Johnstone-Wilder, P.; Pimm, D.; Westwell, J. (Eds.):

Learning to Teach Mathematics in the Secondary School

A Companion to School Experience

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1. Purpose of the book

For reasons that will appear later, this book should interest most mathematics educators, even though it is designed for use by trainee teachers within the British system, who are now constrained by the National Curriculum (which we abbreviate to NC). It is the mathematics representative in a series envisaged by the Publisher, of satellites to a parent-book *Learning to teach in the secondary School; A companion to School Experience,* which is intended especially for students who are learning to teach on initial teaching courses. On these, a large part of the time is spent in a secondary school, to observe qualified teachers (one of whom will be their personal mentor), to lead portions of lessons, imbibe the ethos of a subject department, etc. The action is always implicitly within the British (usually English and Welsh) system, with some explicit references to Scottish or Northern Irish variations. Each satellite has a title of the form: "Learning to teach X in the Secondary School", where X = English, History, Physical Education, etc., and the book under review is the case X=Mathematics. It ignores the problems of classroom discipline, or of stimulating interest among young people who are encouraged by their predators to have non-intellectual, materialist attitudes and to regard knowledge as merely something to pass an examination with, before being forgotten. Such problems are presumably dealt with in the parent-book.

The potential interest for a non-British reader is twofold, because the book is concerned both with how to begin a lifetime's work of becoming an enlightened mathematics teacher, and with showing how to cope with irritants imposed by the political system. (These irritants are likely to spread to other countries, as managerial fashions and tax-cutting politics combine; British education has already had 10 years of such interference with professional judgement.)

The book also makes the implicit assumption that its students have a degree with mathematics as their major subject, with no explicit demands on that background. Rather, the purpose is to convert raw mathematicians, so that they may think and act fluently with the benefit of current findings within mathematics education. But, the book is tied to our recently imposed educational structure, which most British mathematics educators find highly defective and which makes it very difficult for them to carry out "abstract" research. However, the contributors to the book are all more liberal and sophisticated than those who have imposed the NC, so their disciples may eventually have a civilising effect: we are in the middle of a big experiment which will not stabilise the system for years.

Thus, the book is a product of the discipline of mathematics education, in that it is concerned with teaching and learning, and in the context of imposed constraints by society. In Britain, some constraints were always there, of course; but now they have changed radically, and are also much more visible. Therefore I must explain for readers of this review something of the background of the system which stems from the imposition in 1989 of the National Curriculum by the then government.

2. The National Curriculum in England and Wales

Historically, the British had been proud to have no NC whatever. But now all children in state schools (in England and Wales) must follow this tightly specified curriculum between ages 5–16. For different historical reasons, the new rules do not apply to Scotland and Northern Ireland. In all the main school subjects, but especially in mathematics and English, the NC now has a dominant influence on the training and professional life of a teacher. Numerical measures of performance have been introduced, to construct numerically ordered "league tables" of schools, with the underlying (implicit) political purpose of appealing to middleclass voters, for the exercise of "parental choice" in a kind of free market. These crude tables have already caused a shift of middle-class children from "poor" schools to "better" ones, with destabilising implications for per capita funds; yet at the time of writing, one of the responsible Right-wing Ministers (Baker) chuckles as he tells an interviewer that his whole intention was to destroy the comprehensive schools by stealth, in order to bring back the selective schools of his youth. He appears to have followed plans worked out over some years by a small group within his party.

Within the system, schools are subjected to costly inspections by teams that "name and shame" (and even close) schools and teacher-training colleges of whom they disapprove; and rational argument is made difficult by the Chief Inspector, who publicly pours scorn on hostile research findings. He admits to having been at one time a "trendy" teacher (and "trendy" is a term like "pupil-centred", used to conjure up visions of Left-wing subversives). Since the change of Government in 1997, a Left-wing Minister has been in charge, and accepts the NC with enthusiasm because he too must appeal to middle-class voters. Perhaps that is why he still retains the services of the same Chief Inspector, but he does believe that the discipline of the NC will ensure that the average teacher will induce high levels of achievement especially in socially deprived pupils, as a foundation for them to climb out of poverty. (The Thatcher Government refused to admit the existence of poverty!) We can only wait and see, but some would argue that the NC, however wisely used in general, may be useless for many children whose families have no member in regular employment; for, there seems to be a clear inverse correlation between the academic success of a school (using the crude measures) and the proportion of children entitled to free meal vouchers.

