The Policy Pitch – *Is Australia keeping up? Science and technology graduates and the workforce*

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Science and technology have transformed the world, and will continue to do so. But there is widespread concern that Australia is not keeping up with the need for STEM (science, technology, engineering, and maths) skills. Many people believe that our universities produce too few graduates in STEM fields. But the evidence seems mixed, with too many graduates in some science fields and recent IT graduates struggling to find work, despite many job opportunities in the IT industry. Should we focus more on the quality of STEM education, rather than increasing the number of graduates?

Moderator: Dr Jim Minifie, Grattan Institute

Speakers: Alan Finkel AO, Australia's Chief Scientist
Renee Hindmarsh, Executive Director, Australian Technology Network of Universities
Andrew Norton, Grattan Institute

JIM MINIFIE: Thank you so much and it's terrific to continue the relationship that we've built up with the State Library over the years, it's been a tremendous partnership for us as well. Let me just quickly introduce our panel. On my left is Alan Finkel, Australia's Chief Scientist. Alan, it's terrific to have you here, you've got a very extensive background across both business and science and innovation that makes you ideal to introduce the set of issues that we're going to cover tonight. Further to my left is Renee Hindmarsh, who's the Executive Director of the organisation of technical universities known as the Australian Technology Network (ATN). Thank you so much for joining us Renee. Renee has a deep background in policy prior to running the ATN. Then further to my left is Andrew Norton, my colleague at Grattan. Andrew runs the higher Education Program and part of what we'll be discussing tonight draws on work that he and our colleague Ittima Cherastidtham are currently working on, a report that will be released later this year.

So let me now turn to the content. What we are proposing to cover tonight is, first, to have a look at the STEM capabilities in the workforce and try to get an understanding of how that relates to the opportunities that science and technology present to Australia. We're then going to move into some detail about how the experience of the workforce relates to the experience of recent graduates in the workforce and we're then going to flip to look at what universities are doing to prepare graduates for the workforce and what more they may be able to do. Then we're going to open up and have a discussion about policy and then potentially touch on what individual prospective students might want to think about. One of the great things about this process that we run with the State Library is that many of you volunteer questions in advance and we've tried to fold those into the discussion. I'll bring up some of those explicitly after we run through this set of topics and then we'll open up for a broad discussion.

So with that, can I kick off on the first subtopic which is around how the STEM capabilities of an economy's workforce relate to the things that we really care about, which is innovation, productivity, living standards and the economy? Alan, I thought there was nobody better placed than you to kick off the discussion of why STEM is becoming increasingly important.

ALAN FINKEL: Thanks Jim. There's no question that we're in a world in rapid transition, we're all very aware of that, in fact it's daunting for many of us, and we can't be reliant on traditional industries going forward. That doesn't mean we should be in any way moving away from those traditional industries, we should reap as much value from them as possible, but the new opportunities are following the transition towards a knowledge-driven economy. There have been a number of studies from Oxford University, from the Council of Economic Development in Australia and from PWC that talk about the rapid rate of turnover in jobs. It's predicted by most of these studies that 40% of the jobs that exist today will actually disappear in the next 15 years and that 75% of the jobs that replace them won't necessarily be jobs in science, engineering, technology and mathematics, so-called STEM, but they will either be jobs in those areas or jobs that require some degree of STEM capabilities.

So it's important that we're training the next generation of workers to be competent with those skills. That doesn't mean everybody, but a large number of our next generation of workers have to have those skills. We're looking at an onslaught of change. Artificial intelligence started in the 1950s but it didn't get anywhere until about ten years ago. We've had the convergence of algorithms being improved and developed and massive horsepower in the computers themselves, and that combination of computer power and algorithm improvements have led to an explosion in artificial intelligence capabilities and that alone is going to account for a lot of the job changes. So the nature of the jobs that are left to human beings to do in some cases will be perhaps more menial, but in some cases, in many cases, will be the sorts of things that even the artificial intelligence algorithms of the future are not capable of doing.

So there's ample opportunity, tons of opportunity to be reaped, but we need to educate the workforce for that and it's not only the graduates coming through today, but we have to be prepared to be offering re-training opportunities to those people in the workforce whose jobs are displaced.

