

MATTER FOR DEBATE

What makes a good maths teacher?

The work of a mathematics teacher takes place mostly during preparation, in interactions in the classroom, or through marking and quiet exchanges elsewhere. It has occasional highs, and inevitable lows; but these are not easily captured. So a teacher's impact – on students and on institutions – is largely invisible, and is mostly forgotten: *the good that mathematics teachers do is oft interred with their bones*.

Yet it is occasionally worth trying to disinter some of these buried secrets. We focus here on one teacher: Francis James Budden – henceforth referred to simply as "Frank". Frank was unusual in some ways: for example, he was ultimately President of the Mathematical Association in 1982, succeeding Sir Michael Atiyah. But he is also representative of a whole generation of remarkable teachers, who began their teaching careers immediately after the Second World War, and whose contribution to the profession deserves wider recognition.

Frank was an unusually talented mathematician, and a remarkable teacher of able students – if sometimes less successful with those who struggled. He spoke out in the early 1960s *against* the shortcomings of the "modern maths" movement, and then wrote several books which showed how to enliven precisely that "modern" material (number systems; algebraic structures; computing; groups). He also conveyed his profound love of classical music – forming choirs and orchestras, and training school choirs to perform at the very highest level.

*I do present you with a man of mine,
cunning in music and the mathematics.*
(The Taming of the Shrew)

This thumbnail depiction from Shakespeare appeared in the school magazine of his very first school, Ripon Grammar School, where he began teaching mathematics several weeks before he was formally discharged from the Royal Navy on 28 March 1947, and where he soon took effective charge of *music* as well as Mathematics.

*It is a tiny minority who can do anything really well, and
the number of men who can do two things well is negligible.*
(G.H.Hardy, A Mathematician's Apology)

Hidden talents

On the day after the 1953 Coronation, one of a series of six *Coronation Concerts* was broadcast live from London's new Royal Festival Hall. This was a celebration of English music [Figure 1], involving many leading musicians of the time, including Peter Pears as soloist. Sir Malcolm Sargent conducted the BBC Symphony Orchestra, the BBC Choral Society, and the Watford Grammar School Boys' Choir ("Conductor: Frank Budden") in two English masterpieces: Britten's *Spring Symphony* and Elgar's First Symphony. At that time the Watford Boys' Choir was one of the best such choirs in the London area, and could clearly be trusted to master the complex rhythms of a difficult score. Benjamin Britten attended both the rehearsals and the concert.

Mathematics teachers might be forgiven for ignoring the grander details of this national celebration, in order to ask: Why on earth was a young maths teacher in his sixth year of teaching, and with no formal musical training, involved at all? Sir Andrew Davis – one of Malcolm Sargent's successors as conductor of the BBC Symphony Orchestra, and currently director of Lyric Opera of Chicago – sang

as a boy treble in Watford from 1955 to 1957, and has provided us with an insight into Frank's abilities. In his opinion, Frank was simply one of the best chorus masters that he ever worked with in a career spanning more than 50 years.

Frank's Watford choir had already broadcast the *Spring Symphony* on the Third Programme with Sir Malcolm Sargent a year earlier, in May 1952; they gave a third performance with the same forces in the Royal Albert Hall at the Proms in July 1954, again in the composer's presence. In the years between 1951 and 1959 (when Frank moved on from Watford to Mill Hill School), the Watford choir – always under Frank's direction – contributed to a dozen or more broadcasts, and to numerous concerts at major London venues.

The Watford choir's reputation seems to have been built *entirely from scratch*. Frank had already achieved something similar, if in a smaller way, in his first teaching job at Ripon Grammar School. In the under-resourced post-war years of the late 1940s, Frank (aged just 27, fresh from four years' war service in the Royal Navy, and with no previous teaching experience) was appointed "Senior Mathematics Master". Ripon Grammar School had a long tradition dating back to 1555; but in 1947 it had a very small staff, and rather few students (school photos of the time suggest there were around 40 boys in each year group). Despite his inexperience, Frank somehow cajoled colleagues into allowing him to form a choir and an orchestra – persuading several colleagues to take up an instrument in order to make up the numbers. Yet here, as later in Watford, the choir made its first broadcast within 15 months of its foundation [*The Riponian*, December 1947, 1948].