The mathematics NC was produced by an invited committee, which tried to incorporate civilised features, but they were forced by the Education Minister to come to a

speedy conclusion without pilot trials. Teachers in general were not consulted, having been fiercely denigrated since the election of the Thatcher Government in 1979. The result is a curious mixture of managerial measurement, with traces of professionalism here and there. Thus, as Chapter 2 of the book describes, there are 4 "Key Stages" for pupils aged 5–7,7–11,11–14 and 14–16; the traditional A-level mathematics is not included in the NC. At the end of each stage, there is a national examination with up to 8 levels of achievement within 4 "Attainment Targets" labelled (1) Using and Applying Mathematics, (2) Number and Algebra, (3) Shape, Space and Measures, (4) Handling Data. Teachers are expected to keep detailed records (incorporating 8×4 matrices) of the progress of each pupil in terms of the levels reached. On teachers, this imposes an enormous work-load, in addition to the need to learn prescribed styles of presenting the mathematics (including some Back to Basics). At first, schools received masses of documents announcing frequent revisions, but eventually a 5-year moratorium was agreed, and the current curriculum dates from 1995.

3. Structure of the book

As former pupils, most future teachers have experienced little of the NC, so they now need a great deal of new information, and the book under review will be a useful aid. Given the background explained above, the book is mainly concerned with teaching Key Stages 3 and 4 to the age-group 11–16. Something of its scope can be seen from the list of Chapters and their authors:

1. Mathematics Education: Who decides? (J. Westwell)
2. Mathematics in the National Curriculum. (J. Westwell)
3. Pupils learning Mathematics (Maria Goulding)
4. Different Teaching Approaches (D. Pimm and S. Johnston-Wilder)
5. Planning for Mathematics Learning (Keith Jones)
6. Assessment and Public Examinations (P. Johnston-Wilder)
7. Communicating Mathematically (Candia Morgan)
8. Using Information and Communications Technology (ICT) (S. Johnston-Wilder and D. Pimm)
9. Mainstream Mathematics Teaching and Special Educational Needs (M. M. Rodd)
10. Getting the Whole Picture (J. Westwell)
11. Teaching Mathematics Post-16 (Ann Kitchen)
12. Professional Development (Christine Shiu).

These follow an explanatory introduction by the editors. Each Chapter has its own small list of references, and there is an extensive list at the end of the book, plus an index. Also there are 5 appendices: 1. Glossary of terms, 2. Sources and resources, 3. Making closed tasks open, 4. Starting with ICT – practicalities for beginners, 5. Practical task – rolling balls.

Some of these Chapter headings are self-explanatory, and even a raw mathematician might expect that a teacher should be taught something about them; but it is surprising to see how much there is to know. Readers are encouraged to keep reflecting on their experiences, and to keep a journal. Systematic planning is stressed, and exemplified by providing boxes near the start and finish of each Chapter, that describe what you should have learned from it. Such learning is supported by boxes containing highlighted tasks (which may involve considerable work involving interviews, discussions and reading other books). The text is therefore very user-friendly, but a reader who carries out all the work suggested will have had a very strenuous time indeed.

4. Description of the chapters

So much for the general structure, which is well-conceived. What about the detail? Much of it is fascinating, but there is so much, that this review can select only what appealed most to the reviewer. Chapter 1 begins by accepting that a reader may be too concerned about how to handle a classroom of over 30 pupils to bother about "abstract" philosophical issues, but points out that one's view of mathematics itself will affect both the way in which one teaches it, and one's aims in providing pupils with a mathematical education. Therefore, after quotations to dispense with a unique view, four competing views of mathematics are discussed (following Paul Ernest), arising from four social groups labelled mathematical purists, industrial pragmatists, progressive educators, and social reformers. From such groups comes agitation for change in the mathematics curriculum, with associated agencies which are briefly described. As the same author sketches in Chapter 2, the four views leave traces in the mathematics part of the NC. Boxes of questions are supplied to get the reader to begin thinking. While I approved of the approach, I suspect that the average student will find the language difficult; British mathematics graduates are given little practice in reading prose or in philosophical thinking, and many males especially are found to confine their general reading only to factual material. After this rather universal material, the chapter "goes British", and describes various agencies for change. It is then natural to discuss the mathematics part of the NC, and (as mentioned above) this is the concern of Chapter 2, by the same author. He assumes that the reader will have their own copy of the NC, and therefore does not list the required topics in detail.

Chapter 3 is less strongly related to the NC, and sketches some theories of learning and knowledge. It uses terms like "contingent" and "constructivism" without definition (although they are probably defined in the books for Further Reading).