JIM MINIFIE: How would you say Australia is tracking compared to the rest of the world? Are we far off the pace? Has the mining boom caused us to become complacent?

ALAN FINKEL: I won't get into cause and effect, but something has caused us to become somewhat complacent and there is evidence for that. If you look at the international tests, PISA and TIMS run by OECD and organisations like that, in the last 10 to 15 years we've slipped from being firmly in the top 10 to being not that comfortably in the top 20 and I would say there's no excuse for a country like Australia to slip. This is tests of reading, science and mathematics amongst 14 and 15 year olds and it's measured in two ways. Our absolute score is coming down. I'll leave it to the statisticians how they work out how to standardise the scores from year to year, but the size of the number of students being tested is huge and so they can do that. In absolute terms we're going down on the international tests across science, reading and numeracy, and also other countries are improving their students' performance through their educational effort more than ours. So something is slipping and we have to do something about it.

JIM MINIFIE: So what would you say to the perhaps somewhat sceptical view that says you can buy these products off-the-shelf, somebody else around the world is going to create them and all we need to do is download the app or buy the robot and Bob's your uncle?

ALAN FINKEL: Well, I can give you the possibly standard answer that is that certain industries need to be locally driven; the research needs to be locally driven. So, for example, agriculture, you can't

buy agricultural solutions for Australia. You can bring in a lot of the knowledge that's going to underpin what those solutions will be, but the scientific research has to be done in Australia, but you can't use that argument for everything. Then the next level argument, and it's an important one, is that if you just bring in things and try to adapt them you will lose your ability to adapt, because you need to have a vibrant educational system driven by research to produce the educators and the professionals who will be able to do that adaptation, and the best adaptation is done by people who really know their discipline well and have the experience or the encouragement to innovate and not just adapt by plugging it in, but adapt by making it better. So I just don't buy the argument that we can bring it in and use it. That would be a slippery slope type of concern.

JIM MINIFIE: Terrific, thank you. Andrew, perhaps we could turn now to the characteristics of the science, technology, engineering and maths workforce before we then begin to look at the graduate experience?

ANDREW NORTON: Sure. So as Jim said, we've got a report, it's actually a general introduction to higher education which has got a special chapter on STEM employment and, of course, STEM graduates work in lots of different jobs, and that's very, very important to understand, many of which do not formally require a STEM qualification. But at the core there are a range of occupations for which a STEM degree is either essential or highly advantageous, and this will be the core labour market to which the STEM graduates have a monopoly or near monopoly. So looking at professional employment, we've got probably about 100,000 jobs for which a science degree is pretty much essential; we've got about 150,000 engineering jobs for which an engineering degree is probably essential given the professional admission requirements; and a bit over 200,000 IT or ICT jobs. So of the three, ICT is by far the biggest and it's also been growing the most in the last decade or so, so it is the largest but, of course, there are various cognate occupations as well, such as academia and also management, where you're managing these people and it's desirable at least that you've got some overlapping skills.

JIM MINIFIE: So that would mean you had 450,000 that you just mentioned, plus some significant additional groups in those cognate occupations, and so that's in a workforce all up of 11 or 12 million people, so it's a significant fraction of the workforce?

ANDREW NORTON: Yes, it's a reasonable number, but I guess the science number is the smallest of the three and, as we'll discuss later, that's probably the most difficult of the labour markets.

JIM MINIFIE: Is there any sense in which that workforce reflects our industry structure? So is it lower than you might find in Germany, for example, because we've got a much bigger service, agriculture and mining workforce?

ANDREW NORTON: Yes, I think this does reflect. Most countries, probably all countries' education systems reflect their industry structure and that's why Australia has particular historic strengths. Agriculture is an Australian strength in a way that it's not in other countries, whereas engineering in some Asian countries is much stronger than it is in Australia.

JIM MINIFIE: What about the mix between people with potentially high school only that are working in those fields versus undergrad versus later degrees, what are you seeing?

