

Can you teach innovation and entrepreneurship? A new postgraduate programme

Kathryn M. McGrath*

School of Chemical and Physical Sciences, MacDiarmid Institute for Advanced Materials and Nanotechnology, Victoria University of Wellington, PO Box 6140, Wellington

Introduction

Every generation has the potential to say that things were different when they were young; that life was perhaps more simple, straightforward, sure. Equally they might reflect that when they were young it was a time of great change with increased complexity and uncertainty. Considering employment over the past one hundred years, it is evident that with each generation there have been significantly more job choices. In line with this has been the expansion in the diversity of skills and knowledge required in order to take up these employment opportunities and to deliver to the evolving needs of our global society. With choice and opportunity comes uncertainty. How do we deal with uncertainty and the ambiguity it brings with it and ensure that each of us is able to make the most of the opportunities at hand? Mitigation of uncertainty through a reduction of choice, though seemingly initially attractive, does not reflect well the changes that are constantly occurring in any environment or sector of interest. Preparing people to deal with uncertainty, to assess it, understand it and work with it, will ensure that the uncertainty is turned to benefit rather than being a latent barrier to our progress. In doing so, we will expand the proportion of society who will make use of and receive benefit from the consideration of risk and reward.

The enhanced diversity, opportunities and uncertainty in the job market are reflected in the changes in our education system. Thirty or so years ago in School Certificate (year 11), for example, only slightly more than 20 subjects were on offer. In the current equivalent qualification, NCEA level 1, students are able to explore and become proficient in close to 60 subjects. The subjects on offer and the structure of the qualifications reflect society's and the educational system's expanding vocational framework, both national and international. The education system provides the fundamental skills and knowledge base deemed to be important for all people in order to ensure that they can participate fully in society and that New Zealand and New Zealanders are able, at least, to keep pace with, or preferably outstrip, global advancement and change.

People's employment patterns have also been changing. In the mid-20th century people tended to maintain their occupation throughout their lives, without significantly changing career path or employers. Indeed most people had employers, and fewer were self-employed.[1] Entrepreneurs and innovators were generally regarded as a different type of person from others in the sector; the entrepreneurial spirit was a product of nature more than nurture, or a combination of the two.

Since the 1970s and 1980s, significant innovations - such as computerised production lines, global trade, selling via the internet, the introduction of dot coms, changes to the international monetary system and an increased focus on services rather than products - began to take hold, having major ramifications across all sectors. The groundwork for many of these innovations was driven from advances made in science and engineering in the preceding decades, including development of semiconductors and the fabrication of silicon chips. These innovations changed the face of the world, affecting education, expectations, jobs, behaviours, and thinking. The business sector was irreversibly changed. What we could produce, how we made things, what we used and interacted with on a daily basis, how we accessed information, how we sold what we made - all of these things began to change. Furthermore, doing things the way that they had been done previously no longer resulted in the same outcomes. What had changed? Had the new structures and innovation changed the risk/return profile?

Furthermore, the diversity of businesses exploded, both within individual companies and across sectors. Startups made it on the map, catalysed by the shift in innovation. Startups have at their heart people who are working to create something new, to deliver something that was previously not available to consumers, and to create something that could readily be repeated and/or scaled. There was a multiplication of people who wanted to establish a business of their own, a shift in the risk profile, and entrepreneurship and innovation became widely explored concepts.

Consider a three year old entering into early childhood education. For this child there is almost certainly no tidy well known and defined set of jobs that they might end up doing once they

*Correspondence: kate.mcgrath@vuw.ac.nz



Kathryn McGrath BSc (Hons) PhD PGDip Com is the Director of The MacDiarmid Institute for Advanced Materials and Nanotechnology and a Professor in the School of Chemical and Physical Sciences, Victoria University of Wellington. She held post-doctoral positions at L'Université de Pierre et Marie Curie – Paris VI, France and Princeton University, USA. In 1997 she was appointed as a lecturer in Chemistry at the University of Otago, moving to Victoria University of Wellington in 2004. In 2013 she completed the Advanced Management Programme at the Henley Business School, University of Reading, UK.