Frank had no formal musical training. And although self-taught musicians are not uncommon, very few master the craft sufficiently to operate at a high level. How Frank managed this transition remains a mystery.

The bare facts of his musical background, and an indication of the depth of his enthusiasm were revealed in an unlikely source. In 1946, when serving as meteorologist on HMS Orion, Frank was also partly responsible for "Education and Vocational Training" (EVT), a section designed to encourage ordinary naval ratings to prepare for their imminent demobilisation, and their subsequent return to "civvy street". Each week EVT printed an eight-page cyclostyled rag entitled *Group Happy?* – partly to advertise training and job opportunities, but padded out with articles which the editors deemed to be suitably "improving". As co-editor Frank was free to include mathematical puzzles, and to add some "culture": an explanation of the nature of money and savings; or the renewal of the BBC charter; or the history of modern Russia or China; or imports and exports; or the future of democracy; or the challenge of an ageing population; or regular reviews of books in the ship's library. When the ship was to dock in Trieste, or Corfu, or its base in Malta, he wrote about local history and the sights worth visiting "for the benefit of those who might wish to do more than simply drink in the watering holes near the harbour". After visiting Trieste, he wrote [*Group Happy?* No. 28, 12 May 1946] about *The art of conducting*, after a group had gone to a concert conducted by Luigi Toffolo:

"The great conductor combines qualities of leadership and musicianship. [...] *The main work of conductors is done at rehearsals, rather than at performances.* [...]"

The conductor *selects* and *organises* the orchestra. He forms it out of nothing in many cases. He recruits musicians to play for him. Setting himself a very high standard, he auditions those wishing to play under him, admitting only the very best: masters of their instruments – but musicians, not automatons; with a sense of rhythm, and of musical expression. Those who do not make the grade are cast out from time to time, and replaced.

The conductor *coordinates* an undisciplined mob of raw recruits into a unified team, all working together and following him – not because they are driven, but because they want to

achieve the highest possible standard of performance. The conductor becomes the "father" of the orchestra: respected, admired, and obeyed. [...]

This brings me to the question of the conductor's musicianship. Behind him he has many years of study of musical theory. He need not be a skilled performer on any particular instrument, but he needs an intimate *knowledge* of their capabilities, their range, and their tone.

Before [rehearsing a piece], the conductor studies *the full score* of the music – a large book in which is written every single note played by every instrument type in the orchestra. This is the conductor's blueprint. He can read it as easily as you or I can read a book. [...] When he has studied it and is ready to start rehearsing, he jolly well knows it [...] The conductor [then] knows exactly how he [thinks the composer wanted] the piece to sound. [...] *His work in rehearsals consists in getting the orchestra to play exactly what he himself hears in his mind.* This can be a long and tedious process [...]."

The intensity and detail seem remarkable for someone – with no musical training, aged just 26, and writing for conscripted sailors awaiting demobilization in the dog days of early 1946. But it gives a clue about his own subsequent style when working with choirs, and as a teacher with mathematics classes (and may explain why his approach sometimes backfired with those less committed than he was himself).

The following week [*Group Happy?* No. 29, 17 May 1946] Frank wrote an article on *How I became a music fan*. This provides crucial insights into his own *musical* development. And if we read between the lines (e.g. replacing operettas by puzzles, and orchestral music by mathematical themes such as geometry), the extract also illustrates how students can come to appreciate *mathematics*.