ANDREW NORTON: We've got quite interesting patterns for qualifications. In science, which is an area where PhDs tend to matter, there are more of them and they do much better in the labour market. Engineering, in the mature workforce there are still people from an earlier era who didn't need a degree, but on the whole to get into engineering you need a degree now. But the IT industry seems to be the big exception to all of this. What we found is that about a third of the Australian-born people working as IT professionals actually don't have a degree at all and we think this is probably because there are lots entry level technical positions through Microsoft or Cisco certificates where you can demonstrate skills on-the-job. Also in IT we find that post-graduate degrees don't really help you get a job compared to a Bachelor degree, whereas in engineering and science a post-graduate degree is an advantage.

JIM MINIFIE: Australia is an island but there's an international labour market in some specialised areas, so are we a net buyer or a net seller of labour to the rest of the world in these fields?

ANDREW NORTON: Australia is a big importer of labour generally and particularly in IT. I think about 30% of the people working in IT are migrants and this has been one of the very interesting complications in the labour market, that we've got very large inflows of workers into these industries which complicates the market for locals.

JIM MINIFIE: And I presume that there's less good information about the fraction of Australia's million-or-so diaspora working elsewhere around the world and about what their educational background might be?

ANDREW NORTON: Much harder to measure. We've got a few flow figures, but we don't know how many are still overseas. We'd love to know for the purposes of getting HELP (Higher Education Loan Program) money back, but.

JIM MINIFIE: And is there any information about incomes that indicate any sense of the value that the market places on these skills?

ANDREW NORTON: Grattan did do some work a few years ago using the Census on estimated lifetime private additional income compared to just doing Year 12. So for men it's an extra $700,000 over their career, IT is about $1 million extra, and engineering is about $1.2 million extra, so engineering seems to be, at least as of 2011, the most lucrative of the three.

JIM MINIFIE: So we've got then a very high level overview of the STEM workforce, but for that stock of let's called it half a million, you then have got inflows coming out from school and then from university. So can you talk a little bit about new graduates?

ANDREW NORTON: So what really motivated our research in this area was something called the Graduate Destination Survey which looks at graduates four months after completing, so very, very early on, but it's been showing some extremely worrying signs, both generally and in particular for people doing science degrees. They've always been a little bit below average but they've started turning disastrously below average and particularly for biological sciences, which has been a very large field and has very negative employment outcomes.

JIM MINIFIE: So when you say "below average" do you mean the fraction of people in work or full-time work?

ANDREW NORTON: So for the population as a whole about two-thirds who are looking for full-time work have it four months out, but of biological sciences it's about 43%, so much, much lower than the general graduate population.

JIM MINIFIE: Then what about for the other STEM fields, so there are some subfields in science that are having a difficult time of late, what about the T, E and M?

ANDREW NORTON: IT is almost dead on the national average and engineering is still above, so there's a clear hierarchy there.

JIM MINIFIE: So what do you think might be driving that and can I ask, is it a recent drop-off or is it a sudden or steady slide?

ANDREW NORTON: It's been dropping for several years and what we think is going on here is that starting in 2009 there was an enrolment boom across the whole higher education system and particularly strong in science, but then almost at the same time the labour market for professionals started slowing down. So we've got the combination of an increased flow of completing students leaving university and looking for a job at the same time as the labour market is not growing in the way that it had until about 2008, and these employment results are just the maths of more graduates looking for fewer jobs.

JIM MINIFIE: What about on the demand side, is it a broad-based decline in demand or are there factors that are specific to some of the STEM fields that are potentially influencing employment outcomes? I'm thinking, for example, about the mining boom, but there may be other factors.

ANDREW NORTON: So very clearly there's been a decline in the number of engineering professionals who are employed in the economy and that's heavily driven by the decline of the mining boom. But, on the other hand, engineering has always been a boom and bust field and this is one of the busts, but we can be reasonably confident that there'll be a boom coming not too far away because that seems to be the cycle for engineering.

JIM MINIFIE: And then for some of the other fields, so, for example, IT, does that still remain relatively buoyant?

ANDREW NORTON: Yes, it is, that seems to be growing reasonably strongly. It had a catastrophic decline about ten years ago but it has recovered from that and is one of the stronger fields, and I think everything we've said at the start suggests that, even though it might go up and down a little bit, its long term trajectory is upwards.

JIM MINIFIE: Is there any sense in which these declines have been bleeding out into the older workforce, or is it very much concentrated to people who are just new graduates?