In 2003 Kate was awarded the Easterfield Medal by the New Zealand Institute of Chemistry and The Royal Society of Chemistry, UK; in 2007 she was awarded the Research Medal by the New Zealand Association of Scientists; and in 2013 she received the Wellington Gold Award, Wellington City Council Inspire Wellington Award. Kate is a former NZAS president.

leave school or university. The jobs that our children will do most likely have not even been thought of yet and the diversity of skills - hard and soft, wide-ranging and specific – that they will need to actively participate in society and the workplace will be different from those needed now or three or four decades ago. Furthermore, they will change jobs frequently, with their skill set being constantly modified through a driving need to adapt and adopt their skills and knowledge base.

This is already what you see in the job market, our new reality. Where then does that leave vocational training? Where does it leave specialist v. generalist education? How do you educate for a future built on unknowns? What additional things do we need to be teaching? How should we be teaching our students? Are the skills that were once ring-fenced as being the domain of entrepreneurs, skills that everyone now needs to acquire? Is the capacity to be innovative and create valuable innovations a fundamental component of a viable education sector that will sustain New Zealand's prosperity? How do we ensure that we are providing the appropriate platform of base skills to ensure people will be both empowered and enabled to participate fully in society? Furthermore, how does that same education system ignite the desire for us to all do better!?

These questions and many others represent major challenges for our education sector. They cannot however be considered in isolation but must be placed in perspective alongside the rapid pace of change occurring in our business sector. Furthermore, nationally, specifically being driven by our current Government, and globally there is a shift in focus to economies being built predominantly on science and technology platforms. From this basis it is clear, that things need to change, soon and quickly.

What does an education system look like that delivers a robust, healthy, resilient society, environment and economy in a rapidly evolving world?

What do we believe is missing right now in our economy and our educational training framework that if we introduce it will help to deliver this stronger more prosperous future?

How do we better train students for the complex world of innovation?

Teaching innovation

There is a growing amount of academic and business literature focused on how we can teach the process(es) of innovation specifically (and perhaps more broadly or separately, depending on your school of thought, entrepreneurship) and how to include innovation as a fundamental learning concept in all learning forums.[2-6] While different authors have explored different aspects of what underpins innovation, often building on the fundamental work of Wallas [7], common threads are revealed with regard to the critical steps required and the key learning points within the innovative process. This growing literature supports the increasingly held belief that each of these components can be taught and that methods can be introduced into the learning environment to implicitly as well as explicitly teach innovation.

The literature reveals some fundamental components of the innovative process, which are widely agreed upon although they are often presented in seemingly different ways.

In essence the innovation process includes:

- definition of the problem;
- the preparatory stage – analysis of the problem;

- the incubation stage – association of knowledge (generally drawn upon from a wide range of sources), incorporating elements of creativity;
- the formulation stage – this is the crucial step of synthesis of the knowledge into a workable and useful solution to the problem; and
- validation of the solution.

The innovation is stimulated by the occurrence of a problem, irrespective of whether the problem is initially well conceptualised or not. For the innovation process to move forward the problem must eventually be well-defined. Once this has been achieved it can be fully explored from a wide range of perspectives and a greater understanding is gained. Importantly, any constraints or attributes of the problem or environment are also identified at this stage and are factored into solution formulation right from the beginning. This ensures that the framework in which the solution can sit is clear. For this step to be effective it requires specific expertise and a well prepared mind (or collection of minds for problems requiring a mix of expertise). Then, at some level, it is just a matter of time – time to explore the wealth of knowledge that may, in any way, pertain to the problem and be used to formulate a solution. During formulation of a solution, connections are often made between what initially seem to be disparate areas of knowledge – but it is exactly this aspect that is crucial in innovation. Pedestrian use of knowledge in a limited or poorly-connected context to the problem will most likely not produce innovative solutions. The creation of connections between different areas of knowledge enables synthesis of a new concept and delivery of a potentially innovative solution to the problem. Generally the concepts and/or solutions are then increasingly defined, refined and validated.

Given that each of these steps in the innovative process can be undertaken and completed by an individual, they can be taught, learnt, created and nurtured.

