High school mathematics teaching in the USA

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The United States of America is a large and diverse country; nevertheless, high schools have a lot in common across the nation. In particular, mathematics teaching in American high schools, while not stereotyped, has some accepted norms which would be seen as unusual here in Australia. In order for us to learn from the Americans, as well as to properly appreciate the curriculum and assessment materials we receive from them, it is important for us to understand the differences between the two countries in both schools and mathematics teaching.

For many years I have referred to Lingard, Johnson and O'Brien (1985) to give a picture of high school mathematics in the States from an outsider's perspective, but, after twenty three years, I thought it might be a bit outdated, For an up-to-date view, but that of someone working within the system, Cuoco (2003) is very useful, but I was interested in identifying those "commonplaces", as O'Brien terms them, which everybody within the system takes for granted, but which an outsider such as myself finds different. Indeed, I found that I needed to rid myself of my own ingrained assumptions about how schools are organised before I could appreciate these differences – and it took me most of my three months of observations to do this.

Schools in the United States are organised into education districts; there are over 13500 districts throughout the country. Some have a large number of high schools with a retinue of junior high and elementary (primary) schools, whilst others will have only one high school with one or more junior high and elementary schools, some will consist of only elementary schools, some of only high schools. Typically, elementary schools will have grades 1 to 5 or 6, middle schools or junior highs 6 or 7 to 8 or 9, and high schools 9 or 10 to 12, although many different combinations can be found amongst them. The number and composition of districts varies enormously from state to state - for instance, Hawaii has only the one state-wide district, whilst Oregon, a middle-sized state, has 199. Further, there are also non-government schools independent of the districts.

The first major difference I came across in my three months sojourn there was that most schools break for nearly the whole summer; they do not resume

until the start of September, which is the equivalent of March in the Australian context. I was fortunate to have a discussion with a group of teachers in a summer class run by Professor Christine Ebert at the University of Delaware in August 2008, and this was my only contact with teachers in the eastern states. I was able to visit twelve high schools in the mid-west and western states through September and October of 2008, and to interview mathematics teachers there.

High schools, in the main, cover the ninth to twelfth years of schooling; students in these years are referred to as freshmen, sophomores, juniors and seniors—freshmen are year nines, sophomores year tens, juniors year elevens and seniors year twelves. However, this division is more of a social than an academic one; it is not at all unusual for one class to contain students in a number, or even all, of these categories. Sometimes a student may have completed Algebra 1 (or its equivalent) at middle school, and so start with the Geometry course as a freshman; others more mathematically challenged may still be attempting Algebra 1 as a senior.

This ability to spread the students across the courses is the second difference, and is enabled by the third, which is the way in which timetables are managed. In American high schools the norm is the single day timetable - every day has exactly the same classes at the same times, with classes in a subject arranged vertically rather than the horizontal format found in Australian schools. Thus, where we have a subject taught by different teachers to a number of classes all at the same time, in the States one teacher will teach the subject, and hence the same lesson, to his or her classes throughout the day.

The only major variation to this arrangement are the block systems, which use ninety minute lessons in place of the usual fifty to fifty five minute ones. The regular single day timetable will have six or seven periods per day, whereas a block system will have some or all of these combined to double lesson length. For some, this is achieved by first setting a single day timetable of periods 1 to 6, say, and then on some days running periods 1, 3 and 5 as double lessons on the first day, and periods 2, 4 and 6 as doubles on the next. In some schools this is done for only two days of the week, in others four, with the fifth day having regular length lessons. Others will use the alternative of having the same timetable of double length lessons every day, but with the lessons on the second day given to different classes.

This organisation of the timetable has consequences for the teachers; for many of them their teaching day will be made up of giving the same lesson to six different classes, and the next day a different lesson to the same six classes. A good number of the teachers I interviewed were senior teachers who taught two or three different courses, but one indicated that he thought the lot of junior teachers who taught the same lesson six times a day was “pretty awful”. Some schools had recognised this difficulty, and insisted on some variety for all teachers; however, I also received the comment that the system cut down considerably on preparation time.

For the students, though, this meant that some courses were available in every period of the day, and all of them in a number of periods, except in the

smallest of rural schools. So the students could stitch together a timetable which incorporated courses at a variety of levels. Thus American schools are not tied to year levels as we are in Australia; a student can fail a course and then repeat it in the following year without having to repeat the whole year's study. This flexibility enables them to require that, in mathematics at least, a student must pass each subject in a sequence before proceeding to the next one; a typical sequence is Algebra 1, Geometry, Algebra 2 and Pre-calculus. In some schools this can be preceded by Pre-Algebra, usually taught in conjunction with the junior highs, and the sequence can be followed by a Calculus course, which is often given status in a tertiary college.

In most schools the courses are of a full-year's length, and students in mathematics take only one area of the subject for the whole year - a freshman will generally do only algebra, a sophomore geometry, and so on. In some places, though, courses are taken over a semester, but with twice the number of lessons, or daily double-length lessons. A few districts are introducing "Integrated Mathematics", however, and I heard that one such district was even using an Australian textbook series.

