1992

The ideal teacher: A curriculum framework for teachers of primary mathematics

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Abstract

This paper suggests a curriculum framework for training prospective primary teachers of mathematics. Such a framework needs to be viewed in the context of the skills and understandings that are reflected in successful mathematics teachers.

Keywords

teachers, framework, ideal, teacher, primary, mathematics, curriculum

Disciplines

Education | Social and Behavioral Sciences

Publication Details

Herrington, T., Pence, B. & Cockcroft, B. (1992). The ideal teacher: A curriculum framework for teachers of primary mathematics. Australian Mathematics Teacher, 48 (1), 4-7.

TONY HERRINGTON of Edith Cowan University, BARBARA PENCE of San José State University and BILL COCKCROFT, Visiting Fellow, Edith Cowan University investigate a curriculum framework for the training of primary mathematics teachers

THE IDEAL

Introduction

To train the ideal primary school teacher, a Professor of Education once said, needed a minimum of twelve years.

She argued, tongue in cheek, that three years were needed for training as a child psychologist; three more years needed to be spent on the history, philosophy and psychology of education; three years on the academic content of the primary curriculum and a final three years training in method acting could usefully round it all off.

It is surely possible to spend a lifetime arguing about and designing the training of the ideal primary teacher – and many an education lecturer has done exactly that. Any description of the ideal implies the need for an equally ideal training program, and for that matter an equally ideal primary school teaching and learning program.

Without presuming to describe the ideal, this paper suggests a curriculum framework for training prospective primary teachers of mathematics. Such a framework needs to be viewed in the context of the skills and understandings that are reflected in successful mathematics teachers.

Such teachers must surely first of all, be aware of, and be able to react to, all the many and varied calls made upon the profession. For a start, they must be able to learn from the training program to which they have been exposed, using it to build on their strengths and to remedy their weaknesses.

Communicating with students

Knowledge of one's own strengths and weaknesses must be matched by sensitivity towards the strengths and weaknesses in others. Primary teachers cannot teach successfully unless they are able to listen with sensitivity and care to their students, and act accordingly. Their own use of language must enrich the students' linguistic experience. All their actions must sustain and enhance the children's work, whatever their level of attainment.

Indeed, the skills of communication which are needed in the primary classroom are of the highest degree. Simply knowing when to stimulate and excite on one occasion, and when to listen and react passively, on another, is basic to the teaching process.

They must also have the confidence to be able to say 'I'm not sure', or 'I don't know', but to be able to add, 'but I think we can find out', knowing that solutions and ways forward are not just to be found in books kept on shelves, or from colleagues, but also on occasion from the students themselves (and not necessarily from their correct answers - sometimes the germ of a right idea can be found in a wrong answer to a question).

Those who underestimate the care we need to take in planning teacher-training curriculum fail to understand that we are not talking about an occasional need to use such skills, but about a day-by-day, week-by-week, term-by-term and year-by-year activity.

Communicating with colleagues

In the best of all possible worlds – apart from expecting all primary teachers to be able to work with children in the way we have been suggesting – we might assume that every primary school teacher would also be capable of the scholarly activity (and what is more, have the time) needed to create his or her own teaching program. In practice, we do not assume this is possible, and the help of others is provided from outside the classroom, to develop the primary curriculum. We must therefore have teachers who can react positively with these professionals, whose job it is to write the primary school programs in English, mathematics, and science. We need teachers who are able to debate and argue with confidence, giving advice based on their practical experience, so that the curriculum can become a proper amalgam of the needs of the children as seen from outside the classroom with those needs as seen from inside.

To successfully communicate with students and colleagues, teachers need to share common understandings about mathematics, about how it is learnt and taught, and about other significant issues that surround the subject. The basis for these understandings lie to a large extent in the beliefs that teachers hold.

Beliefs about mathematics

What is meant when we talk about a belief? The term *belief* is interpreted in many ways. McLeod (1989), in his work on a theoretical model for affective issues in mathematics learning, describes the three factors: emotions, attitudes, and beliefs.

Emotions may change rapidly and can be quite physiological in nature. For example, students who become frustrated and upset when working on a problem may become very positive just minutes later when the problem is solved. Attitudes toward mathematics refer to feelings about math-

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ematics that are relatively consistent. As an illustration, when students say that they dislike mathematics one day, they are likely to express the same attitude the next day.