Having listed the crucial steps of the innovation process we can now consider the key learning points and personal attributes that underpin our ability to be innovative. It is these skills and behaviours that need to be understood, acquired and practised in order to facilitate our ready participation in, and development of, innovation:

- analysis, critical thinking, formulation of useful probing questions;
- problem solving;
- working in and/or forming and utilising effective highly functioning teams, including consideration of the roles of collaboration, individual responsibilities, incorporation and use of appropriate expertise;
- perseverance, the capacity to continue to analyse the problem and apply different knowledge to conceive a solution;
- of the unknown risk profile and ability to mitigate risks through viable routes;
- learning from failure, self-reflection; and
- experiential learning.

Furthermore, the following personal attributes aid in a person's ability to be innovative, all of which can also be taught and nurtured:

- agility and flexibility;

- initiative/motivation;
- good communication skills; and
- curiosity and imagination.

Markham recently outlined ten ways to teach innovation, building on the above and providing practical ways in which teachers can incorporate innovative learning and practice into their learning environment.[8] For Markham's full description the reader is referred directly to the website. I have selected three of the methods to expand on here.

Use project-based learning

Project-based learning allows for a variety of subject areas to be incorporated into a single learning programme. For example, a project-based learning approach formulated on musical instruments could include the physics of sound, materials science, social activities of music, the workings of the ear, the processes and economics of recording studios, plagiarism, ethics, mathematics, creative writing, performance art, etc. Within this approach different skills can be practised, developed and embedded. Additionally the student develops specific knowledge, sees the interplay and connectivity of different areas of knowledge and begins to learn how knowledge from seemingly different areas can be brought to bear to stimulate the development of new concepts.

No single outcome or result will necessarily be delivered using this approach, and it allows the programme to be readily adjusted and explored to meet the needs of the age group and the level of the students. Project-based learning enables straightforward incorporation of individual and team goals and activities, and allows individual students to be guided in their skills development, knowledge base and practical abilities.

Furthermore a variety of assessment tools can be utilised enabling communication across a range of platforms to be developed. Perhaps most importantly, project-based learning provides a wealth of opportunities for students to engage more broadly with their classmates, families and communities.

Teach concepts, not facts

Content and facts are important, but just knowing a fact does not correlate to knowing what it means or why it might be important in any given context. Teaching concepts (within which facts and content will necessarily be taught) allows students to more straightforwardly broaden their knowledge and use information outside of the original context in which the concept was taught. For example, in chemistry and physics a central concept is that the surface (essentially any interface where two materials meet) of a material has different properties from the corresponding bulk material, and therefore surfaces behave and respond differently than the bulk. This has consequences for cellular responses, water treatment, computer chip production, etc. This concept is fundamentally important in many different contexts, so knowing and understanding the basis for the concept makes the information more readily usable in other contexts.

Make skills as important as knowledge

We need to be able to create a learning environment that ensures our students develop the skills enabling them to be more flexible and adaptable, applying what they have learnt more readily and to a greater range of situations. By making skills, such as ability to communicate, to work well in or lead a team, to problem-solve, and to utilise well the full range of resources available to them, we are supporting and training our students

in the best possible way. The combination of a strong skill set and a deep knowledge base ensure that students can analyse and work within situations of seemingly greater complexity and uncertainty; these are crucial capabilities in the modern world.

Master of Advanced Technology Enterprise (MATE)

Aspects of the above and in particular the pedagogical base for teaching innovation have been incorporated into the new degree programme launched at Victoria University of Wellington by Hon Steven Joyce, in his capacity as Minister for Tertiary Education, in January 2013. The MATE programme was created largely around the desire to facilitate the multi-disciplinary team-based process of transforming science and technology into high-value products. However, it is much more than just a programme in which teams of students experientially learn about the process of research translation in what is as close as possible to a real pre-startup business environment within an academic programme¹.

The programme is really a 'People Incubator' programme. Basically it is about working with people as they learn how to use and develop their own skills and expertise in order to achieve more for themselves and for others. This is achieved, in part, by learning how to leverage off other people's skills, knowledge and resources. Through the multi-disciplinary team approach it brings together the different discipline areas within a university to collectively create a specific commercial outcome, be it a service or hardware. By setting the context as 'transforming science and technology into high-value products', it ensures that the business and academic environments are brought into juxtaposition. Collectively the programme realises opportunities that create value, change perspectives and mind-sets, change working processes and practices, extend capabilities, and create further opportunities.