"At the age of about 15, I began to like some of the singers I heard on the screen – Grace Moore, Jan Kiepura, Richard Tauber – and soon developed a taste for solo singing, particularly for Italian songs and operetta of the early 20th century. From this curious mixture I graduated to Italian opera, with its many tuneful arias; and it was not long before I became conscious of the orchestra, not as a mere accompaniment to the more conspicuous efforts of the singer, but as a thing which could play by itself – overtures to operas. A friend of mine who played the clarinet stimulated my interest in instruments of the orchestra, and I became absorbed in their various tone-colours.

A great deal of your taste for music will depend on the influence of other people. You need someone to guide you, and to influence your search. Having "discovered" the orchestra, and found a delight in its variety of sound, it only needed another friend when I was about 17 to introduce me to a symphony concert. I was fortunate to be living in London at the time, and a shilling's worth of Sir Thomas Beecham was available every Sunday. I did not enjoy every concert: but I approached each one thinking "Perhaps there is something in this".

There was much that I did not (yet) like; but my interest had been aroused. I tried to *remember tunes*, jotting them down in a peculiar tonic sol-fa system of my own. I added to my small collection of vocal records – odd movements of orchestral and instrumental works; and by repeated hearings I began to enjoy Beethoven, Mozart, and Schubert. Notice that *repeated hearings* – hearing the same thing time and time again – is essential, and by far the best way of doing this is through *gramophone records*: in fact, it is the only really satisfactory way. You will find that if you play the same record many times (say three or four times a week for a month or so), there comes, quite suddenly, a point where the music *dawns* on you. That is to say, it becomes *familiar* to you, where previously it had been rather strange; you suddenly "catch on" and say to yourself "By Jove, I *know* this"; and you hum it, and

know what's coming next. This is a sure sign that you are making progress in your appreciation.

Three years ago I could see little in Brahms' symphonies, although I loved Tchaikovsky's. If anyone had told me "In three years' time you will have three of Brahms' symphonies in your collection", I should have said "Sorry chum, but Brahms is not my cup of tea!". But in your approach to music, you are led, or you wander, through a series of doors; and each one, as it is opened, reveals something new, and fresh, and more beautiful, without making what went before seem any less worthy. At present I don't like William Walton; but I know that some day he will *dawn* on me!

I have gone into this long story about myself just to show you what a long job it is; and it is *because* it is a long job that comparatively few people like classical music."

This musical testimony is consistent with our other piece of evidence – an undergraduate manuscript book, labelled "KCL", in which Frank completed some simple 4-part harmony exercises. As an adult, he was a committed Anglican and had a good tenor voice: so he may have been in a church choir as a boy. (A local Portsmouth paper in 1949 announces him giving a recital of extracts from *Elijah* and the *Messiah* in Milton Church Hall.)

Later Frank set himself to learn one instrument from each of the main sections of the orchestra (cello, bassoon, and horn) in order to inform his orchestral conducting. He continued playing the cello for many years [Figure 2]. He also played the piano.

But none of this explains what he achieved. Frank somehow developed the competence to read and interpret scores, and to select interesting and suitably demanding repertoire. And he mastered the art of forging bright young lads into remarkable choral units – maintaining the level of his Watford Boys' Choir over an extended period of 8-9 years, despite losing his best singers each year – and then having to train a fresh contingent. Their repertoire ranged from early 17th century to 20th century – giving the premiere of a work by Rubbra, and performances of works by Benjamin Britten and Vaughan Williams that were deeply appreciated by the composers themselves. And all this had to be fitted in alongside the constraints and commitments of day-to-day schooling!

Origins

Frank's father, Henry Francis Budden (known as "Harry"), was born on 7 May 1883 in Horndean (near Portsmouth). In the mid-1890s he "ran away to sea", joined the Merchant Navy, and later worked on the convoys repatriating the wounded after the Siege of Ladysmith 1899-1900. He joined the Royal Navy as a Gunner (1913/14), served at the Battle of Jutland, rose to become Lieutenant in 1932, and retired in 1933. He re-enlisted as a Lieutenant Commander 1939-44 for shore-based duties: the 1939 *National Register* (a national census conducted in great haste just 26 days after the declaration of war) lists him as "Master of HM Tug St Cyrus" in Portsmouth. In the 1940s he moved to shore bases near Portsmouth.

