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COLLECTIVE DREAMING: A SCHOOL-UNIVERSITY INTERFACE

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Abstract. In 2008 the New Zealand Institute of Mathematics and Its Applications (NZIMA) funded a project to take a hard look at mathematics education in the four years from the last two years of secondary education to the first two years of undergraduate university education. The structure, pedagogy and content of mathematics in this period have been largely driven by tradition and particular interest groups. However not only has mathematics changed, but also the student body has changed, the teaching and lecturing body has changed, the reasons people study the mathematical sciences have changed, and the mathematical preliminaries have changed.

The prime aim of the project was to get mathematical science senior secondary teachers and undergraduate lecturers to talk to each other. Such communication has not happened before in New Zealand on a large scale, and the ongoing discourse is couched in terms of blame and complaint. We explain how the project overcame these obstacles, and describe the emerging vision.

In New Zealand, we do not have gang warfare in the mathematical sciences, but we do have separate communities. Secondary mathematics teachers and university lecturers only occasionally talk to each other. These communities hold separate conferences in which attendance by each other is minimal and rarely planned. Any contact is local and sporadic - either lecturers giving talks in schools as part of outreach to encourage enrolment, or individual teachers on Study Awards or Fellowships spending time in university departments.

Separate discourses have therefore developed about the problems and solutions to mathematics education for 16 to 20 year-olds. "Students these days are not as good as they were" remains a common refrain, and school teachers reply "we are not here to prepare students for specialised scholarship".

Where is the space that can be inhabited equally by members of these two communities? Where is the playground where we can talk together, create a new and positive discourse, and imagine what mathematical environments are possible for our students?

Do we need such a space? Yes. The gap in understanding and awareness continues to yawn. For more than sixty years up to 2006, the senior secondary school mathematics curriculum has been driven by an examination regime controlled in New Zealand by university mathematics departments. Those departments adapted

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only slowly to changes in the subject, and changes in the student body. Students entering university to study post Year 13 mathematics meet further calculus and linear algebra. What is more, not only have the courses evolved slowly, but also has the delivery style, with some conservative initiatives in the use of computer environments or other technology. The notable exception is statistics education, where the New Zealand curriculum is larger than most in the world.

There are few channels by which school teachers and students learn about contemporary developments in the mathematical sciences. Overfull curricula, constant assessment, fragmented qualification regimes, and insistent organisational demands continue to squeeze the time and energy available to teachers for focussing on wider mathematical developments.

Within universities, developments in the mathematical sciences have seen the formation of departments or sections such Applied Mathematics, Computer Science, Engineering Science, Pure Mathematics, and Statistics. Each makes different demands of secondary graduates and school advisers receive mixed messages.

What of the transition between school and university? The transition is bridging a widening gap [**8**]. It is generally assumed that in some past halcyon time the move between school and university mathematics courses was smooth, but two of the authors attest from personal experience that this was not the case in the 1960s. It is further assumed that the ride should be smooth - an assumption strongly disputed by Clark and Lovric [**6**]. The communication channels between lecturers and schools are, despite the outreach programmes of the universities, not as easy to manage. Not only do secondary teachers have a chorus of university voices to understand and interpret for their students, but also the university lecturers have an increasingly complex school mathematical context to appreciate.

The statistics section of school mathematics is larger than many other countries. However, even here, the impact at university is less clear: some university mathematics courses build on this knowledge, others do not distinguish between students who have taken statistics at school and those who have not. Certainly, more of the total population have basic statistical understanding than in the past, but only a small proportion undertake further study in mathematical statistics.

A continued disconnection between school teachers and undergraduate lecturers is not acceptable. Our first task is to create a space where teachers and lecturers can stretch their imaginations, and talk to each other free from prejudice, habit, and practical restrictions.

Two notes on terminology: "Mathematical sciences" is used in its broadest sense to include statistics, operations research, engineering mathematics, pure and applied mathematics, and financial mathematics. The forms "mathematical" and "mathematically" are also always used in the sense of mathematical science. Secondly, by "undergraduate" we mean courses that lead on from Year 13 studies. We are not including Foundation or Bridging Courses of any kind.

The NZIMA Project

In 2008 a group representing the mathematical sciences in five universities was awarded funding by NZIMA to develop the mathematical conditions in the last years of schooling and in undergraduate courses in New Zealand. The general aim is to enhance the flow of mathematically competent graduates in order to meet the needs of those sectors of society that require mathematical knowledge and abilities beyond Year 11.

