enactivism shifts learning from being teacher directed to being based on learner-growth. It assumes complexity rather than cause and effect, and it moves the role of the teacher from one of instructor with knowledge to one of co-learner and facilitator.

Complexity

Inherent in my views about knowledge, the aims of education, and learning is the notion of complexity. I am convinced that I can not simply teach and assume that my students will learn. For me, being a teacher means being a learner, and being a lecturer, a researcher, and a curriculum developer (in any sense of the word), also means being a learner. To plan for these activities means to anticipate what might happen and to be prepared to work in different ways. This is no different to what we do in all aspects of our life and fits with the idea of what it means to be a human and a living system—to live is to know (Maturana and Varela, 1987). Whether one agrees with this idea or not is

not important, most teachers in my experience do recognise at least the complexity of the educational and the schooling processes.

Implications for curriculum

So far I have used the word ‘curriculum’ loosely. For some it means the policy statements from central authorities that define what students should learn, for others it means textbooks, while for others it means the school programme, and these notions all fit with the idea of ‘levels of curriculum’. For me curriculum is more encompassing, it means “all planned activity for the classroom” and includes all these different meanings and levels.

How we might plan curriculum using these notions about knowledge, educational purposes, and how we learn remains problematic. In addition, change is evolutionary and just as teachers ‘start where the learner is’, so with curriculum we need to start where teachers are and be satisfied with making and enabling others to make small changes. However, to say to teachers that we need a mathematics curriculum that is thinking-oriented rather than content-oriented is not enough. We need to share ideas, demonstrate possibilities, and experiment with them (not on them), so that they are empowered to make changes.

Curriculum development

For many years the research-development-dissemination (RDD) model has dominated curriculum development in many countries. It was the linear model, shown in figure 1.

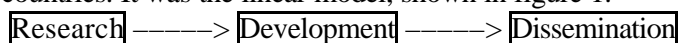


Figure 1: *RDD model for development*

The model did not consider all the influences that impact on development. To improve the model I identified other influences on change. With the emergent view of learning developed while working with Davis and colleagues, I came to see that the question was not ‘what are the influences that impact on curriculum and professional development?’ but rather, ‘what co-emerging development activities impact on each other?’ The activities were—teacher development, teacher practice, research, theory, policy development, assessment development, curriculum development, and resource development. These nouns were replaced by verbs to emphasise a process rather than product perspective on change and are shown in figure 2. The dotted lines represent links between the activities, these being two-way, and being lines of influence rather than causal relationships. The model has 28 lines of influence and these are what is important and what make the model complex. It becomes even more complex when one considers ‘ideas’ flowing into the activity nodes from outside.

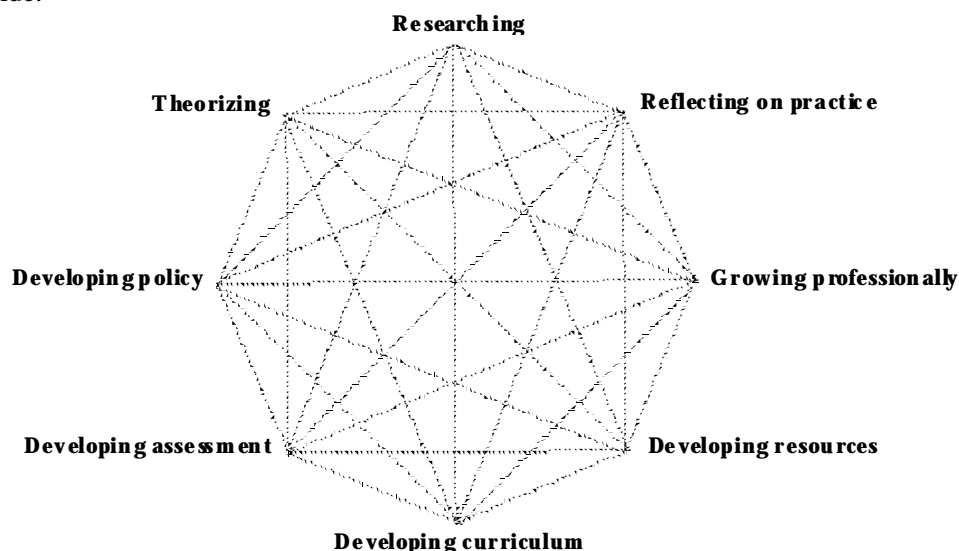


Figure 2: *The eight co-emerging activities in the educational change process*

For some the model implies teachers grow professionally and reflect on practice, academics research and theorize, and others develop policy, assessment, curriculum, and resources. This is not intended. I see teachers involved in all eight activities and at three levels—the individual teacher level, school level, and regional level, and this adds further to the complexity of the model. The three-levels recognize that development is not top-down, nor bottom-up, but both-ways. Coping with this complexity is part of the challenge with development and part of what makes teachers professional. *Growing professionally*

Professional development is not changing other people. One can only oneself, but one can help others change if and when they want to do so. Teachers may plan change as individual initiatives, within school projects, or as part of a regional activities, and the growth that results will vary between individuals. The growth may focus on any mix of personal, social or professional aspects and the professional aspect may include developing understanding about learning and teaching, and subject-content and subject-pedagogical knowledge.