In September 1910 Harry married Maude Frances Smith (born 1884 in Kentish Town, but then living in Horndean) at Christ Church, Notting Hill. In the months following the Great War, Harry must have been based at what is now the Rosyth Dockyard, near the north end of the Forth Bridge, with the family living at 24 Hill St, Dunfermline, where Francis James Budden was born, on 16 May 1919. In 1922, Harry was posted to HMS Excellent (the naval Headquarters at Whale Island in Portsmouth) and the family moved to 69 Shelford Road, Milton, a suburb of Portsmouth.

Schooling c.1930

At that time, school attendance was nominally compulsory to age 14, but for most children did not extend much beyond primary level. There were very few "secondary schools": after completing primary school, pupils simply stayed on for an extra year or two. The 1926 Hadow Report (*The Education of the Adolescent*) had recommended the separation of primary and secondary schools, with a break at the age of 11; the Report also suggested that secondary schools might be tailored to the ability of the intake. However, until the 1944 Education Act, whether and how to respond to such recommendations was left to local school boards.

Portsmouth was a dockyard town, and most employment was related to the dockyard. Average income was low, so the local Council had limited resources. Following the Hadow Report, the 1928-9 reorganisation of schools in Portsmouth was decidedly modest in scope. In particular, there was no selection of pupils on the basis of academic ability. And there were very few school places available for anyone who might wish to continue beyond the age of 14. Nevertheless, as the 1930s progressed, some local schools in Portsmouth seem to have performed well.

We do not know which primary school Frank attended; but in 1930, at age 11, he gained admission to the Southern Secondary School for Boys. He completed his secondary education in six years rather than the usual seven – leaving school in 1936 with Distinctions in four Higher School Certificate subjects, rather than the usual three (Pure Mathematics, Applied Mathematics, Physics, Chemistry), and with a State Scholarship and a Royal Scholarship for his future university studies [<https://www.southerngrammar.com/index.php/the-school/people/academic-honours-some-former-pupils>].

Frank then studied Mathematics at King's College, London, graduating with a first class honours degree in 1939. He is said to have received the Lubbock Memorial Prize for the best mathematics student graduating in the whole University.

What next?

This was a uniquely difficult time for all new graduates – even those with an unusually strong track record. Although Frank had already graduated, the 1939 *National Register* has him at home, at 69 Shelford Road, Milton, and still listed as "student, King's College London".

King's College was then evacuated to Bristol – and it is here that we find Frank taking assiduous notes, in "Bristol University" notebooks, from lectures on education. Much later, in the Preface to [1], he attributed "the creatures depicted in" several diagrams as "the brainchild of Miss Jean Bowie who, at King's College, London, in 1941 alleged that she saw them peering at her through a microscope". We infer that the years 1939-41 were spent at least partly in gaining some postgraduate teacher training qualification "at King's", but based in Bristol.

In 1941-43 Frank served as a Junior Scientific Officer at the Royal Aircraft Establishment. However, we have been unable to access their archives to fill in the details, or to discover what he might have been working on.

In 1943, Frank was commissioned into the Royal Navy as a Temporary Instructor Lieutenant – a class that allowed an instant commission without going through the usual officer training course. He served as Instructor at various shore bases (mostly along the south coast) until the late summer of 1945, when the war was officially over. Then on 27 August he transferred to the Royal Naval College in Greenwich to train as a Meteorological Officer, graduating with 24 others from this three-month course on 1 December 1945. He was posted to the Mediterranean Fleet, based in Malta – at one stage claiming the title "Fleet Meteorological Officer". In 1946 he was on board the famous cruiser HMS Orion shortly before she was decommissioned and was fired on at the *Corfu Channel Incident*.