The MATE programme is geared at developing a new class of entrepreneurial leaders - people who have the confidence and capability to create a groundswell of innovation in New Zealand leading to a step change in the New Zealand economy.

What makes the MATE programme so different that anyone would believe that the audacious goal stated above will, or indeed can, through a single academic programme be attained? Alone, of course it can't. But as a part of a broader educational framework in innovation, it will. And even as a standalone programme it will foster changes that will be of long-term benefit to the education and business sectors.

The MATE programme is founded around answering one of our earlier questions: What do we believe is missing right now in our economy and our educational training framework that, if we introduce it, will help to deliver a 'stronger, more prosperous future'?

To answer this question requires a number of different factors to be considered, a few of which, outlined below, have become foundation stones of the MATE programme. There are of course many other factors that are important. Some of these are well beyond the ability of a single Masters' programme to begin to address; however, some are included in the programme, and here discussion is limited to just four.

¹ See <http://www.victoria.ac.nz/science/study/postgraduate/specmasters/advanced-technology-enterprise>

Jargon and silos

One of the things commonly thrown up as being a major barrier to science advances achieving the level of commercial exploitation deemed possible is that scientist can't, don't, or won't talk to business people and vice versa. Germany and France are often used as an analogy of this confused or mixed ability or complete inability to communicate; with Belgians acting as conduits, French and German interactions are facilitated and smooth working relationships are established, with gains made by all parties. There is therefore some precedent for the need of a middle person, one who is adept at communicating within and between both sectors and enabling coherency between the disparate groupings.

But is the science and business communication divide as big as it is made out to be? Is there a real need to educate people who sit in the middle area moving readily between the two, rather than achieving direct interaction? Or are both approaches required to facilitate progress in this area?

The environment and support around the science/business interface needed to activate commercial successes from the advanced technology sector in New Zealand are currently in an embryonic state. Much work and enhanced infrastructure support are required to transform this into a resilient and thriving sector. Addressing the jargon and silo issue is indeed part of us getting this right.

Consider any of the languages of science, engineering, design, commerce or the humanities and it is immediately evident that the realm of commonality between any of them is small. Even between specialities within a discipline, straightforward communication, achievement of understanding and the setting of mutual goals or visions are not immediately practicable. This language barrier has a tendency to keep everyone apart, maintained in their own silos. Addressing this must therefore be an aspect of creating solutions and opportunities for those in the advanced technology space and business-trained people to combine their skills in a manner that will deliver an economic outcome.

Traditional entrepreneur courses and programmes, nationally and internationally, are most often run by and organised within commerce faculties or business schools. Targeting commerce students or those returning to education after working in the business sector means that few scientists, designers or media people are found in the student ranks. But what makes entrepreneurship and innovation inherently a characteristic of a business- or commerce-minded person and not someone with expertise and experience in physics, biology, systems engineering, industrial design, linguistics, or...? How are business entrepreneurs different from and similar to science entrepreneurs or engineering entrepreneurs? Should anyone who is interested in innovation and entrepreneurship only be able to be trained to be a generalist business entrepreneur? Do we need to start creating business-ready scientists? Should entrepreneur and innovation programmes just be about 'making' entrepreneurs or innovators, however one might define such exotic people?

Furthermore, what would attract scientists, designers, or engineers, whose speciality training and learning framework sees them actively applying their knowledge to solve problems to participate in traditional entrepreneurship programmes, where the emphasis often lies on the examination of theories and case studies, rather than the acquisition, practice and application of

skills? Moving beyond that perspective, what makes someone with marketing or accounting expertise begin to drive forward the development of an innovation, for example a new medical diagnostic tool? How would they be able to do a risk analysis, know the stop and start strategies, the lifetime cycle, the key science and technology pressure points? Is it possible to bring the dichotomous worlds of science and business together and have them working and learning together, and in doing so create something much more desirable?

The MATE programme is designed to address this aspect: removing the barriers created by language and knowledge differences. Students from different discipline backgrounds, who have a diverse range of expertise and experiences, work together to define common goals with respect to the development of an advanced technology enterprise.