ANDREW NORTON: We don't have good employment figures for some of the older workers, but the usual thing in downturns is that the main people who suffer are new entrants to the labour force before the older workers. So my view is that new graduates are taking the brunt of this.

JIM MINIFIE: What about net migration? I'm thinking, for example, we've had a very significant downturn in Europe and at least in the backpacker end of the market there's been quite an uptick in

labour supply. Has that been something that you would see in the professional end of the market as well?

ANDREW NORTON: During the boom we were heavily importing workers particularly in engineering and IT, and one of the measures of this are the 457 visas. Over the last few years IT is still growing but the other two have gone down, so workers in those areas are going home.

JIM MINIFIE: It's quite a complex picture. We've talked a bit about quantity and subfields, if we turn now to workforce preparedness, because you hear anecdotally that workers if they're new to the workforce are not necessarily perceived by employers to be a good substitute for experienced workers and so forth. Renee, are you seeing evidence from employer surveys that they're looking for pretty much what they're getting or are they looking for a different skillset than they're finding in new graduates?

RENEE HINDMARSH: I can't speak for all employers obviously, but what we find when we engage with industry, and we do that every day, is that they're looking for people with an ability to solve problems. So what we try and do in terms of our graduates is to make sure that they have every opportunity to be exposed to industry through things like work-integrated learning, and that's a really great opportunity for them to get a sense of what industry is looking for and to broaden out the technical skills that they're getting through their undergraduate education as well.

Just last week we had a group of students go to China with Huawei, the Chinese telco, and that's great on-the-ground experience. It gives an industry partner an opportunity to see what our students are like and hopefully that leads to great outcomes in the future, and it's also great for the students in that they get to see what it is that they're looking for. We also have a range of programs where we try and broaden out the skills that our graduates are getting, so we run a thing called the ATN e-Grad School, it's open to all of our students and it's free, which is also very important for students. Basically the philosophy behind it is to provide those opportunities so it gives them skills in things like communication, research, commercialisation and entrepreneurship, which is really important. Last year UTS did a survey of their students and they found that 40% of them didn't want to get a job at the end of their degree, they wanted to create a job and I think that's fantastic. We are seeing that there is a shift in terms of what people want to do and we need to be able to enable them to do that.

JIM MINIFIE: That's terrific. Let me just turn back, I forgot to ask to loop back around this potential short term oversupply, I guess a question for all three of you is what do you think led to the oversupply? So there are a range of proximate factors and if I were in a commodity market I would say there's going to be an adjustment, and people make a forecast about demand and supply and what have you. Has there been a factor on the supply side that students don't have good information about their employment outcomes?

ALAN FINKEL: I think there a lot of issues. The first one is, as Andrew referred to, we're graduating a lot more students. We've opened up the opportunities for students to go to university and they've got to choose something, some will choose engineering, science, law, medicine or whatever. We are graduating a larger percentage of school leavers through the university system as well as through the VET system. In Victoria last year 53% of school leavers enrolled in university, that's a big percentage, and another 24% enrolled in the VET sector. So 77% altogether are going to tertiary education, so there are a lot coming through. On the demand side we're moving inexorably towards a service

economy, more and more towards a service economy. The number of people employed in manufacturing, which is the sector that tends to employ technically trained people, is going down and down, I think we're somewhere between 7% and 8% of the moment of people are employed in manufacturing down, say, from 30% after the war.

So there are more and more people going into the service sector and we're graduating more and more specially trained people which means that we need to go through a whole mindset of what we're expecting. So I'm going to challenge the underlying assumption here that there should be a match between the students who we put through the system and graduate and the demand from the market. The reality is young people want to go to university, they're entitled to go to university, and most of the jobs in the service sector expect that people will have the communication skills and the analytical skills, the problem solving skills that come from having done tertiary education. So what we could do is try and say 70% of people who go through university should do, I don't know, business studies and accounting and law and arts to match the service economy demand, but we'll never get it right anyway. Young people who've graduated have a lot of versatility, we can talk about that later, but I think there's a big mismatch in the sense that the service economy's growing and the number of students going through is increasing. We've got an expectation that there should be a perfect match between supply and demand, and at the discipline level I don't think it's conceivable.