Beginning to teach mathematics – and music

In February/March of 1947 we find Frank in his first teaching job, as Senior Mathematics Master in Ripon Grammar School. Times were hard – and the winter of early 1947 was even harder. Among the motley crew of staff were three young bachelors, who, after they had finished their marking and preparation, used to meet regularly in Frank's rooms "to swing the lantern". One of them, the school's first ever French *Assistant* John Jammes (still alive and living in Buckinghamshire) had been a young member of the *Maquis*, with plenty of his own tales to tell. But, after a whole year of such meetings, he had no idea that Frank was a mathematician: rather he insisted that Frank must have been Head of Music "because that was all he talked about". When assessing the contributions of (even the best) mathematics teachers, one must perhaps look more widely than the mathematics classroom.

The 1947 edition of *The Riponian* magazine has Frank helping in March/April with the school's dramatic production (James Bridie's *Tobias and the angel*), starting an orchestra and a choir, purloining instruments, etc.. Frank wrote:

"Twelve boys are learning the violin and two boys the cello [...] But it is only a nucleus yet, and we will have to expand before we can "put on a show". The School Choir, which started rehearsing at the beginning of term, is making good progress in spite of its comparatively low strength (about 25 boys)."

Mathematics was (as so often) almost completely invisible in the magazine. The one exception indicated that the school nevertheless must have had a decent academic mathematical tradition:

"We have at last solved the mystery of the haunted Geography Rooms, which baffled us throughout the Summer Holidays. Apparently the visitor was David Kendall of Magdalen College, Oxford, who was engaged on a learned paper on population growth, and honoured the school by composing it in our precincts."

This ex-pupil David Kendall was later to become the inaugural Professor of Mathematical Statistics in the Cambridge Statistical Laboratory.

By the end of the next school year, the choir had performed concerts and services within the school and in Ripon Cathedral. They had also prepared a varied programme and travelled to the BBC studios in Leeds for a recording, which was broadcast on 6 July 1948. The 1948 school magazine includes mentions of a visit to the school by The West Riding Orchestra, a visit to "Intimate Opera" at the Royal Hall in Harrogate, and a visit by budding school instrumentalists to a rehearsal of the Hallé Orchestra under Sir John Barbirolli.

A year later, in the December 1949 issue of *The Riponian*, we read:

"In July [1949] ... Mr Budden left us to go to Watford Grammar School. He was Senior Mathematics Master, but it is not for this, well though he carried out his duties, that he will be remembered. Before Mr Budden came, music was an almost unknown quantity within the school, but through his untiring efforts during his years here he developed an interest in music throughout the school that previously had been almost non-existent. He left behind him a choir, which he built up to broadcasting standard, an orchestra, a music club and an appreciation of things musical which will remain with many boys for the rest of their lives."

Watford

Watford Grammar School for Boys was a much larger institution. And Frank must have been a rather junior member of staff – having just two and a half years' teaching experience. We do not know what role the Headmaster Percy Bolton played in Frank's appointment, or in subsequently

encouraging his musical bent. However, Bolton had been a Junior Wrangler; and ten years before, as Head of Dean Close School (1924-38), he had overseen something of a musical revival, with an emphasis on choral activity.

Before Frank's arrival in Watford there is no trace of serious musical activity on a wider stage. With Frank's arrival, orchestral – and especially choral – music took off: within 15 months, the choir had established itself on the London music scene. They gave 30-60 minute concerts on the Light Programme and the Home Service; classical concerts on the Home Service and Third Programme; and they were soon performing in the main London concert venues with major orchestras and soloists – always listed as being under Frank's direction. It is not easy to convey the amount of time and effort that is required to get busy schoolboys to a level where they can perform reliably alongside professionals – not least because a new group of boys had to be trained each year (as voices changed)! Frank somehow kept this going for almost a decade.