It was decided to achieve this by bringing together senior secondary mathematics teachers, undergraduate mathematical science lecturers, and other stakeholders, to construct a shared vision of the nature of mathematics education in Years 12-13 and the first two years of undergraduate study. We aim to agree on an Action Plan of how to work towards this vision. The vision will include goals for a mathematical curriculum; a statement about mathematical pedagogy; a description of the desirable mathematical and pedagogical knowledge of teachers and lecturers; and a goal statement about the mathematical understandings and habits of students entering and leaving this period.

The project is not concerned with evaluating national curricula or commenting on national or university qualifications or assessment. Nor does it seek to prescribe or direct teachers and lecturers. Rather it brings together concerned people to reach a consensus on what an ideal education for those advancing in the mathematical sciences would look like. Then will we turn to the question of how this might be achieved. We expect the project to guide our future discussions as a community.

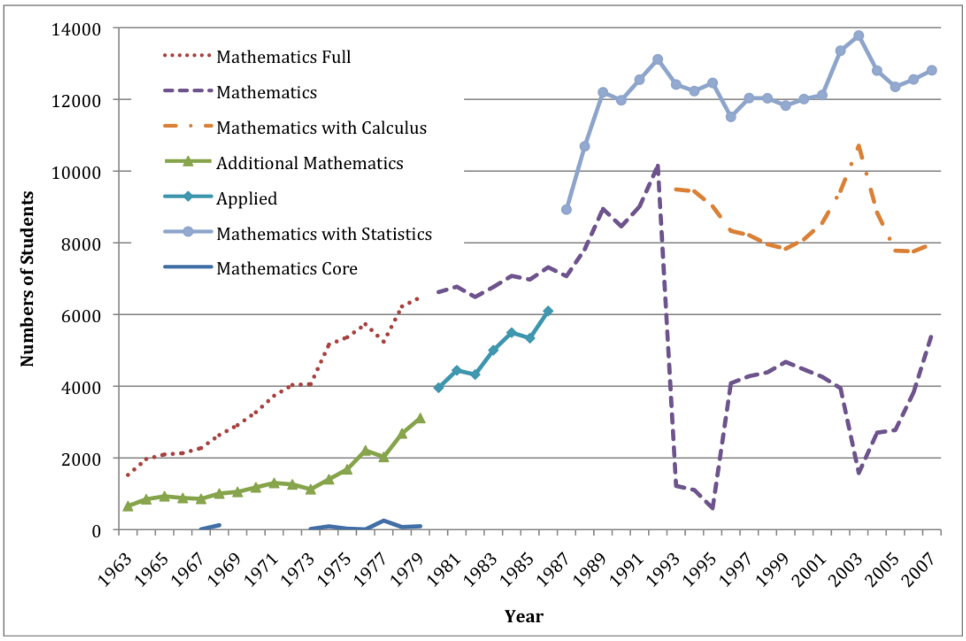
The project has three phases: initial data collection and analysis; informed consensus-making; and reporting. This paper reports on the first two phases, which took place in 2009-2010. In particular, we discuss the creation of a collective vision by teachers and lecturers.

Data

Three types of information were gathered so that debate could be founded in data:

- The numbers of students in mathematical study over a 60-year period.
- The mathematical qualifications of secondary teachers.
- An investigation of the relationship between school qualifications and university success.

The first two sets of data were the New Zealand part of a world wide project commissioned by the International Mathematical Union (IMU) entitled the Pipeline Project. The New Zealand data was broadly similar to that from Australia and UK - overall a general growth in reported absolute numbers of students in the mathematical sciences at all levels. In NZ the proportion of students in the mathematical sciences constitutes a more or less constant proportion of all Bachelor students.