Placing the context for the business in the advanced technology space ensures that the expertise needed to add value to the idea/invention is diverse. Furthermore the students, who have different perspectives and languages, actively work together strengthening and deepening their own discipline knowledge and capability while learning how to share, in a meaningful and useful way, their knowledge with team members. In doing this they derive benefit themselves through this shared process and use their specialist knowledge to proactively move the invention further along the value chain. They also learn individually and collectively how to bring all of that diversity and capability to bear on a single entity, how to integrate skills, set responsibilities and deliver value. These outcomes are not achieved when the idea or invention requires no science or technology expertise in its development.

Are all startups the same?

There is considerable knowledge and literature pertaining to startup companies, most of which is sourced outside of New Zealand. How does the New Zealand context (in particular our economic reliance on the primary and tourism industries) and, on an international comparison, the domination of micro-enterprises² change the startup space and influence our ability to move ideas and inventions along the value chain to successful commercial realisation? Is this different for different sectors? Does New Zealand's economic and demographic context essentially change best practice or can we in a straightforward way apply the lessons from international studies?

In short: Is building a strong and diverse science-based economy really different from building an economy based on dot coms, adventure tourism, retail shops and milk powder, and is it different in New Zealand from elsewhere?

How, for example, do we factor in different risk analyses, time scales, financial requirements, resilience, available resources, continued research requirements, the roles of the inventor/science adviser, etc? Do we even know what the major pressure points in the advanced technology space are in New Zealand compared with other areas of entrepreneurship?

In order to consider these and other questions many components must be explored. Ultimately such considerations will provide, if not a formal framework, at least potentially one that

² In New Zealand small and medium-sized enterprises are classified as being up to 20 employees; internationally they are 10-250 employees, with micro-enterprises being up to 10 employees.

is widely practised and that evolves with the progression of the economy and the enrichment of the advanced technology sector. The MATE programme acts, from this context, essentially as a rich source of data and a forum to experientially explore the best processes and support environments for the development of an advanced technology startup community. As the number of teams that have gone through the programme increases and the diversity of the pre-startup companies expands a wealth of information will be captured. The students' theses collectively amass to be a powerful study of entrepreneurship in advanced technology. With each new cohort the starting point for the individual students and teams is raised due to the feeding back of information and understanding gained previously. The learning and support environments and the approaches utilised to develop and advance the enterprises or to mitigate the pressure points will have been altered to reflect the lessons learnt from the previous cohort and the appropriate resources will have been changed and/or new ones put in place. As this programme evolves, best practice for advanced technology pre-startups will emerge and as a consequence the sector will be strengthened from both the people and company perspectives.

Teamwork

Another key factor that has the potential to stop science-based enterprises delivering commercial outcomes is the New Zealand 'man-alone syndrome'. The idea that a single person can acquire most or all of the skills needed to successfully deliver a desired outcome is increasingly outdated and is essentially incompatible with the development of advanced-technology enterprises. These need different high-level skills to be brought to bear in concert in order to deliver success. This requires, therefore, the capacity to assess one's own skills, interests, motivation and capabilities as well as the skill-based and personality needs of the enterprise.

Working in teams that encompass a diverse set of skills, as described above, facilitates people's ability to place their knowledge and expertise in context for themselves and others and to release its inherent value. Requiring students to work as a 'company' necessitates individual team members to gain the skills needed for them to function effectively in the team environment. Demonstrated capacity to work in, or lead a team is a crucial skill in the modern working environment. But where do people learn the essential factors for building and maintaining highly effective teams? When do people acquire their soft skills?

There are few of us who can avoid working in teams during our careers. Therefore, each of us needs to learn how to work within a team, how to become a strong team member and how to evolve, as the team also evolves from its first formation to becoming a highly functioning group that delivers results. We will also hold different roles, potentially simultaneously if we are members of multiple teams. Where then do you learn what a team is, what different elements, stages and forms a team has, how to deal with issues as they arise, what a successfully functioning team looks like, and how you create such a team? How do you work out how to apply your own knowledge and skills in concert with someone else's to collectively solve a problem and in doing so enhance your own and others' expertise?