Our evidence from numerous sources conveys a consistent impression. Frank was never the kind of teacher who might these days be classed as "excellent": he was competent, entirely genuine, and deadly serious. His occasional jokes were remembered because they were often found slightly surprising. But those willing (and able) to follow his lead knew that they were experiencing something of lasting value – something that may have been even more true in music than in mathematics (if only because the tone-deaf stayed away, or were denied entry). Numerous future musicians – amateur and professional, classical and jazz – recalled the strict vocal training they received with deep appreciation, *even when the same students struggled in mathematics with the very same teacher, and recount very different experiences!* Andrew Davis's memories are the more striking because of his subsequent eminence; but they are entirely typical of what we have heard from many other sources:

"The results he achieved with a bunch of schoolboys were remarkable. In 1956, we trebles took part in a recording of Vaughan Williams' last choral work, his cantata *Hodie*, conducted by Alfred Wallenstein, the conductor of the Los Angeles Philharmonic. Vaughan Williams was present, sitting up in the balcony complete with baggy tweed suit and ear trumpet (he must have been working on his final symphony at the time). At the end he came down and shook hands with each of us boys. Mr. Budden's conducting style was flamboyant; one of our party pieces ended with the phrase "and round as the lusty grape" which he demonstrated by massaging an imaginary Falstaffian paunch. We loved him. He had a fine tenor voice and, as a parting gift when he left the school, I composed for him a setting of *The Listeners* by Walter de la Mare with a chamber ensemble accompaniment. I had made no copy of the score and was astonished when he sent me a reduced short score transcription of it from Newcastle. I still have it."

Teaching mathematics: The student's view

*Matthew Arnold's lyrical statement that
'Truth sits upon the lips of dying men'
was paraphrased by Mr. Budden as
'if you know you're about to kick the bucket,
you might as well spill the beans'*
[Report of a debate: *Novocastrian* 1980 Autumn]

Frank was much more than a mere mathematics teacher – and this often left a trace, even on those who saw mathematics as alien territory:

"Looking back, I realise that he worked his classroom in a rather more confident style than the other masters. He used the space in front of the blackboard as a stage, and positioned himself to make points. He held the class, not heroically like the heroes of Mafeking, but

by self-confidence and knowledge. I neither dreaded nor looked forward to it. This was not my territory, but it was a necessary place to cross to go somewhere else. (Would it horrify and shock you to tell you that it was just a collection of dark and burnt sticks thrust out of somewhere without a leaf, or a glimmer of joy?) Yet his passion gave him a dignity that less able teachers didn't have.

And this is where regret moves in. Now I know more about him it's my regret that I didn't know or appreciate his abilities when he taught me, or his abilities with music. Perhaps there's a problem with education? We know so little about the people who teach us. But good teaching is rarely wasted: knowing that I did in some way waste my time with Frank Budden is a lesson in itself."

Frank was clearly most at home with those (whether students or colleagues) who were prepared to take his beloved subject (whether maths or music) as seriously as he did himself. The testimonies from those who flourished often exhibit respect, if very much at arm's length.

"My summary of being taught by him was that he was a brilliant teacher for the top set and very inspirational (but not a success with the bottom set!).

He informed us during the year that the Lower Sixth exams would be so difficult that we would find A Levels trivial by comparison! It turned out to be true: I was top of the Lower Sixth class with 54%, where we were more used to scoring around 90%, and almost all of us got grade A's the following year (and 1 in the S Levels).

When my father asked him at a parents' evening if he was sure I was good enough to go to Cambridge, the reply was "Well if he does really badly in the exams we could always send him to Oxford". We were never sure whether he actually knew that my father was an Oxford graduate."

Frank's attempt to adapt his methods to those who found maths elusive seem to have worked some of the time:

"I don't know how he got me to do the maths I did."

"One of the best teachers ever! He managed to get Set 4 to outperform Set 2. He was brilliant! His favourite way to communicate poor work was to write *Balderdash* across the paper! Great guy!"

But reactions to this bluntness varied, and his efforts with strugglers sometimes misfired badly – leaving long-remembered scars. We were told of several painful disasters – for which the following relatively mild example will have to serve:

"He never taught me. But he did mark my additional maths mock O level. I still remember what he wrote on mine: "17/40. This is appalling!" But it was the best I could do."