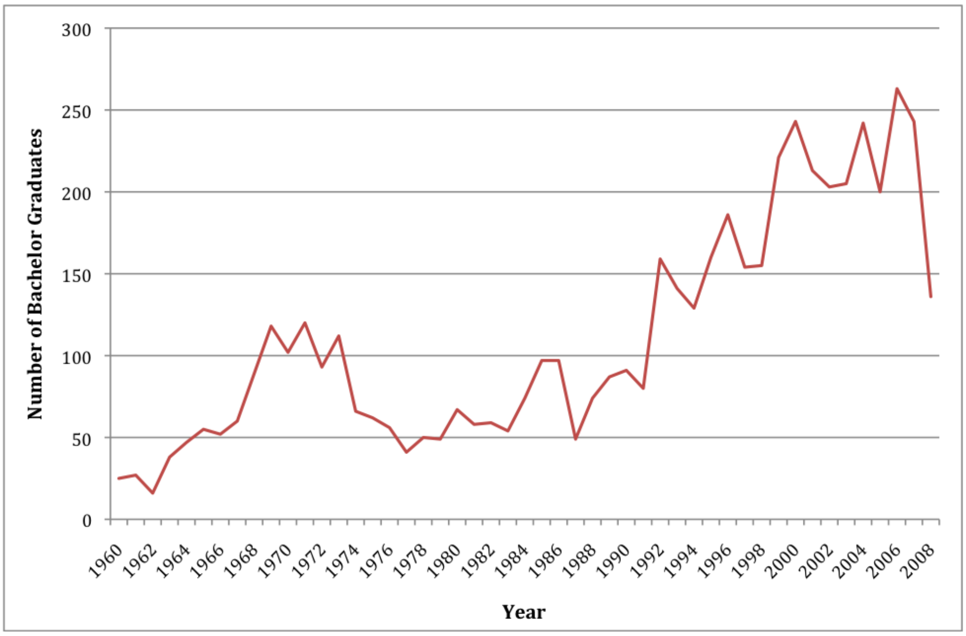
Graph.1. Numbers of students enrolled in Yr 13 mathematical science subjects in NZ

An increasing proportion of the population cohort is entering university, as is the trend across all subjects. The fears of many with respect to numbers are without foundation.

The school data illustrates both the general trends and the difficulties in data collection. There have been many changes in the mathematical courses that can be taken in the final year of school, and it is common to take more than one subject, for example, in recent years students take both Mathematics with Statistics and Mathematics with Calculus. Students intending to continue in the mathematical sciences in the past took Additional Mathematics, and now must take Mathematics with Calculus - so following those two subjects we get a rough indication over a 40-year period (Graph. 1.). The numbers of students enrolled in continuing mathematics has nearly doubled from 1981 to 2007 whereas the population of 15-19 year olds has increased by only 5% (305,000 to 320,000).

Graduate data is even more difficult to obtain because of the plethora of degree courses, and the inconsistencies in national data gathering. Graph.2. shows data from The University of Auckland, which is representative of New Zealand as a whole.

Even allowing for the sharp decrease in 2008, the trend mirrors that of the secondary data (from 1981 to 2007 numbers doubled or tripled whereas the 20-24 year old population increased 9%). Furthermore, data from all majoring subjects shows that the number of mathematical sciences graduates has fluctuated around 4% of



Graph.2. Bachelor graduates majoring in the mathematical sciences from The University of Auckland

all graduates since the early 1970s despite dropping as low as 2% in 1986 [**4**]. Data on the number of PhD graduates is unreliable prior to 1994 because of the small numbers of graduates, but is showing steady increases since then (Graph.3.).

However, numbers of students are not the whole story. There is also a perception that the mathematical quality of students is declining. We have not found any way of measuring this, but the data on teachers does give cause for pause. In New Zealand we have been fortunate to have four surveys from 1956 to 2004 all giving information about the mathematical qualifications of secondary teachers [**3**], [**14**], [**7**], [**11**]. Barton and Sheryn [**2**] summarise as follows:

> In 1956, around 50% of secondary mathematics teachers had not done any university mathematics course. By 1977 this had dropped to 21%, and stayed at that level until 1987, but in 2004 it had risen again to 25%. ... The figures refer to all teachers who take any mathematics class in a secondary school (Years 9-13). ... [We calculate that] the proportion of students transitioning from school to university has doubled since 1977. Thus, we would expect the proportion of mathematically unqualified teachers to drop from 21% to about 17% in 2004 - but it has risen to 25%.
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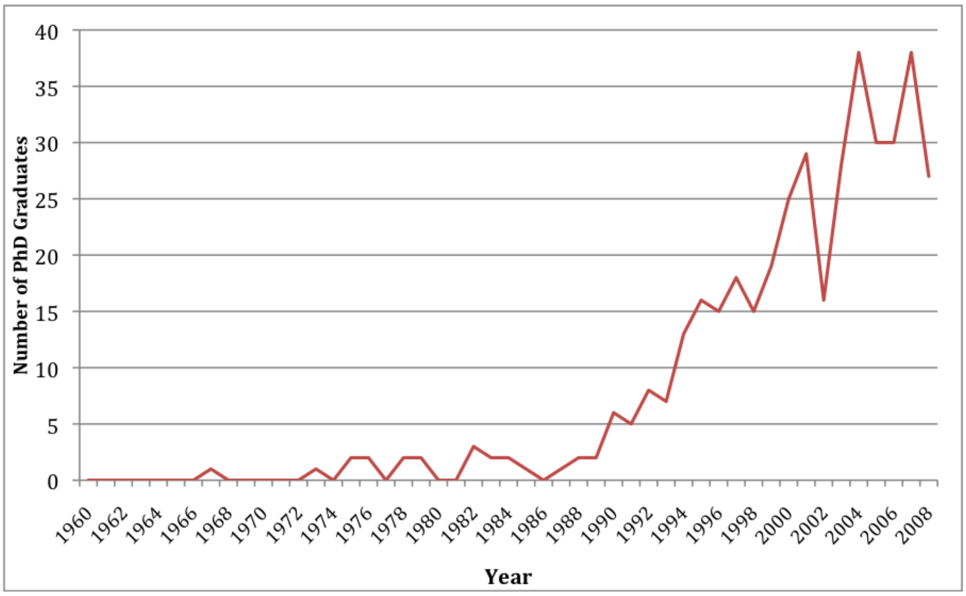
> The 2004 teacher census data also contains figures broken down by the socio-economic status of the school. In the top 10% of schools on a socio-economic measure, only 4% of secondary mathematics teachers have not