I will just add one thing, I've got a copy here of the Financial Review. There was a study published today reporting from a Korn Ferry study done internationally where they contacted 20,000 firms and looked at 5.7 million graduate entry jobs. They found that amongst those graduate entry jobs, which were across all careers, the ones that were STEM-oriented and people had STEM graduate degrees were significantly better paid across the whole spectrum of those 5.7 million jobs. So even if those jobs aren't, "Gosh, I did a Bachelor of Science major in chemistry and I'm looking for a job as an academic chemical sciences person", even if you don't get that level of match you're still getting some advantage from having done the degree.

ANDREW NORTON: I think there are two groups to look at here. One is that there are a range of skills for which there is definite need, and we saw this during the mining boom where engineers were in very short supply, graduate employment rates for new graduates was well under the 90-something per cent because as soon as you had the degree they were scooping you up, and they were importing lots of people. Ideally the system should be able to respond to meet those needs and it actually did in engineering, so the numbers have gone up. Similarly, it's kind of the cognate field of health. For many years Australia's had skills shortages in the health field and one of the strengths of the demand-driven system is that it has responded and delivered more health professionals to meet more not hypothetical, but actual current needs. Then you've got the bigger graduate labour market where it's always been very, very hard to predict where it's going. None of the people on this panel have jobs for which there is a clear degree that you should be doing and there are -

JIM MINIFIE: Or any degree.

ANDREW NORTON: Or maybe any degree - and there are lots and lots of jobs being created like that where particular skills may be more or less useful, but there is no precise qualification.

JIM MINIFIE: So from your point of view then, you look at this apparent short term mismatch and what's the explanation? It looks like there was "excess" enrolment at least in the short run, was that

just potentially a forecasting error made by individual students in now what is a demand-driven system?

ANDREW NORTON: I guess my view is that this was partly caused by government in that they did actively promote science in particular and my concern was that that wasn't particularly well-founded, at least over the medium term. So this started when Labor announced they were going to cut the student contributions for science and maths, which was back in the 2007 election campaign. So basically we're nearly a decade in to this round and I'd say so far, ten years on, things aren't looking too good for that prediction.

JIM MINIFIE: But wasn't that reduction in student contributions reversed just a few years later?

ANDREW NORTON: It was in 2013, which had no effect on demand incidentally. The really interesting thing about this I think was that was a lot of publicity around the reduced student contributions, it was part of an active publicity effort, whereas the increase back in 2013 was so obscure I almost missed it. It was completely under the radar and therefore wasn't given any publicity at all. So my view is that it wasn't actually the price change that had an impact. The historic research in this area says the price isn't a big factor in choosing between disciplines, but it was the associated publicity around it that was driving it.

ALAN FINKEL: I just don't think it's possible to get a perfect match. There are so many people involved and discipline needs, the jobs are changing. Gosh, if 40% of jobs are going to disappear in 15 years then some substantial fraction is going to disappear in five or six years, which is about the time it takes to see an impact of changing the priorities for university entrants. Andrew, you've mentioned that there was a shortage of engineers and we've met that, there was a shortage of doctors and we've met that, but we're overshooting. So now we're producing more engineers than the system needs at graduate entry and we're at risk of doing that for medicine. Last year we graduated I think 3,600 medical students and there were only 3,300 clinical placements. So for the first time we're getting to the point where we're graduating more medical students than we can actually allow to do the final year that they need to be qualified, so we're even starting to lose the match in the medical area.

It's a long term problem and for some reason people focus on it with science, technology, engineering and mathematics more than in other areas. So law, only about one in six students who graduate from law have any hope at all of having a long term career in law. There are 66,000 lawyers in Australia and we graduate 12,000 new lawyers every year. It's not hard to do the maths, every five-and-a-half years we're putting out as many lawyers as the total workforce and, if anything, the workforce is trending down because of automation and internationalisation. Now economics, I don't hear a lot of people complaining about the fact that we're graduating too many economists.

JIM MINIFIE: I don't think that's possible, the laws of supply and demand don't apply!