In later years his efforts were increasingly focused on more able students.

Mill Hill School

Frank's father had died in 1953. His mother moved to Watford to be near her son, but died in 1957. And in July 1957, in Newcastle Cathedral, Frank married Elsie Lee. Elsie had been the Bursar of Central Newcastle High School, and they had met when they were each on school skiing trips to Norway. They adopted a daughter (Janet) in 1961, and a son (David) in 1963.

Meantime, in 1959, Frank had moved briefly to Mill Hill School, where his colleagues included Chris Wormell and Bob Burn (Douglas Quadling and Alan Bell had recently left). Frank immediately insisted on entering his top set for Additional Mathematics as well as O Level – with some success. His approach to school mathematics found something of an echo with Wormell, but may have been less congenial to others. It remains unclear why Frank moved from Watford to another middling position. We also do not know why music suddenly took a back seat: perhaps commuting to and

from Watford, and being relatively newly married made extra-curricular commitments more difficult. What is clear is that at Mill Hill Frank began to stretch his *mathematical* muscles in new ways.

In 1961, Frank attended the *Southampton Mathematics Conference*, where the fruits of the 1959 Royaumont Conference and the delights of "modern maths" were promulgated, and where the embryonic *School Mathematics Project* (SMP) made its first major public appearance. In this post-Sputnik era, there was a genuine thirst for change. And, as with so many reform movements, no amount of rational argument seemed likely to stand in the way:

"To some the mere existence of a well-organized movement, apparently dedicated to "syllabus reform" and "modernization", is enough. They hasten to join the side of progress, and to deplore the blind conservatism which opposes it. But the matter is really not so simple [...] Who can guarantee beforehand that the youngsters who are being used as guinea-pigs will thrive on the mathematical diet they are being given? The innovators themselves have no educational-psychological theory which underwrites the certainty of it making sense to the youngster." [2]

Sixty years on this seems rather perceptive, and in no way reactionary. In the years since the 1960s, syllabuses have retained some of the features advocated by the reformers; but in many ways they have reverted to classical content, while losing much of their old depth (because two or more generations later, teachers, textbook authors, and examiners no longer appreciate the richness that lies just below the surface of essential elementary material).

One of the pet targets of the reforms was traditional geometry – a topic which many mathematics teachers knew from experience could be formative for young minds, but which was often poorly taught and examined. Over the next couple of years, Frank and Chris Wormell drafted their own counter-manifesto [2]. Wormell wrote the first Part – a one hundred page polemic (from which the above quotation is taken), explaining why the reformers were wrong, and why geometry should remain central. Frank wrote the second Part – one hundred and twenty pages bursting with examples.

The book is still very much worth reading. It sold 3000 copies; but it is hard to find much trace of its impact at the time. This may be partly for the reasons given in the above extract: namely, that it is always hard to resist a rising tide. However, as so often with first books, it may have been written in a way that demonstrated erudition at the expense of communication. (For example, the *second* geometric example in Part 2 – out of many hundred – reads:

"In any quadrilateral $ABCD$, if P and Q are the midpoints of AD and BC , then
4. $PQ^2 = AB^2 + BD^2 + CD^2 + AC^2 - AD^2 - BC^2$."

This stumped the first author here for an embarrassing length of time.)

Having opposed the headlong rush toward "modern maths", Frank promptly set about writing several books in the "modern" spirit – books that reveal unusual competence, and that provided just the sort of material teachers, and bright students prior to university, might enjoy [1, 3, 4, 5]. The second and third of these books are relatively standard (though still interesting); but the books on complex numbers and on groups are unusually rich, and contain a mass of material of lasting value.

Frank also co-authored a two volume A level textbook – mainly with one of his colleagues in Watford, Leonard Keith Turner [6]. Turner did most of the heavy lifting, with Frank contributing the sections on more advanced, or more modern topics (often drawing on his other books).