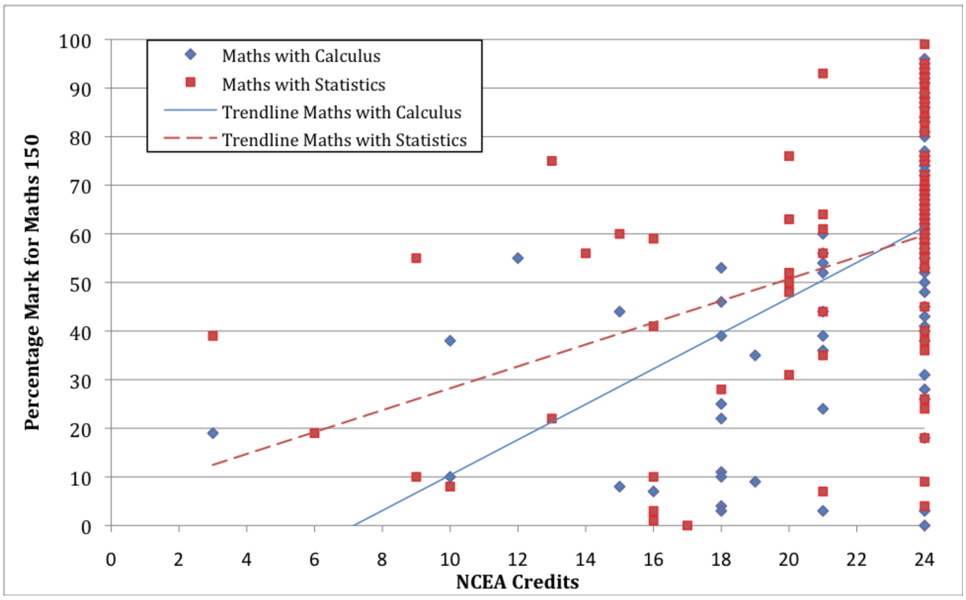
Graph.3. PhD graduates majoring in the mathematical sciences from all New Zealand universities

> studied the subject at university level. In the bottom 10% of schools the average is 50%, a figure that compares very unfavourably with the state of education in 1956 considering the lower proportion of people attending university at that time.

The third set of preliminary data comes from Canterbury University, where first year mathematics students' results were compared with their Year 13 results. James, Montelle and Williams [**10**] found there was a strong correlation between students' performance at Year 13 mathematics and their performance in the first year of university mathematics. However they indicate there are many factors that can contribute to a student successfully transitioning from school to university.

Data from The University of Auckland from 2009 indicates a similar correlation (Graph.4.). Students earning less than 24 credits in either course do not do well in the continuing course MATHS 150. On the other hand, those with 24 credits generally pass well.

The NZIMA project also surveyed opinion of mathematical science teachers and lecturers with online and postal questionnaires.



Graph.4. Performance at Year 13 and first year mathematics courses

The Teacher Survey

The teacher survey focused on barriers to enrolment in advancing secondary mathematics courses and was available both online, through the NZIMA website, and through a hard copy questionnaire. It was completed by 192 senior secondary mathematics teachers nationwide.

The majority of respondents used the survey to berate the current system of mathematics education. In hindsight, the survey promoted this kind of response. The questions focused on negatives aspects: the declining numbers of students taking advancing mathematics courses, and reasons why students are not choosing this subject. The open questions allowed respondents to describe a single change that would address the issue of declining numbers, but few respondents suggested positive changes.