ALAN FINKEL: That's right, they wouldn't understand it! Only 5% of people of people who graduate with an economics degree get a job in anything that you would recognise as being an economics job. So I'm at a little bit of a loss to understand why we're striving publically to get a really good match between science, technology, engineering and mathematics and the demand, rather than saying these, like other degrees, are really good degrees for training young people to deeply learn

something, to develop work skills, work ethics, and then go out and work in the workforce. And if they don't end up in that position, well I can tell you some really good stories of prominent people who take their engineering degrees and end up in very surprising places - Chief Scientist.

RENEE HINDMARSH: I think students are voting with their feet on this, that they actively want to pursue these degrees, and I think that we should be doing everything we can to make sure that they have skills that will enable them not just for a job four months out when we do the survey and we don't have enough information about what happens to them after that, but that's a policy discussion we can have later. I do think that, as Alan said, it's important to recognise that a lot of these people will go out into the workforce and do something that's completely different to what they studied. I did philosophy and that's not helping me in my everyday work, but it did help me to think about problems in a certain way and I think that's applicable for science as well.

JIM MINIFIE: Andrew, just out of curiosity, I seem to recall you might have looked at these ratios, graduates compared to the installed workforce, across a range of fields?

ANDREW NORTON: Yes, though of course my panellists would say that's irrelevant. We did have a look at this and this is just looking at the narrow professions for which the degree is going to be essential or highly advantageous. What we found was that IT was in the best situation where there were 60 IT professional jobs for every one completer each year, so quite a big labour market; for engineering there were 22 professional jobs for every one Bachelor degree domestic completer; but in science there were only six jobs.

JIM MINIFIE: Almost as bad as law.

ANDREW NORTON: Almost as bad as law. So to me this is the key issue. There are lots of other jobs for which these things are useful, but if you have a reasonable size labour market to which your degree has an enormous advantage that just means that fewer of you are competing for those more general jobs, therefore it's a less risky option. You see this in humanities as well, that even though, for example, journalism is not a great industry to go into, people who do journalism degrees are still getting better jobs than people who do, say, history or English literature who draw on the same kinds of humanities skills, because there at least a core of occupations - journalism, public relations etc. - where you have some genuine advantage in the labour market.

JIM MINIFIE: We haven't touched much on the issue of grad versus post-grad degrees and I presume the employment outcomes are different, you make a bigger, a longer commitment, you get more depth. Is there experience around the panel about what the labour market's telling about the value of staying on and doing yet more years?

ANDREW NORTON: I think the PhD outcomes are still pretty good. There hasn't been a demand-driven system for PhDs, so the number is limited which means it's less competitive. There are markets for which you've got an incredible advantage - academia, research labs - where basically nobody else is in contention for the job, and the fact that you've got a PhD makes you competitive for a range of other jobs. So I'm not worried about PhDs.

RENEE HINDMARSH: The PhD question is an interesting one. We want to make sure that we're graduating PhD students who have the skills for what they go on to do next and we're graduating

more PhDs than there are academic positions by a huge number. So certainly from the ATN perspective, we introduced what we call the Industry Doctoral Training Centre and it's to provide PhD level training but to have an industry partner, so you're working on an applied problem, but have what we call broader life skills so that you can go out there and communicate what it is that you're doing at that level that industry is calling out for.

ALAN FINKEL: I want to pull a couple of things together. Renee mentioned that the four month graduate outcome is not necessarily the best indicator of what's happening out there. My office in a project led by Roslyn Prinsley did a study, we didn't do a survey but we took the ABS Census data from 2011 and mapped out the whole of the working population placements. One thing we found is that, as Andrew and Renee said, PhDs do earn significantly better, really very good, like double the probability of being in the highest income bracket. We also found that in the extent population about 53%, I think it is, of STEM graduates have a job in an area that you would call a STEM job and another 18% have a professional job that might be related to a STEM area. So in the extent population it's quite significant, in fact, the alignment of graduate degree and jobs surprised me about how strong it is, but it's changing at the moment, there's no question of it.

JIM MINIFIE: Have we missed any topics around quality or work preparedness?

ANDREW NORTON: Just on the post-grad issue, we looked at the percentage of graduates who have professional managerial jobs and if you just look at Bachelor degrees the science grads were the worst off, but once you included the post-grads in the data they were basically the same as IT, and engineering was a little bit better. So that post-grad is very, very important in explaining what's going on.