It will now be simpler to mention certain other chapters without following their indexed order. Thus, given the purposes behind the imposition of the NC, it is not surprising to see the title "Assessment and Public Examinations" for Chapter 6, but its author points out that reasons for assessment include obtaining feedback for the teacher as well as examination records, and gives a good survey. He refers to the problem of interpreting and using the information that each pupil brings when leaving Key Stage 2, and of considering the purposes and style of assessment records (e.g. for parents). Some of the Chapter's Tasks involve open-ended and investigational work, or collaboration with other teachers; and there is a warning about keeping the workload within bounds. It is more surprising to find that Chapter 10 is concerned with the

role of a mathematics teacher in contributing to a "whole-curriculum perspective", but the NC requires the promotion of the "spiritual, moral, cultural, mental and physical development of pupils ... and preparation for the opportunities, responsibilities and experiences of adult life". Short of writing a full book, the author can only sketch various points, about cross-curricular work with other teachers, the spiritual and cultural dimensions of mathematics, the need to listen to arguments and for toleration, etc. Also he stresses that teachers should not abdicate responsibility by adopting attitudes such as "it is not my job to teach them to write good English". This is not understood by many academic mathematicians either (how else can pupils learn to communicate mathematics?

Chapter 4 surveys different approaches to teaching, and begins by suggesting the observation of all sorts of teaching practices, in music, sport, etc., with the advice of the actor, Michael Caine – "Steal, steal, steal!". Within the NC, the new orthodoxy favours "whole-class teaching", a term used by Right-wing commentators to imply the wholesome security of their own youth, as opposed to the "trendy" (hence Left-wing) small-group teaching that became fashionable after the 1960's. Here the authors show that whole class-teaching can take various forms, and they go on to discuss teaching by telling, asking or listening, and the difference between exposition and explanation. On p. 59, I was astonished to find the term "teacher lust" (which I first heard in the 1970's) used in a quotation from Mary Boole in the 19th Century, who meant "desire to control classroom activity" and associated it with "sex-lust" – for her Society, another shockingly unladylike term. The chapter concludes by referring to such types of resource as history of mathematics, role-play, parents etc.

But, against all these stimulating ideas, we have to reckon with that managerial tool, the lesson plan, which can inhibit spontaneity and the role of teacher as actor-comedian. Government Inspectors are keen to see lesson plans, which are the concern of Chapter 5. It warns that the "level descriptions and associated testing can suggest teaching strategies that give prominence to a fragmented view of mathematics, and an instrumental view of learning", and the author gives brief examples of the structure of lessons from Japan and the USA. He adds much sensible advice about planning a lesson, and touches on the setting of homework.

Chapter 8 is also a "practical" chapter, which explains some important general features of working mathematically with computers. (Information technology (IT) is part of the general NC, and in mathematics it is required only that "pupils should be given opportunities ... to develop their IT capability in mathematics".) The authors assume no background, and give short descriptions of the slide-rule, and abacus, before mentioning the calculator and the arguments for and against banning its use in school; these still rage after Baker's early decree in favour of long-division.

Because of changed social attitudes to disabled persons, every teacher can nowadays expect to have a few pupils in the mainstream class with "Special Educational Needs" (SEN). Chapter 9 puts to the student teacher two questions: "what is special?" and "what is needed?", and suggests that (as always in mathematics) insight is gained through observing errors. While some disabilities of limbs, sight or hearing may be obvious, the teacher may be the first to uncover others (such as dyslexia and discalculia), and needs to know whom then to consult. Some exceptionally bright pupils may appear to have behavioural difficulties through boredom – how can they then be supplied with stimulating mathematics, and would this be appropriate for an autistic pupil? And there are the many otherwise "normal" children who do not have English as Mother Tongue, and for whom the standard texts need extra explanation. With so many examples, the chapter cannot hope to do much more than implant awareness of the types of problem that can occur, but adds several suggestions for further reading. Additionally, it naturally draws attention to Chapter 7, whose author begins by remarking that the NC requires all teachers to be responsible for ensuring that pupils communicate well in English, but she stresses that mathematics teachers must be responsible for providing practice in communicating mathematics, even though it might be useful to work jointly with a teacher of English. Starting with notes on the need for careful planting of the vocabulary of mathematics, she quotes a study of 16 high-attainers aged 14, who interpreted the word "diagonal" in 6 different ways, only one of which was the conventional meaning. One of its tasks gives useful exercises for the trainee teacher, who is explicitly and realistically (but regrettably) assumed to have had little experience of mathematical writing for the work of their own mathematics degree courses. Another task concerns both listening to pupils' explanations, and reading their written work; this could be about what they think they have learned, or to explain why something holds, or how to work out something. The summary concludes with the warning of the tension between the wish to have pupils using the conventional means of communicating mathematics, and the need to avoid the mystification and anxiety caused by using unfamiliar language. Four books are suggested for further reading.