Overall, there was a perception that there was a slight decline in the number of students taking advancing mathematics courses at Year 12/13, although many teachers reported that numbers taking Mathematics with Statistics were increasing while the numbers taking Mathematics with Calculus were decreasing. (Our data does not confirm such a trend up to 2007).

The teachers thought the prime reason why students choose not to take Year 12/13 mathematics courses is that they were more difficult compared to alternative courses at that level and hence credits were more easily gained in other subject areas. They also wrote that students were reluctant to commit to the homework and extra practice that mathematics requires if a student is to be successful. Another concern was the lack of informed careers advice that is being offered to students. It was reported that students are being advised erroneously that mathematics, or calculus in particular, is not required for many university programmes.

The respondents also thought that students were not sufficiently prepared for Year 12/13 mathematics courses because they lacked mental arithmetic, algebraic skills, and the impetus to practice mathematics skills beyond the classroom. Students were now thought to be improving in statistics and using technology, but were struggling in algebra, calculus, and critical thinking and problem solving.

Suggestions to increase the number of students taking advancing mathematics courses at Year 12/13 included the following:

- an improved public perception of mathematics;
- appointment of specialised teachers for mathematics at Years 0-8 levels;
- significant professional development for mathematics teachers;
- a two-tiered examination system;
- more practical and creative mathematics lessons;
- mathematics to be put into accessible contexts;
- links between mathematics and other curriculum subjects;
- an increase in technology use;
- NCEA Level 2 mathematics should be compulsory for university entrance.

This survey may have served a useful procedural function. The teachers who participated in the later conference had already had an opportunity to let off steam about issues in mathematics education, enabling them to participate more positively.

The Lecturer Survey

We contacted university lecturers to survey their expectations of the mathematical understanding of students entering university. The questionnaire was distributed by post to mathematics departments at universities throughout NZ. There were 51 responses, the majority from mathematics lecturers with a few responses from engineering and statistics lecturers. The survey questions were more positive in tone than the teachers' survey and this was reflected in the responses from the lecturers.

In general, the respondents to the questionnaire thought that there was only a slight decrease in mathematics ability of entering students during the last 10 years.

The most crucial mathematical skills that students should posses on arrival at university were thought to be:

- coordinate geometry skills - be able to find the distance between two points and find the equation of a line;
- the ability to solve all quadratic equations;
- to recognise quadratic, cubic and exponential graphs;
- to find the gradient function for polynomials;
- to know how to test turning points & points of inflection;

- to integrate polynomials;
- to know how to sketch trigonometric graphs;

The lecturers also wished the students to have some initial experiences of conjecturing, justifying and verifying, proving, modelling, predicting, theorems, logical reasoning, and notation.

The lecturers believe that students transitioning from school to university anticipate that university will be similar to school and are frequently unprepared for self-motivated learning and the independent thinking that characterises lectures and tutorials. Their view was that school assessment of small "packets" allows students to focus on those topics where they experience success and ignore those they find difficult, resulting in gaps in their understanding. Lecturers find students unaware that mathematics relies heavily on cumulative knowledge and that there is considerable skills crossover between topics.

The main message the respondents wanted to send to students was to practice mathematics and not to study only the minimum required to achieve, as in NCEA. It is hard to predict what mathematics may be required in the future and as mathematics opens the doors to almost every subject, students should take the opportunity to study as much mathematics as possible. Although skills and techniques are important, understanding why a particular rule or method works is equally important. It is also important to reflect on the answer to each problem and take responsibility for your solution.

The lecturers' message to teachers was to be enthusiastic and passionate about mathematics and teaching. It is necessary to help students develop good study skills and move away from memorisation and towards understanding. Teachers should also illustrate the applications of mathematics in the real world. It is important to make connections between algebra, graphs, problems, topics as well as the applications - even if the mathematics is, at that moment, beyond the student.

Students should be encouraged to develop an enquiring mathematical mind and be reminded that there is a skill in checking answers for being reasonable and recognising and correcting errors. It is also necessary to provide more opportunities for self-directed study as well as more open-ended, group-based activities. Learning assignments should be introduced to encourage students to take responsibility for their own learning.

<u>The Conference</u>

A two-day conference for those involved in the teaching of senior secondary mathematics and undergraduate mathematics was held at The University of Auckland in April 2010. It was promoted as not about revising the curriculum but rather as an opportunity to share visions, brainstorm ideas and envisage a new framework. About 100 people attended (44 senior secondary school teachers, 49 university lecturers, a few representatives from government, and some overseas attendees).