In the MATE programme, utilisation of a 'company structure' ensures that students gain both the theoretical knowledge and understanding of team structure, setup and function, as well as experientially learning how to create highly functioning

teams. They acquire and apply a range of soft skills and learn how to enhance these, while accommodating different traits and drivers of both themselves and their team members.

Furthermore, the different teams learn to work with each other and from each other. They generate a community in their own right. Through this community they explore the concepts of collaboration, competition, trade secrets, competitive advantage, and shared resources.

Failing

The final factor is not something that people tend to focus on, especially not in a formal academic qualification – failing. But the reality is that companies fail. A lot! How do you learn to deal with failure and to deal with it well? Failing is one of the most important things to learn in innovation and entrepreneurship – but most often our young people are not allowed to lose or fail; it is hidden, covered up. Failing is not, in general, given merit. We do not teach our students how to reflect on failure, understand why the failure happened, and ascertain ways to ensure that it does not happen again – or at least not in the same way. We do not significantly push our students beyond their current limits, forcing them into situations where they do not necessarily have the skills, knowledge or resources to succeed and then use the failure that ensues as a learning tool. In short, we do not recognise that failing is very important and that it must be incorporated into all our different learning environments.

How exactly do you get to be better at something? You fail. Consider learning to snowboard. When you wipe out on your snowboard you do so because you try something you are not quite up to yet; you push yourself beyond your limits, fail and then you learn from the failure and you get up and you do it again but this time a little bit better. You keep doing it until the slopes or jumps that you used to wipe out on all the time become easy and then you push yourself to the next limit. Inherently when you learn to snowboard do you think of these steps as fail points? Do you consciously analyse how to do it better? Probably not, but in many situations that is exactly what you need to be doing.

Part of taking yourself into seemingly unknown territory is learning how to perform an appropriate risk analysis and to ascertain whether the prepared plan of progress is within the allowed range of uncertainty. Learning to deal with uncertainty and not allowing that uncertainty to overly restrict progress, in part by factoring in acceptable failure rates, is a crucial component for success, not only in innovation and entrepreneurship, but increasingly in life and certainly when dealing with the uncertainty of the job market.

In the MATE programme, failure is encouraged and used as a learning point by employing a series of reflective practice processes. The students undertake an exegesis of the outcome and all steps leading up to the outcome. The risks and landscape are reassessed incorporating the new information, a new plan is formulated, and the next step is taken. This approach applies equally to successes as it does to failures. Both are strong learning points. The students follow this set plan on a six-week cycle (or more frequently if major failures or successes occur). Over time this becomes a standard component of their innovative practice.

These four factors are critical components of the MATE programme providing a platform for experiential learning in the advance technology enterprise space.

The capacity to be innovative and create valuable innovations is a fundamental component of a viable education sector that will sustain New Zealand's prosperity. The challenge now is how to implement this in New Zealand?

References

- [1] Rupasingha, A.; Goetz, S.J. 2013. Self-employment and local economic performance: Evidence from US counties. *Papers in Regional Science* 92: 141–161.
- [2] Ferrari, A.; Cachia, R.; Punie, Y. 2009. Innovation and Creativity in Education and Training in the EU Member States: Fostering creative learning and supporting innovative teaching. *EU Joint Research Centre Technical Notes, JRC52374*. http://ftp.jrc.es/EURdoc/JRC52374_TN.pdf
- [3] Amabile, T.M. 1996. *Creativity in Context*. Westview Press, Boulder, Colorado.
- [4] Amabile, T.M. 2000. A model of creativity and innovation in organizations. In: Staw, B.; Sutton, R. (eds) *Research in Organizational Behavior*. Vol. 22, Elsevier Science.
- [5] Kuehner, T. 2009. Engaging students on innovation. *FootNotes (Foreign Policy Research Institute, Philadelphia)* 14.
- [6] Wagner, T. 2012. *Creating Innovators: The making of young people who will change the world*. Scribner, New York.
- [7] Wallas, G. 1926. *The Art of Thought*. Harcourt Brace and World, New York.
- [8] Markham, T. [2011] Ten ways to teach innovation. http://edge.ascd.org/_Ten-Ways-to-Teach-Innovation/blog/5545792/127586.html