Nowadays, several different types of post-16 student are found in the system. These include not only the traditional age-group 16–18 that specialises in A-level mathematics and science, but some pupils re-taking the earlier Key Stages, or taking "vocational" courses. Their problems are discussed in Chapter 11, which suggests that the teacher will probably need a different teaching style, if only because of the likely gender imbalance – average male to female ratio is 3:2 . There is a survey of the various post-16 qualifications and styles of assessment, and the final summary concludes with the warning: "Whilst you will have to work within all these constraints, you will also find that you must have complete mastery of all the mathematics needed." That surely holds for all age-groups, but here it is stressed that the pupils are likely to be more persistent as questioners. The final Chapter 12 is a straightforward essay on the ways in which teachers, once settled in, may develop professionally, by joining various groups, taking greater administrative responsibility in school, increasing their mathematical strength, or taking part-time degrees.

5. Appendices and omissions

As to the Appendices, the first is a useful reference for the many acronyms that abound in the educational system, while the second lists relevant journals, web sites, and addresses of organisations, suppliers and publishers. Appendix 3 lists 9 closed mathematical questions, with suggested modifications to convert them into open tasks (taken from the non-statutory guidance to the NC), and Appendix 4 gives more detail (necessarily brief) on graphic calculators, spreadsheets, dynamical geometry, Logo, and the Internet. Finally, Appendix 5 starts with the practical experiment of rolling balls down an inclined plane, in order to ask and settle relevant questions about the observed motion. Advice is given about technique, accuracy and handling graphs of experimental information in this type of applying mathematics.

Such uses of specific examples could well have been used at other points in the book, although perhaps the editors preferred to leave them to the references, to save space. But, those references may not supply adequate guidance. For example, there are two textual references to fractals (not mentioned in the Index) suggested as a topic of enrichment, but where is the mathematics? One can show pupils beautiful fractal graphics, but some indication is needed as to what else the teacher might say to make the topic truly mathematical. The inexperienced can easily start on an attractive topic and then find that it turns out to be too complicated, or takes too much time – even when pupils don't want to leave it. Another omission is an extended discussion of "proof", which has 9 entries in the index, but each refers only to a use of the word in passing. True, the NC requires very little on the topic, and several of the chapters mention forms of classroom argument that give experiences of justifying assertions. These are an important preliminary, often omitted in the days of formal Euclid, but should there not be some formal practice with well-chosen examples? What can we suggest to new teachers, about modifying into suitable arguments, those relevant formal proofs they may have learned (often imperfectly) in their own mathematics courses? How can they make it plausible that $(-1)^2 = 1$, or teach a consistent notion of area? How can they avoid unwittingly giving their pupils the impression that Pythagoras' Theorem is proved by verifying that $3^2 + 4^2 = 5^2$, or remove other errors of elementary logic? Few academic university courses pay any attention to such basic matters, even while claiming high "standards" (which they leave unanalysed). The editors might reply that such matters are dealt with in other books, but it is still important to guide students to them; and especially to arrest a tendency among some writings on mathematics education, to ignore the mathematical detail altogether. I am moved to dwell on this, after reading Howe 1999, which is a review of a comparison (Ma,1999) between US teachers and their Chinese counterparts.

The criticism of that review is based on a certain tendency in United States K-12 education, to emphasise "knowing the student over knowing subject matter". By contrast, one of the Chinese teachers makes a neat epigram: "In a word, one thing is to study whom you are teaching, the other is to study what you are teaching". Perhaps, too, they can assume that Chinese children are less content to be ignorant, than their more affluent Western counterparts.

Apart from such omissions, we may safely expect that any student-teachers who become fluent in all the topics of this book will have a very wide knowledge of the facts and thinking of contemporary mathematics education, as stimulated by British constraints. But will such students eventually be "good" classroom teachers? The attempt to become fluent could inhibit practical teaching, because there seem to be so many pitfalls. Even if they are "good" (in the eyes of readers such as ourselves) they may then clash with reactionary inspectors, so they must learn some tact. Then they can become a useful force for modifying and humanising the managerial intentions of misguided politicians. Certainly the book is, for all students of mathematics education, an excellent survey of many problems that may well arise in many different societies in future, and which may well need different, but appropriate solutions.

6. References

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