The conference had three plenary addresses and some plenary feedback sessions, but mostly consisted of a series of workshops that developed consensus towards a vision for mathematics at this level. Each workshop mixed secondary teachers, mathematics lectures, and mathematics educators.

As organisers of the conference, we were surprised at the readiness and positive tone of engagement, and the extent of consensus. Admittedly, the need for these was expressly requested in the opening session, but chairs found that they did not need to enforce constructive comment, nor did groups struggle to agree.

The first workshop formed statements of the form "Wouldn't it be nice if ...?" Responses included:

- ... we could rebrand mathematics to make it relevant and cool and exciting;
- ... we could be more oriented to the nature of mathematics rather than examinations;
- ... we could find ways for teachers and students to behave more like mathematicians;
- ... we were able to present a more holistic picture of mathematics to our students;
- ... we could better engage the middle group of learners;
- ... we had more opportunities to collaborate about teaching;
- ... we had better information flows to students about mathematics at university and in their potential careers.

The second workshop developed statements of the form "We can use (technology, diversity, teachers and lecturers, curriculum) in order to ...". Sample responses were:

- (technology) - access and explore higher levels of mathematics;
- (technology) - share resources, and share in the production of resources;
- (diversity) - obtain different perspectives (and use them in peer teaching);
- (teachers & lecturers) - to break the school/university barriers, each enhancing the others' work (lecturers communicating about mathematics, teachers facilitating communication with students and community);
- (curriculum) - address the need for a wide view of mathematics.

The third workshop used the form "We can imagine ...". The groups imagined, amongst other things, these ideas:

- mathematics evangelists;
- a repository of profiles of mathematics graduates;
- teachers in universities, and lecturers in schools;
- an organised and indexed, easily accessible, comprehensive, resource repository;
- the school/university transition as an exciting, anticipated process.

Finally, the visions were encapsulated into a picture of mathematics as exciting, accessible for everyone, and universally valued as a powerful way to make sense of the world. Mathematics, in this vision, will be passionately pursued and confidently practiced by all. Key ideas for the realisation of this dream were: that mathematics education needs to be recognised as a lifelong task in which students became increasingly independent; that curricula were constantly renewed and taught by enthusiastic teachers who were regularly reinvigorated; and that technology and assessment were exploited to achieve desirable outcomes.

Consensus was reached on a variety of themes for mathematics in these four years:

- emphasising mathematical habits and processes over content, with particular emphasis on problem-solving;
- the gradual introduction to justifying and proving;
- building relationships between the world and mathematics;
- a more fully developed and intelligent use of technology;
- extending the curriculum to accommodate the big ideas in mathematics.

Participants expressed a need for:

- greater attention to attitudes so that students (and society at large) like the feel of mathematics and want to do it;
- the means and opportunity to continue the conversation about mathematics with students, amongst teachers, between teachers and university lecturers, and to extend it to the community (this implies a closer relationship between schools and universities);
- a repository of resources teachers can access and people who can visit to give wider perspectives (including podcasts, Twitter, Facebook);
- smoother transitions between institutions;
- better information about mathematics requirements at university to people who help students make choices within school (careers officers/families/students /teachers).

No consensus was reached (in some cases it was not discussed) in the following areas.

- Qualifications and assessment.
- Teacher education.
- Basic skills.
- The place of competition.
- Cross- curricular links (there was debate about whether mathematics was to be seen as an art or a science or both). Effective pedagogy (there was consensus on wanting this but none on how to do it).
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Conference Analysis

The success of this conference will ultimately be measured by the emergence of a written consensus document at the end of the project, and by whether or not a productive community continues. As an event it had more than expected numbers from a wide range of schools and universities, with participants from all major centres. Feedback was positive.

The workshop group sessions were characterised by animated discussion and broad agreement on common threads. Participation was high, with people listening to each other as well as talking. What occurred in this conference such that these two groups engaged in this way? We can identify several surface factors: the need to talk positively and work together was explicitly mentioned both in the advertising for the conference and in the opening introduction; the workshops were focused on positive "prompts"; the workshop leaders were briefed to direct the conversations constructively. Perhaps this was sufficient, but the prior experiences of the authors with groups of teachers talking about university mathematics or groups of lecturers talking about school mathematics, would indicate otherwise.