Reflecting on practice

The centrality of teachers' practice needs recognition. When teachers are busy they find little time to reflect, yet until they are aware of what they do it is unlikely that they will change. Reflecting-on-practice can be done individually or with colleagues, and it may include feedback from students or the community. Reflecting-on-practice is often considered as thinking about what has happened. I would call this descriptive reflection. Reflecting-on-practice involves working at this descriptive level, and at an interpretive level thinking about why things happened, and delving deeper into assumptions and alternatives. This deeper aspect is the 'critical' level, its aim is to critique assumptions and actions, and to empower the person to act differently in the future if they wish to; that is to anticipate possibilities.

Researching

Research is often thought of as academic (acquiring and generating new knowledge, researching for specific objectives, evaluation, and scholarship), but it could include:

- the scholarship of teaching where knowledge is transformed (e.g., exploratory studies);
- creative work to generate ideas, hypotheses, images, performances and artifacts, leading to the development of new knowledge, understanding or expertise;
- consultancies involving working with clients in professional contexts in problem solving;
- action research where existing knowledge is used in the resolution of problems;
- developmental research to develop, trial and improve resources for professional use;
- hermeneutic reflection for the development of understandings, interpretations, and applications in professional situations; and
- professional practice to theorise about practice and make it more effective.

Teachers research in many ways but do not always write up their work. While their research impacts on change and development, it can be argued that it is of most benefit to them and fits within growing professionally. However, my belief is that teacher research is important, particularly in terms of policy and curriculum development. Without such research there may be too much reliance on politically motivated research that is not always neutral, and on international research that puts systems in danger of forms of cultural imperialism.

Theorizing

An example of theorizing is what I am doing here. Based on experience, research, and the work of others, I put together a model or theory. It is not right nor wrong, nor tested, but for me it explains what I have seen happening. Others will critique it, and if it is thought to be useful it will be adopted or adapted, but no doubt at some stage it will be replaced.

When theorizing one starts with personal ideas/assumptions and makes these explicit, and then considers alternative assumptions/theories and identifies possible conflicts. For example when looking at learning theories we see that behaviourism is concerned with the *analysis* of subject matter into objectives for teaching and assessment and assumes (and constructs) progression. On the other hand constructivism emphasises *synthesis*, which requires us to look at the big ideas within mathematics, and assumes knowledge schemas are built up by individuals and not necessarily in a similarly ordered way. When learning is based on constructivism but curriculum and assessment on behaviourism we have conflict.

Developing policy

While policy development occurs at regional level, schools determine aims and rules, and teachers (and students) determine classroom policies. Thus people at all levels are involved in developing policy. Further, when class and school policies have desirable results then they influence other schools and more general policies. Class and school aims and how they are operationalized are important because they reflect context-specific values of decision-makers. A concern I have relates to imposing policies, aims, and values if they are not acceptable to the people from the diverse groups represented in schools. One such example is regional policies related to curriculum, assessment and resources that have been used in various ways to control what is done in classrooms. While such

policies have influenced the related development activities, the lack of wholehearted endorsement of these policies by schools supports the notion that links within the model are influential but not causal.

Developing assessment

National (and international) assessment has a marked influence on what is done in schools and often causes teachers to teach to the test, which means emphasising the things most likely to be tested. This is unfortunate as ‘not everything that can be measured, counts, and not everything that counts, can be measured.’ School-wide common assessment tasks have a similar but somewhat lesser influence. While assessment occurs at regional level, school level and in classrooms, student self-assessment is often neglected, yet if a school is concerned about developing autonomous learners, then self-assessment is an important skill.

There is a need to develop new and improved assessment policies and strategies that have less negative impact on learning and provide the required information. This is likely to be done by teachers who think of the desirable aspects of learning rather than assessment ‘experts’ who have other agendas, and is a good example of teacher-driven development.

Developing curriculum

Regional curriculum development usually involves some teachers directly and all teachers during implementation. However, if curriculum development means school programming and lesson planning that consider the schools particular situations and resources, then all teachers are curriculum developers. Numerous questions arise when developing curriculum—what should the curriculum contain, who decides this, and how do the developers find out? Even in terms of mathematics there are questions—some countries do not teach statistics, and some universities do not teach geometry. Other questions relate to the purpose of curriculum, is it what students must know, or what teachers must teach, or both? And, linked to this is the issue of who uses the curriculum, if it is teachers, then what curriculum structure suits them?