Beliefs about mathematics are frequently based as much on cognitive factors as on feelings or affective responses. Beliefs about self may have more of an affective component, but in general, beliefs involve mainly cognitive aspects that are typically built up over a long period of time. Consider for example, the beliefs about the usefulness of mathematics, the nature of mathematics, the view of a problem and problem solving, and the conception of the learning and teaching of mathematics. Each is a belief which is not likely to change day-by-day and encompasses a strong cognitive component.

An instrumental belief

Brown, Cooney, and Jones (1990) describe the commonly held view that mathematics is cut-and-dried and the belief that the discipline is composed of many disparate and already prepared parts. This instrumental belief is embodied in the following response given by a teacher when asked about the nature of mathematics:

> For me, mathematics is the basic operation of addition, multiplication, subtraction and division used as the fundamental building blocks to show definite relationships of numbers and symbols that can be extended into higher and more difficult levels of numeric and symbolic relationships.

The above quote is taken from data collected during a study by Becker and Pence (1988). In this project, 43 teachers from an inservice program were asked to discuss their views of 'what is mathematics'. A number of teachers took this question seriously and bravely discussed their own views. All of the quotes attributed to teachers come from this data source.

A Platonist belief

Another view of mathematics is illustrated by the teacher who states that:

> To me, mathematics is a set of theorems and postulates which are used to organize data, and to put some order into the physical aspects of the real world. Mathematics is often simplified into a set of algorithms which can be applied to real problems or abstract problems.

This statement seems to correlate more closely to a Platonist view of mathematics as a static but unified body of knowledge. The mathematics is discovered, not created.

Harold Austin

A problem solving belief

A third view of mathematics is reflected in this next quote by a primary school teacher:

> Mathematics is a way of describing our universe and our world. Poets may use adjectives and historians use dates and artifacts to describe our environment. Mathematicians use numbers, form, patterns, and graphs to help us understand the world we live in. For me, mathematics has always been a process of discovery.

Here, there is a problem solving view of mathematics, one in which mathematics is a dynamic, continually expanding field of human creation and invention. Mathematics is a process of inquiry and discovery.

Implications of belief systems

Ernest (1988) suggests that there may be three general categories of beliefs about mathematics typified by these examples. To each of these conceptions of the nature of mathematics, Ernest maps a view of both the teaching and learning of mathematics. In the case in which mathematics is an accumulation of facts, rules and skills, the teacher's role is perceived as that of an instructor working to show or tell students the proper techniques in the clearest way possible, and helping the children to reach the 'correct' way of thinking about mathematics. For the Platonist, the view of the role of the teacher becomes that of an explainer of conceptual understanding of a unified knowledge. Finally, where mathematics is seen as a process of discovery, the role of the teacher becomes that of a facilitator helping the students become problem posers and problem solvers.

Beliefs affect communication as well as classroom practices. The word *problem*, for example, does not mean the same thing to everyone. It may mean a routine word problem to one person, and to another it may mean the process of discovery. The following examples illustrate this variety in the meaning of problem:

- Steers sell for $25 a head and cows for $26 a head. A farmer has $1 000 to spend and must spend it all on cattle. How many cows and how many steers could she buy?
- Steers sell for $25 a head and cows for $26 a head. A farmer bought 14 steers and 25 cows. How much did he spend?

Table 1: DIMENSIONS AND ELEMENTS O

AGES	STRANDS	WORKING WITH CHILDREN	LEARNING OUTCOMES	TEACHING STRATEGIES
Early childhood	**Number**	**Individuals**	**Content**	**Problem solving**
	+/−/x/÷		Conceptual structures	Non-routine
K	Number patterns and relations	**Small groups**		Modelling
			Processes	Strategy games
1	Chance	**Large groups**	Cognitive	**Applications**
	Statistics		Metacognitive	**Investigations**
2	Graphs		**Attitudes**	Open-ended
3	**Space**		Feelings	Guided discovery
	2D, 3D		Beliefs	**Practical work**
4	**Measurement**		Emotions	**Discussion**
	Length			
5	Area			**Exposition**
6	Volume			**Practice**
	Capacity			
7	Mass			
	Time			
8 - adult	Angle			
	Temperature			

For some, the first would be a problem because it provides some room for exploration while for others the first could not possibly be a problem for exactly the same reasons. Thus in a conversation about mathematical problems, the difference in conceptions might never surface and thus similarly stated ideas may bear little similarity of meaning and no overlap in classroom practice.

Thus recent research highlights the importance of the relationship between beliefs, communication and classroom practice (e.g. Thompson, 1984). With this relationship in mind it seems clear that we must seek ways to incorporate experiences in our teacher education courses that engender beliefs conducive to successful mathematics teaching.