We hypothesise that, in addition to the exhortations, three other factors played a role. We believe that an important condition was that curriculum, assessment and qualifications were explicitly not to be discussed. Again experience tells us that teachers and lecturers have strong and fixed opinions about what students should know, or should be taught, in what order, how it should be assessed, what qualifications should result, and to what such qualifications give access. The removal (or inclusion) of certain topics in past curricula, the ability of students to remember topics they have been taught, the "correctness" of the teaching of certain topics, the meaning of examination passes, all engender animated statements of views that have often been long-held and are based on incident rather than any research. Removing the opportunity for the re-expression of such mythology in the early stages of the project increased the chance for productive conversation.

Another implicit factor was the chance to have an influence. Recent qualification and curricular changes in schools have been Ministry of Education driven with little chance for effective consultation on the overall design [**12**]. Here was a project driven by the mathematics teaching community, where teachers and lecturers have the dominant voice. Although the project is not seeking curriculum content change, the idea of creating a collective vision and an Action Plan that will move towards it has a hopeful aura.

Finally, the Hawthorne Effect of something new should not be dismissed. The senior secondary and undergraduate years are seen by most involved as containing significant problems. Here was a new opportunity to address the issue.

All the above points to the construction of a community of practice [**13**], or, to adopt the less theorized phrase of Barton and Paterson [**1**], of a professional community of teachers. Hence the ultimate success should be regarded in terms of the maintenance and development of the community. We have the opportunity to retain ownership of the common space between school and university and prevent it being subsumed within larger educational systems. A pleasing outcome of the conference, then, has been a major, national, grant proposal (currently short-listed) to Ako Aotearoa for direct school/university interaction - the genesis of the idea was a conference discussion. At The University of Auckland another project focusing on undergraduate mathematics has arisen since the conference.

Parallels with the international Klein Project are consistent with the above analysis. The Klein Project (http://kleinproject.org) has been commissioned by the

International Mathematical Union and the International Commission for Mathematical Instruction to produce a book and website that will help senior secondary teachers understand the relations between what they teach and research mathematics, and at the same time inspire them with renewed interest in the dynamic, contemporary field of the mathematical sciences. The project has been holding meetings where mathematicians, mathematics educators and teachers get together to discuss the book's design and contents. It was expected that the Klein meetings would be difficult, especially in countries where there is a history of miscommunication or antagonism between the three groups involved (USA, Spain, Brazil, and England for example). On the contrary, all meetings have been productive, characterized by intense but positive debate, participants listening to each other and responding constructively. Why had the anticipated difficulties not eventuated? Perhaps the USA Math wars had cleared the air in advance? However, the Klein Design Group believes that the discussion "space" of the interface between schools and university is like a new children's playground. No participants own the space, each comes in voluntarily under their own terms and the games that are enacted come from creatively engaging with the others who happen to be there and what equipment exists. The stakes are not high. Arguments do erupt, but are settled within the space, and the dominant activity is cooperative. The "spaces" where teachers and mathematicians have previously clashed are not neutral in this sense (curriculum, assessment), and have been rehearsed many times in the past.

The NZIMA Project has two major sets of activities: a series of six regional meetings where the conclusions of the conference will be discussed and an emerging Action Plan formulated; and a final set of dissemination activities, both conference presentations and journal articles. Having established the community and a discourse, we are sufficiently convinced of their value to plan further forward. We are now thinking of future meetings or events, possibly around the implementation of the Action Plan.

The Emerging Vision

The emerging vision for the mathematics to be presented in these four critical years has four components.

A Broad Vision

As a result of an examination/qualification-oriented curriculum, students are developing a limited idea of the nature of mathematics. Mathematics outside a classroom or lecture theatre is not a fixed set of techniques that are handed down, nor does doing mathematics mean solving exercises that require a few minutes each. Mathematics is a subject of creativity and imagination, of doubt and fallibility, of struggle and persistence, and of excitement and beauty.

Furthermore, the content of mathematics is wider than that represented in a school or undergraduate curriculum. Not only do applications range over a great variety of fields and careers, but even within the mathematical sciences there are different paradigms, objects of interest, and modes of enquiry. Education in the mathematical sciences must represent these facets to our students.

We must develop a broad vision of the mathematical sciences. In our teaching we need to encompass all aspects of the mathematical sciences, including both technical skills and conceptual understanding. We should promote both mathematics leading to professions such as economics, geophysics, and engineering and also formal mathematics for those advancing in pure and applied fields as well as subjects like statistics, theoretical computing, optimisation and physics.

