

Guest Editorial

Welcome to this Special Issue of *Mathematics Today* devoted to the broadly defined topic of Knowledge Exchange (KE). IMA members must be well aware of the benefits of knowledge exchange; without it our own understanding would not have developed and our subject would not have grown to encompass the numerous strands it now has.

Nonetheless, two years ago, Philip Bond's report brought KE to the forefront of our minds by highlighting the necessity of creating more opportunities for KE between academia, government, industry and the general public. Increasingly, universities are actively encouraging their research teams to engage with industry and vice versa; but there is still work to do to bridge the gap between these two very different worlds, especially in the mathematical sciences.

In a sense, since its inception, the IMA is an organisation that is devoted to KE, as reflected in our membership of mathematical scientists in industry, academia, education and elsewhere. The Bond Review has brought this into focus for us as an organisation, leading to conferences, forums and working parties.

While many might still feel that fundamental mathematics research is of more value than KE, there are numerous examples throughout history that show how research without KE can stagnate and lack impact. Also, although fundamental mathematical research can be extremely difficult, it tends to bring its own rewards and accolades; and frankly does not involve individuals leaving their comfort zone. To make a real impact often involves taking risks, embracing different worldviews and inhabiting environments that may not seem like a natural home to mathematicians. Our ability to communicate mathematical insights and discoveries in a way that the rest of the world can understand is crucial, as is learning to listen and learn from them.

In this issue we are delighted to announce the first call for the IMA's new knowledge exchange award, the IMA Hedy Lamarr Prize, which recognises the importance of those who are prepared to take those risks. Hedy, as well as being a Hollywood actress, was also an inventor. She helped to design the frequency-hopping system intended for use in torpedoes and now incorporated into Bluetooth technology. As is clear from the content of this issue, the satisfaction gained from solving a problem involving KE is worth celebrating: be it seeing the face of a child light up as they understand the importance of mathematics for the first time, making possible the design of a new product or improving a process in order to save an organisation time and/or money.

Communication with different audiences is something that many of the contributors to this edition highlight. Through a series of interviews with a diverse group of members at different stages of their careers and in various employment sectors, we discover how they perceive KE and what they are doing to encourage this. For example, Ben Dias talks about bringing university academics into companies, Karrie Liu mentions discussing real world applications of maths in a primary school whilst Martine Barons comments that many people do not naturally understand that maths is relevant to their problems. She goes on to say how important it is to describe case studies like the IMA Mathematics Matters series some of which are reproduced

in this edition. These and the five other interviews, from Chris Budd, Nira Chamberlain, Diane Crann, Joanna Jordan and Kevin Wagstaff, will also be made available on the IMA website so they will be easier to share with your friends and colleagues.

Steve King (see page 178) also highlights that many people in industry don't understand that maths underpins their engineering problems. In his article, from the perspective of a career within a high-tech manufacturing company, he discusses an example of an online platform for collaborations between engineering and AI. These types of hackathon in coding or data science are sponsored by many companies, but why are examples in a wider range of mathematical topics much less common? Several of our interviewees mention the excellent mathematics Study Groups with Industry. Perhaps the IMA could explore a way of enabling similar activities to become more mainstream.

We have also attempted to offer a glimpse into some of the wonderful KE projects that are happening across all UK regions (see pages 184–188) in sectors such as health, engineering and data science. Paul Harper talks about his work with NHS Wales, Dawn Wasley and Belle Taylor describe the work of the International Centre for Mathematical Sciences (ICMS), Edinburgh and Adele Marshall discusses her experience in data science and operational research to support decision making in Northern Ireland.

In a recent podcast *How to Think like a Rocket Scientist* Ozan Varol (a member of the NASA team leading the Mars Exploration Rover project)

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discussed the way that scientists actively try to disprove their new hypotheses preferring to find what's right rather than to be right. Getting out of the ivory towers of academia and into industry R&D might open our eyes to a whole new variety of problems and puzzles that need mathematical input to solve. Knowledge Transfer Partnerships (KTP), like those featured here from Exeter, Greenwich and Manchester, with large companies such as Dyson and Argos, as well as with small and medium-sized enterprises (SMEs), are excellent examples of this (see pages 192–195). They start with a problem and a potential way of obtaining a solution and then through working with the university and industry, the KTP associate is able to try out a range of possible ideas before hopefully finding the 'right' or best and most useful solution.

Podcasts themselves can offer an effective medium of knowledge exchange. One of the 'book' reviews in this edition is of a podcast series: *A Podcast of Unnecessary Detail* from the Festival of the Spoken Nerd. Some readers might find this rather odd but in the current situation where many people working from home feel chained to their computers and at the mercy of Zoom or Teams there is a need to get away and exercise in a way that reading a book doesn't enable. Listening to podcasts whilst exercising, walking or just doing everyday things like cooking and cleaning is an excellent way of recharging one's batteries. Further suggestions of recent mathematical podcasts to review in future editions of *Mathematics Today* would be very welcome.

Teacher turned comedian Matt Parker is celebrated in this issue after he was awarded the 2020 Christopher Zeeman Medal for maths promotion. Matt's work is a great example of KE, with over 100 million views of his videos across YouTube

it's hard to imagine a better promoter of mathematics to the general public. We need more expositors of the true impact of mathematics to excite and enthuse society and, in particular children, who will eventually help to grow and strengthen the mathematical pipeline.

One of the discussions arising out of the Bond Review has been the BIG Mathematics Initiative which involves the possibility of there being an Academy for the Mathematical Sciences in order for our discipline to increase its visibility. IMA members may remember that the initials BIG were previously proposed to stand for Business, Industry and Government, and many of us have been involved in recent discussions about how forming an Academy can facilitate these links. Although the devil is very much in the detail, it is clear that a more joined-up approach is vitally important if we want to see more impact from UK mathematics research. Indeed, the recent pandemic has highlighted the need for mathematical and statistical modelling to inform evidence-based policy.

Another of Bond's recommendations was to embed KE in the mathematics curriculum at all levels. So, in one feature we explore ways in which this has been done at several universities as well as offer suggestions for improvements. How many of us are in touch with the universities we graduated from? Could more universities invite input from graduates now working in business, industry or government? Using these simple connections would be one way to enrich the undergraduate curriculum in the way

that Birmingham, Greenwich, Sheffield Hallam, Bristol, Leeds and Leicester (and many others) have done (see page 198).

Effective KE can be inspiring and transformative and clearly should be encouraged and celebrated among early career mathematicians. Showcasing the potential influence of student research is the subject of the Smith Institute's TakeAIM competition. This year the competition celebrates its 10th anniversary

and to mark this we've selected eight of the recent entrants, giving a flavour of the impact student research has in a variety of industries (see page 205).

Apart from enjoying this issue, we hope readers will feel challenged. As already said, KE generally involves leaving comfort zones. Perhaps, ask

yourself the question what can I do to improve knowledge exchange? As our interviewees demonstrate, KE is also commensurate with flexible career pathways. Even we, the Guest Editors, represent different possible journeys. Alan spent the first half of an academic career as an applied mathematician not especially focussed on KE, before seeing the light. Noel-Ann, made a life-changing move from a stay-at-home mum to studying and working in academia and then industry, followed by a recent move into university management. For Sarah, her journey has been a change of focus from a love of pure mathematics to a career solving applied mathematics problems in industry.

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Alan Champneys CMath FIMA, University of Bristol
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