Royal Grammar School, Newcastle

In 1962 Frank moved to the Royal Grammar School Newcastle as Head of Mathematics – a position he vacated in 1980 while teaching for a further couple of years. For these 20 years his central focus was on the teaching of *mathematics*. Under his direction, the school produced a steady stream of able young mathematicians at all levels. In 1977 the number of A level mathematicians was over 100; there were significant numbers of successful Oxbridge mathematicians (including Derek Wanless, Senior Wrangler in 1970, and future head of NatWest Bank); and the school produced nine students (and one reserve) who represented the UK in the International Mathematical Olympiad. Frank also contributed nationally to Olympiad preparation – serving as Leader of the IMO team in 1971 and 1975, and as Deputy Leader in 1984. His contributions of all kinds over many years were reflected in his nomination as President of the Mathematical Association in 1982.

At RGS Frank was involved in school music-making, but more in a supportive, back-seat manner than in Watford. Outside school he started a couple of small choral groups, sang in a choir, and played in a local orchestra.

Now that he had a degree of seniority, one aspect of Frank's character (which has rather gone out of fashion, but which has been implicit in everything we have seen above) found more explicit expression. He was "a champion of honesty and integrity, a man of principle, and an opponent of slovenliness both in appearance and in behaviour" (though the fashion-conscious teenagers of the 1960 and 70s found his own appearance and dress distinctly fusty). This integrity could make him an uncomfortable colleague, and "at times added a new dimension to staff meetings"! The approach permeates his MA Presidential address [7]. Whether teaching mathematics, or conducting a choir, he took for granted the importance of moral values – a position which derived both from his upbringing, and from a faith which made him a loyal member of his local church: All Saints in Gosforth.

Conclusion

Effective education is rooted in habits and discipline: of mind and body, and of knowledge and ideas. Students differ markedly; but they can all learn to listen to their inner voice, while remaining sensitive to, and learning to work with, others. And all can move (if at their own pace) from *subjective* early knowledge to an emerging *objective* understanding of the wider universe. We recognise the successful end-products – even if the underlying details in an individual case remain elusive (memories fade; teachers retire and are forgotten; schools close; records are lost).

Histories of education therefore tend to focus on what survives (on documents, reports, Acts of Parliament, influential books or papers), rather than on the dynamics of *teaching*, of classroom interactions, and of the school community. And despite clear evidence to the contrary, politicians and ambitious educators make the mistake of thinking that educational success depends largely on structures, regulations, targets, and accountability – in short, on *management*. Management is important; but the excessive emphasis is misplaced. Effective education ultimately depends on people like Frank. And management can only be deemed "successful" insofar as it nurtures more of them, with all their idiosyncrasies.

Compulsory state education (like any centrally funded monolith) has to be *managed*: supported, guided, challenged, monitored, and improved. There needs to be a measure of agreement about the discipline-specific goals towards which everyone is working. And there are bound to be national modes of assessing the achievement of individual students at key transition points. But if such structures are to deliver something useful, one needs something more profound than a mere *bureaucracy*. One needs **quality teachers**, who have a clear grasp of the discipline they profess and who manage to convey its intrinsic value; one also needs a surrounding framework that actively encourages such effective teaching.

There was no "Golden Age". Yet Frank was part of a forgotten tribe – a cohort of teachers, often from modest backgrounds, who had lived through the 1920s and 30s, and who understood deprivation at first hand; who had contributed in different ways during the war – and who therefore knew how highly educational opportunity should be valued. The hiatus of the war disrupted their early careers. This enforced discontinuity, and the idealism which infected so many at the end of the war (when Winston Churchill and the Conservatives were swept aside), led many into teaching who might have gone in other directions. School mathematics benefitted from thousands of such teachers, whose extraordinary technical competence, and seriousness of purpose enriched the lives of many who were at school during the otherwise rather grey years of the 1950s, 60s, and 70s. After which they mostly retired unheralded – and were never really replaced.

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