Report of Subcommittee V

Steering Committee for the development of

The Mathematical Sciences in Australia

A Vision for 2025

The Decadal Plan for the Mathematical Sciences 2016-25

Mathematics and statistics

in business and industry

Business and Industry Subcommittee Report

Scope

The Business and Industry Subcommittee focuses on the views of the Mathematical Sciences from the Business and Industry perspective.

Mathematical sciences have always gone hand in hand with practical application and technological success, which most often leads to economic prosperity. Indeed, mathematics is the "foundation science" underpinning many fields of endeavour.

With the advent of widespread access to inexpensive computing, the mathematical sciences have emerged as indispensable tools for studying a variety of problems in scientific research, in product and process development and manufacturing, among many others. This is an important development for the general deployment of quantitatively trained people, as quantitative skills are almost always used in conjunction a software enabling technology in business and industry.

Areas as diverse as Finance, Science and Engineering, Medicine don't need to rely only on the traditional scientific method of theory and experiment but can utilise simulation techniques to solve complex problems. This may not be an entirely new development – for example 20th century physics did much with the so called *Gedanken Experiment* to lead to conclusions that were subsequently measured by experiment. But what is new is that the approach is being pushed to many other fields and the potential for up scaling with the use of software is enormous, as is the potential for mathematical scientists to be at the forefront of numerical simulations by applying their skills in these disparate areas – either collaboratively or by acquiring domain knowledge[1].

Numerical simulations can supplement experiments and can even allow the examination of systems and problems that would be too time-consuming, expensive, dangerous or impossible to study by the traditional methods alone. Many realistic systems can only be modelled and analysed computationally, so an ability to simulate realistic systems is a critically important aspect of their design, construction and operation.

The high level of detail and realism in these simulations requires advanced skills in mathematical modelling, numerical analysis, efficient algorithms, computer architecture, software design and implementation, validation, and visualization of results.

Many diverse businesses across industry have already been hiring staff with strong mathematical background and others are starting to go down this path. These business need staff with a strong understanding of the latest developments in the mathematical sciences and can adapt techniques and technical knowledge to difficult real world problems. With 'big data' becoming a business catch phrase the opportunities for businesses that hitherto did not utilise these skills are now realising that if they don't hire these quantitative knowledge workers their competitiveness will erode.

[1] For example many finance so called "quants" will also at some stage either study finance or learn enough through the organisation's internal training or self-study.

The opportunities for people with quantitative skills are deep and success is predicated on the following areas of proven capability:

1. Very good to exceptional computing skills (i.e. programming, statistical/mathematical packages and data manipulation).
2. Able to define and solve problems and assist with solution integration and implementation across the organisation and clients;
3. Quickly develop subject matter expertise in the field where the quantitative skills are deployed;
4. Display versatility with developed oral and written communication skills and ability to work well in teams;

Finally, maturity in mathematical thinking coupled together with creative analysis of data are critical for businesses to navigate many regulatory and competitive issues and better decision making. People from quantitative fields that have already succeeded in the business environment have displayed the above qualities and business and industry now understand the value proposition. However all this is not without major threats, the primary of which is that many software firms are working hard to ensure that quantitative work is made largely automatic and thereby handed back to the traditional managers and analysts.

Value Proposition

In a modern economy it is very important to estimate the contributions of input factors. The estimates of “hard to measure” factors should be always caveated by the appropriate comments lest they are taken at face value and do more damage than good.

For example in the mathematical sciences we may measure the direct input to business and completely forgoe the cultural, broader knowledge deepening and contribution to other fields in a direct or indirect way.

Having said this we have not seen and study to date emanating from Australia that tries to measure the monetary contribution of the Mathematical Sciences to the economy and we will urge that such a study be performed as a benchmark to inform future decision making in our recommendations below.

We have however reviewed a recent wide-ranging UK study[2] which had the following to say regarding the contribution to that country:

- Building the infrastructure upon which myriad businesses and individuals rely;
- Supplying the tools and techniques to analyse and interpret large datasets;
- Providing a public good such as modelling the impacts of natural disasters and testing drugs;
- Contributing to national security and other necessary 'public goods' through advanced data security tools and infrastructure provision;
- Creating robust forecasts to address uncertainty and a for better planning; and
- Optimising processes to increase efficiency.

[2] Deloitte. Measuring the Economic Benefits of Mathematical Science Research in the UK. November 2012

The same report also highlighted certain "hard" facts around the contribution of the mathematical sciences (tables below);

- Mathematical Sciences Research contribute 10% of jobs and approximately 16% of Gross Value Added to the UK economy.
- In addition to these direct impacts, mathematical research activities by organisations and employees have impact across the supply chain (indirect effects) and also affect household spending (induced effects).
- There are also wider impacts and benefits generated by organisations using the research.

Jobs	
Mathematical science occupation jobs as % of total employment in sector	**Top 5 sectors for mathematical science occupations (absolute numbers)**
R&D: 80%	Computer Science: 347k
Computer Services: 70%	Public Admin and Defence: 257k
Aircraft & Spacecraft: 50%	Architectural Activities & Consulting: 213k
Pharmaceuticals: 50%	Construction: 204k
Architectural Activities & Consulting: 40%	Education: 189k

Comment [CRL1]: Do they mean engineers etc here too?