A curriculum framework

Teacher training courses need to provide for the realities of the primary classroom: the vast range of student abilities and attitudes; the need to work with individuals, and small and large groups; familiarity with manipulatives and schemes of work, as well as more than an instrumental understanding of mathematical content. These courses also need to provide varied situations in which students encounter the major and significant issues that arise in teaching mathematics with the aim of developing belief systems that can accommodate new ideas and new approaches.

Faced with the *Discipline Review of Teacher Education in Mathematics and Science* (DEET, 1989) lecturers in the Department of Mathematics Education at Edith Cowan University felt a need to debate again the fundamental issues of teacher education in their subject.

Disentangling these issues was a major problem, and Table 1 helped provide a framework for the task. Within Table 1, there is a set of broad dimensions that need to be continuously addressed by a course on teaching mathematics. Within each dimension is a further set of specific topics or elements that require consideration at some stage throughout the course.

There is no intention to suggest a sequence of instruction. Clearly some courses function particularly well where mathematical content is divorced from teaching issues. However, it would seem more than useful to suggest that content ideas may be learnt effectively and with a clearer purpose in mind if both content and methodology are intertwined. Further benefits may ensue if these experiences are similarly worked with children and then later reflected upon (NCTM, 1991). Experiences within courses and with school children can be conceptualized as interactions of the various dimensions and the elements within each dimension. For example, an activity involving calculators from the upper primary number strand can provide the focus for a discussion on the issue of assessment. The *Mathematics Curriculum and Teaching Program* (Lovitt & Clarke, 1989) resource provides such a teaching episode that incorporates these three elements.

Similarly, teaching problem solving can be considered across strands and stages using a variety of materials and technologies. The focus of any series of teaching episodes will depend on pre-service teachers' past experiences, knowledge, and attitudes, and will need to be considered in much the same way as teachers consider children's development. As pre-service teachers gain in knowledge, experience and confidence, issues will be developed with an ever-increasing depth of awareness and understanding.

The dimensions that form the framework for considering the significant ideas of a primary mathematics education course are described as follows:

1. Ages. The chronological age of the children for whom the activities apply.

2. Strands. The content of the mathematics syllabus partitioned

SIGNIFICANT ISSUES		SIGNIFICANT RESOURCES	
How children learn Aspects of development Construction of understanding Representation **Attitudes to mathematics** **Language and mathematics** **Mental mathematics** **What is mathematics?** **Place of technology** Calculators Computers Video **Planning for learning** Small group activities Lesson planning Long-term planning	**Assessment** Diagnosis/remediation Marking/grading/reporting Self-assessment **Gender** **Multiculturalism** **Multi-level teaching** **Integration** **Parents and community** **Future directions** Written computations **Curricula** **History of mathematics** **Transition** **Resource teachers**	**For children** Computer software Logo Basic Calculators MABs Cuisenaire Unifix Attribute blocks Pegboards Pattern blocks Geostrips Centicubes Measuring instruments	3D solids Lego material Textbooks Activity cards Various kits Commercial games **For teachers** Syllabus Published texts Associations Research Journals Reports

into areas that are conceptually similar. For example, the space strand, which incorporates 2D and 3D knowledge.

3. Learning outcomes. This dimension describes qualitatively different outcomes that children learn, for example, the conceptual structures (understandings) of mathematical content and the processes of mathematical thinking and problem solving (Shuard, 1986).

4. Working with groups. Activities involving children are considered in relation to the size of the group.

5. Teaching strategies. Different teaching strategies that incorporate those identified in the Cockcroft report (DES, 1982).

6. Significant issues. This dimension includes issues that provide the basis for developing appropriate beliefs about, for example, how children learn.

7. Significant resources. This category includes both materials considered essential for the development of mathematical understanding of children and the professional development of teachers.

The interaction between various dimensions and elements of the framework are numerous. Spending some time in discussion and selection of appropriate dimensions and elements can result in a teaching episode that is a rich and rewarding learning experience.

Conclusion

The beliefs that teachers hold about mathematics and how it is learnt will certainly be influenced by the approaches taken in mathematics education courses. The framework provided here allows us to step back and reflect upon the myriad connections that can occur.

Our task, then, is not to spend 12 years training students in an attempt to 'cover' all the possible routes of understanding resulting in the 'ideal teacher', but to choose pathways – and allow pathways to be chosen – that reflect both the nature of understanding and discovery, and provide teachers with an awareness, and a desire, for future growth.

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