Concentration on just one mathematics subject for a whole year does mean that geometry in particular has become rather fossilised; as a whole year's curriculum must be based in the subject, much of it relies on the theorem and proof structure of Euclidean geometry. This gives American students earlier exposure to the concepts and process of proof than Australian students receive. Of course, this also explains why American textbooks are rarely seen in Australian schools—the textbooks will be for Algebra 1 or 2, for Geometry, or for Pre-calculus, or other one-topic subjects, whereas an Australian teacher will need to cover all the relevant subject areas.

Textbooks in the United States are usually chosen by the education district rather than the individual teacher or the school (the exception to this which I saw was in a private school, where the teacher was trialling his own notes in preparation for consolidating them into a textbook). Of course, the senior mathematics teachers in the high schools of a district would meet to discuss the possible texts and make recommendations to the district board, but at least a third of the teachers I spoke to were not completely happy with the choices that had been made for them.

A huge variety of technological aids were used in mathematics classrooms, although the graphics calculator was ubiquitous. These were almost universally Texas Instruments machines; one teacher indicated concern that his district was seriously considering converting to the "cheaper" Casio models, his worry being that both students and teachers were unfamiliar with them. It was interesting to see the gradual introduction of graphics calculators into everyday life. I must admit that I was sceptical about their use outside the classroom, but a number of teachers indicated that they themselves as well as their students found a graphics calculator valuable for a variety of tasks (e.g., see Figure 1).

Computer access for mathematics classes was as much a problem in the United States as it is in Australia: whilst some schools coped with the problem by having dedicated computer rooms for mathematics, most had to share the

facilities with other subject areas, and competition for scheduled places in the laboratories was increasing enormously. Certainly most of the teachers I spoke to were aware of a wide range of software, and tried to provide what they could of it for their students.

Figure 1. A graphing calculator in use at the Farmers' Market, Bloomington, Indiana

Most assessment is, as in Australia, in the form of free response testing by the teacher, but some is imposed by the school, the district, the state or even the federal government, and most of this tends to be multiple choice. The "No Child Left Behind" program, an initiative of the Bush government (US Department of Education, 2001), requires schools to undergo the system entitled "Adequate Yearly Progress", for which mathematics is one of three areas tested; the results from this testing, according to the teachers interviewed, are used to measure schools rather than individual students.

Most states also have their own state-wide assessment system, and both format and requirements vary considerably from state to state; a number of them test mathematics in multiple choice format, whilst others offer a mixture of multiple choice, short answer or free response. Testing offered by the various textbooks generally offers much the same mixture.

Most of the teachers interviewed preferred to use free response where possible, although some indicated that they would use multiple choice when a quick turnaround of results was required, as, for instance, at the end of the year. Free response was the main choice for formative assessment, but sometimes it was necessary to have the students practise multiple choice questions to prepare them for an upcoming district, state or federal test.

How can Australia benefit from the practices of the American system? Ours has evolved from a system where we had annual external examinations at Intermediate (Year 10), Leaving (Year 11) and Matriculation or Leaving Honours (Year 12); this developed a straightjacket where a student needed to pass the whole year in order to progress to the next. We have maintained this straightjacket despite removing all but the Year 12 formal assessment, and, in many places, reasons of social equity have meant automatic progression for a student despite the lack of academic achievement. It has also meant that we have developed and presented many courses at upper levels which are clearly of a standard relevant to much lower levels.

Appropriate timetabling and individualised student timetables, which are much more viable in this age of computerised administration, should enable us to divorce the courses from the year levels, as the Americans do. We should be able to have a student able to take Year 12 level English with Year 10 level

mathematics, and a class at Year 11 level in Chemistry taken by students from Year 9 to Year 12. To suggest that it is too difficult is to ignore the fact that it is the norm in schools right across a country fifteen times the size of ours, with much the same culture and attitudes.

I do not believe, however, that it would be worthwhile to follow the Americans in studying only one facet of mathematics for the whole year; some knowledge of geometry, for instance, is important for all students, particularly for those who enter some of the trades—but these are often the students who do not progress through the hurdle race which is the US system.

I would like to express my gratitude to all those who participated in my series of interviews:

- the students in Professor Christine Ebert's class at the University of Delaware, and Christine herself;
- Sue Dolezal of Sentinel High School in Missoula, Montana,
- Gail Farmer of Bisbee High School in Arizona,
- Diana Fisher of Woodrow Wilson High School in Portland, Oregon,
- Joe Franco of Fort Stockton High School in Texas,
- Roger Fuller of Grand Prairie High School in Texas,
- Brian Graham and Esteban Delgadillo of Hudson's Bay High School in Vancouver, Washington,
- John Holmes of Pinole Valley High School in Pinole, California,
- Christine Mathis of Las Cruces High School in New Mexico,
- Karen McClure of West Yellowstone High School in Montana,
- Scott Miller of Cañon City High School in Colorado,
- George Mills of St. Louis University High School in Missouri, and
- Michelle Panizzi of University High School in Normal, Illinois.

They ranged from one with only a few years in the classroom to veterans approaching retirement; there was a great deal of enthusiasm amongst the group, leavened by a degree of cynicism from one or two of the more experienced. Most of them appeared to be enjoying their teaching, and many were full of ideas for benefitting their students, and aware of, and using, a wide range of resources.

All of them were most gracious in their acceptance of a foreigner quizzing them about their livelihood, and participated enthusiastically in the process. I offer further thanks to those of the above who provided me with some of the resources they use in their classes; these were of great interest and could be of use to Australian teachers.

References

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