Just as my model suggests complexity rather than linearity, perhaps a new curriculum might have to reflect complexity too. One possibility is a curriculum that focuses on the ‘big ideas’ of mathematics, that lists successfully trialled ‘rich mathematical activities’ (Ahmed, 1987) that could be used with these big ideas, and then assumes lesson planning based on what Davis (1996) called ‘curriculum anticipating’. This might involve individual teachers selecting appropriate and inclusive activities for all students regardless of gender, culture and ability, and then analysing how the lesson might develop, working out the paths students might take, finding ways to extend the activity, considering possible blind alleys, and so on.

Developing resources

The first resource that comes to mind is the textbook. In some countries developing textbooks is thought of as developing curriculum. Elsewhere textbooks follow curriculum development, but even then, they influence lesson planning and teaching, and can have a major influence on the implemented curriculum. Textbook production may be initiated by small groups of authors, by research teams, or by a bureaucracy, but teachers become resource developers as they adapt the books to suit their classes and as they produce worksheets to supplement the text or to use other ideas. When such adaptations are discussed and shared with colleagues the influence of teachers as resource developers moves beyond the single teacher level.

After textbooks, calculators and computers are important resources influencing mathematics. Their influence was summarised for me by Engelbrecht & Harding (2001) who summed up the influence of technology with:

- Some mathematics becomes more important because technology requires it
- Some mathematics becomes less important because technology replaces it
- Some mathematics becomes possible because technology allows it
- Some mathematics can be taught using technology

However, there is much to be done in the development of resources that consider these four categories, although many resources currently being developed will influence later developments. The development of technology is simply another example where all eight activities in the model are relevant.

Curriculum as product and process

Much of the above implies curriculum-as-product, as a regional or school policy document. This was not intended. While products exist, curriculum documents and textbooks, curriculum means more, it is what is planned for the classroom. I know that my teaching of a topic will change when I do it next, in addition, I will have learnt other things that will affect what I do, and my students will have also

learnt, grown, and changed. I know that every time I interact with students they grow (though not always in the direction that I had intended), and that each class I teach is made up of unique individuals. Thus my curriculum changes as I come to know the needs and interests of my students, as I observe their responses to what I have done, and as I note the applicability of current events. It develops in my response to theory and practice. It involves anticipating (Davis, 1996) which learning activity I might use and how I work with it, and this, together with my responses-in-action are curriculum-as-process.

With curriculum conceptualised as a process and as a product, aspects of development should include critiquing the present curriculum and its implementation, and identifying changes that might be desirable in schools now and in the national curriculum at some later time. This contrasts with traditional practice where teacher input is only gained part way through development by a request for comments on drafts that had already made assumptions that were hidden and not up for debate. One difficulty with curriculum as a process involving many teachers is that different assumptions emerge and inconsistencies become unavoidable, thus an overall sense of direction becomes more important than a list of specific requirements.

Future challenges

Regional and local educational systems, school and classroom, educators and learners are for me a nested group of complex, dynamic and self-organizing systems. From this perspective models for change need to recognize the complexity and consider all the influences on development rather than assume that specific inputs will result in desired changes. My model is an attempt to do this but further activities may need to be added, and research is needed on how the links between activities operate, how the activities might best be carried out, how communication between the three levels might best be facilitated, and whether the model encourages continual change. In addition, I am not sure whether educators and policy makers will be comfortable with the implicit uncertainty of the model.

I imagine that my model is perplexing because it lacks a straightforward way of going about things. If so, then this paper has been worthwhile. I do not see one right way, and coping with complexity can be overwhelming. I take heart in the saying 'think globally but act locally'. Our professional responsibility seems to me to be to do the best we can in the change activities we are involved in, implement change in our own immediate environments, accept the complexity, and don't lose heart when others are not willing to do the same.

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- Baker, Robyn & Begg, Andy (in progress) Overview—Change in the School Curriculum: Past, Present and Future. In Keeves J P & Watanabe R (Eds) *The Handbook of Educational Research in the Asia-Pacific Region*, Dordrecht: Kluwer Academic Publishers
- Begg, Andy (2002) *Rethinking curriculum, a developer's perspective*. Paper presented to the annual conference of the Mathematics Education Research Group Australasia, held in July, at Auckland NZ.
- Begg, Andy (in progress) Mathematics Curricula. In Keeves J P & Watanabe R (Eds) *The Handbook of Educational Research in the Asia-Pacific Region*, Dordrecht: Kluwer Academic Publishers
- Begg, Davis & Bramald (in progress) [see references]