Contribution	
Direct MSR[3] GVA[4] contribution	**(%)**
Banking & Finance: £27 bn	13
Computer Services: £19 bn	9
Pharmaceuticals: £16 bn	8
Construction: £13 bn	6
Public Administration and Defence: £12	6

[3] Mathematical Science Research
[4] Gross Value Added

Challenges and Opportunities

The mathematical sciences value creation potential does not come without any risks, these risk may have to so with local factors and not global ones.

The key industries we see in Australia that have had traditionally employed mathematical scientists are:

1. Finance
2. Resources sector (mining, oil and gas) – Big employer of related quantitative fields like engineering
3. Information Technology
4. Pharmaceuticals
5. Medicine?
6. Agriculture
7. Consultants
8. Telecommunications
9. Manufacturing
10. Utilities (power, gas, water)?

Some industries have had enormous success and one of our recommendations below advises to seek if there are any lessons to be gleaned for the mathematical sciences deployment in those industries.

Australia has a world-class education system and this extends to the mathematical sciences and we believe that Australia should further develop this competitive advantage by leveraging its educational and research strengths and if necessary seek to reposition them.

The skills required from mathematical scientists within business and industry have been outlined above but we believe that a key responsibility for the Academic and Policy communities will be to ensure that the community's investment is not underutilised.

The most risky underutilisation will be to be complacent and not seek to put in place the right measures to ensure that Australia is pressing its competitive advantage when it comes to the mathematical sciences. Understanding that this may sound obvious but the outcome from such a risk may be that as a nation we are left behind with potentially devastating consequences.

In our opinion much of the mathematical science knowledge required in business & industry is making its way into software packages at extraordinary speed. Moreover the software costs have dropped dramatically and in some case open source software has the robustness to be utilised within industry and this is almost free of any costs.

There are extremely inexpensive ways to get "big data" or predictive analytic projects completed – via kaggle or similar competitions – that has led to a commodification of the mathematical scientist, which is going to be a reality the mathematical and policy community needs to come to terms with or preferably work out a way to take advantage of it

Many Australian companies are piloting analytics centres in less developed countries which use their in-house experience to educate staff in these countries to perform the analytic function at a small fraction of the cost.

This is the big challenge for mathematical science as this is not confined to predictive analytics and big data.

Conclusion

We believe that the mathematical sciences have a very large role to play Australia's future prosperity. Any policy response needs to not only view the issues around insufficient supply of people with quantitative skills but how to ensure that future students will be attracted to the mathematical sciences as a career of choice. Innovation will in all likelihood come from those that are the most talented but a "critical mass" still needs to be maintained. The biggest threats are cheaper analytic labour from abroad and the huge incentives for software firms to build user friendly software that can provide automate quantitative analytics to non-mathematical workers.

Both of these trends are not going to abate and nor is it desirable for them to do so. Australia has the advantage of having firms that are at the forefront and mathematical scientists here need to show that they are adding value above and beyond simplistic modelling and excel in quantitative problem solving by attain domain knowledge in the industries they work in.

This will require a concerted effort from government, industry and academia as innovation needs to be at the crosshairs for all the sectors above.

On the basis of our conclusions we make the following recommendations below, targeted to address the opportunities but being cognizant that there are challenges that need to be addressed as well.

Recommendations

Our subcommittee views itself as a voice on the demand side of the equation, hence we also view our recommendations as input to the other subcommittees when they are making their strategic recommendations regarding the supply side.

The key theme for our recommendation section is the trend we see in business and industry and named it the "Democratisation" of the mathematical sciences. This we believe has two aspects:

a) The traditional input of the mathematical sciences into other areas and/or a deep collaboration across multiple disciplines, including computational methods and
b) The increasing software automation of many tasks that quantitatively trained staff traditionally performed.

We recommend that;

1. Emphasis and recognition is placed around the fact that mathematical scientists are "problem solvers". This aspect of a mathematical scientist is in our experience one of the more valuable skills in the workplace. These skills can be bolstered and given broader areas for training by providing educational opportunities to develop a portfolio of supporting skills. This can be achieved by well-defined project work or more sophisticated assignments that can showcase the problem solving ability.

2. The Mathematical Sciences engage in Brand Creation to make the communication as simple as possible with the wider business community.
3. An extended dialogue be established with the industries that already have a tradition of engaging mathematical scientists. Some practical ways to engage will be to create secondment opportunities or summer internships for students, participation in research programs and broader cross-fertilisation of ideas. We believe that this will provide an understanding of what mathematical scientists do, help with brand creation and recognition and assist students thinking where to with a mathematical science degree.
4. An independent study be undertaken in Australia to better understand Australia's leverage to the mathematical sciences. This should be similar to the UK study mentioned above. Our experience strongly implies that Australia also depends on a strong mathematical sciences culture but it would be better for policy and certainly business to be quantify, as accurately as possible, the similarities and differences to other nations both in our neighbourhood and farther afield. We also recommend that this study seeks out lessons learned from Australian success stories that companies attribute to a mathematical sciences foundation.