A Contemporary Vision

Many mathematics courses are rooted in mathematics that is centuries old. Such mathematics is relevant, but the nature of mathematics in the 21st century must also be presented. Not only does this include new areas of application and new developments in mathematics itself, but also new ways of working, (in particular those resulting from computers), and the renewal of old areas that are newly accessible. We must reflect a contemporary, up-to-date vision of the mathematical sciences so that our students grasp the breadth of modern activity in their subject.

It is not only the subject matter of our mathematical education that must be contemporary, but also our modes of teaching and learning, for example the effective use of modern technology. The implications are that not only resources, but also teachers and lecturers need to be up to date. In addition, students need a contemporary picture of the nature of mathematical activity in their future careers with an updated perception of what a mathematician (or a mathematically competent professional) actually does.

An Active Vision

Curricula at senior secondary and undergraduate level are overfull. The list of required content gets longer rather than smaller, partly because students spend less time on mathematics as education becomes broader, and partly because there is more mathematics to learn as the field expands. Thus “covering the syllabus” becomes an important preoccupation of all teachers.

But a mathematical education is not just about learning content. In these critical years it is just as important that we induct students into mathematical processes and habits as much as we insist that they remember content and techniques. Mathematical modes of behaving need to be explicitly developed: conjecturing, justifying, proving; persisting, problem analysis, problem-solving; creative thinking, pattern spotting, logical exploration; and rational thinking, abstraction and generalization. Mathematical habits of mind, and the willingness to apply them in a variety of situations, are critical to becoming educated.

A Coherent Vision

We would like students to experience the mathematical sciences as a coherent field of enquiry that is visibly developing in sophistication at the same time as their ability to study and undertake mathematics is also becoming more mature and more independent.

Action Plan

The emerging Action plan has three components.

Development of a professional community

A recurring theme from the conference was to continue the communication between teachers and lecturers and to start developing a community. The vision proposed can only be developed with input from each of secondary teachers and research mathematicians working together. Furthermore, the promotion of the vision requires a unified community across the mathematical sciences, and including stakeholders in government and the commercial sector. This community could help drive understanding and change.

Our educative task can be made significantly better if we share and collectively construct resources, and if we have avenues along which we can discuss what and how we teach at various levels. Significant research exists, and more is being done, to understand mathematics education in these years - we need to disseminate it and discuss its implications rationally.

In particular:

- we must create opportunities to be together, and make use of them;
- we must maintain and expand the community;
- we must establish resource creation, renewal, and sharing mechanisms;
- we must collectively organise professional development towards mathematics education in these four years.

These actions do not start from scratch. The NZ Association of Mathematics Teachers conferences and NZ Mathematical Society colloquia already provide forums that can be used; Ministry of Education links and some industry contacts are potentially useful; and university/school links through NZIMA and outreach programmes may develop resource features. Perhaps the professional development component needs explicit attention.

Promotion of our mathematical vision

The thirst for information about the mathematical sciences is evidenced by public interest in books, films, radio and television media, and public lectures. As well as the general promotion of the field, we need to spread our broad, contemporary, active vision of mathematics amongst students and the community at large, and emphasise that a more organic approach to the subject is important at university level. We wish to generate a perception of mathematics as necessary, useful, interesting, and able to enhance the intellectual life of all students.

Specifically, students, parents, teachers and advisors require updated information on the mathematical science requirements of university programmes in a variety of fields (various sciences, medicine, arts, engineering, business, architecture, and so on).

In particular:

- we must create channels for contemporary mathematics to get to schools and undergraduate students;
- we must be ready to use media opportunities in a coherent way, and actively seek new opportunities;
- we need a database of university mathematics requirements and pathways;
- we need to ensure that correct information flows into schools about the consequences of taking particular courses;

Many people in our community spend a large amount of time and effort in activities of this kind. Supporting and building on their good work will be key to fulfilling our role.

Aligning the systemic variables

The conference participants were concerned that any vision would be rendered ineffectual through systemic variables. For example, the examinations and qualifications system acts against teachers having the ability to spend significant time developing habits and processes; the content weight of the curriculum orients students to covering topics, rather than understanding mathematical principles. The indicated course of action, therefore, is to start from the vision of mathematical sciences we wish to project and, carefully and rationally, argue/move/influence the systems that surround us so that they support rather than oppose the vision.

In this process there will need to be some hard talking, in particular confronting divergent views in the community about curriculum, examinations and assessment. We believe that now the ground has been laid for productive debate even on these contentious matters.

Exactly how such a project will work is not immediately clear. We, the authors, hope that the regional meetings that round of the NZIMA project, will guide us as together we develop a blueprint for mathematics education in New Zealand at senior secondary and early tertiary level.

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