RENEE HINDMARSH: One other thing that I wanted to touch on is just following on from Andrew's earlier point, I think when you look at matching people into jobs, so say you get a maths degree and are you working as a mathematician? No, but I am applying those big data skills to transform what I'm doing in agriculture or I'm applying those skills in whatever field it is. I don't think that you're necessarily getting a completely accurate picture if you are just doing it in silos to say, "Okay, I'm a mathematician, I'm doing this" or "I've got an IT degree and I'm working in this". I do think that it's a bit more porous these days.

ANDREW NORTON: I agree it's porous and we've tried to match it lots of different ways, looked at broader professional managerial occupations, looking at questions that ask "Is your degree relevant, what's your subjective feeling about it?" So there are lots of ways of looking at it.

ALAN FINKEL: The classic example is physics, physics PhDs and physics graduates. Many, many more of them go into financial careers than end up doing anything related to pure physics because they've been trained in mathematical analysis and problem solving and they can apply that so well to the complexities of financial fields, better than people who trained in finance I think or economics.

JIM MINIFIE: Shall we move on to whether there are things that universities could do that they're not doing now, then move on to policy, and then we'll open up to questions. Are there gaps in what universities are offering their STEM students that ought to be filled?

RENEE HINDMARSH: Yes, I think we can always do better as universities and I think it's important to look at what industry wants and also what our students want, and we do that all the time. As I said, work-integrated learning is something that is a real priority for us as a group of universities and also it's something that we're looking at at the national level. Universities Australia is working on their work-integrated learning strategy recognising the importance of it, so I think that's really good. I think having a co-ordinated approach as well at a national level, and that's probably more for the policy discussion, but I do think that we need to look at this in a strategic way. But I think universities are recognising that there's a shift, we're trying to provide those broader skills, so it's not just a passive thing. Even in the way that we teach, having things like flipped classrooms is more responsive to what both students and industry is asking for.

JIM MINIFIE: Do people know what a flipped classroom is?

RENEE HINDMARSH: A flipped classroom is where basically instead of the traditional lecture format where it's broadcast, you do your reading beforehand and then it's more interactive way of engaging and learning.

JIM MINIFIE: Tremendous. Alan or Andrew, other things universities ought to start doing that they're not doing?

ANDREW NORTON: I agree with what Renee said. One thing that particularly intrigued us when we were doing this research was why is it that we have an industry in IT which is doing extremely well but the graduates are not? Why is their employment rate no better than the national average? There's a survey done of graduate employers and 50% of those in the IT industry said they would have employed more graduates if they could find someone appropriate. Why are they saying that? Why is student satisfaction very low in IT faculties? Why is attrition very high? I think everything is pointing to IT faculties having issues and probably not preparing their students as well as they should.

RENEE HINDMARSH: Can I respond to that? We do talk to industry a lot about what it is that they want and we are changing some of the offerings that we have. So at the University of South Australia, for example, they've partnered with HP to run an Honours program. HP has been very active in the content of that program and it involves industry internships for the participants in that program, and we imagine that the outcomes for those students are going to be particularly good. We also partner with Huawei and Cisco. We are talking to industry to make sure that we're delivering what they want. Obviously you referred to the negative employment outcomes and the dissatisfaction and attribute, but I think those trends are actually improving, the attrition trends.

ANDREW NORTON: It is improving, yes.

RENEE HINDMARSH: And I think part of that is that it's not just about getting a job today. I think the underpinning technologies that people understand by doing an IT degree enable them to do so many different things and to really embrace this new culture of innovation and entrepreneurship that young people are getting really excited about. I think if we can respond as institutions to allow them to have those skills to create their own jobs but also to get the jobs that are out there and to communicate well and all of those things that we touched on before, then I think we'll start to see a real shift.

ALAN FINKEL: I think IT is probably *the* most difficult discipline to get the right match between what's being taught and what's needed, because IT as a field is changing incredibly fast, the tools that software engineers use are changing rapidly, and the problems we have are not unique to us. Everybody thinks in Silicon Valley, in America it's all easy, but they're employing vast numbers of IT experts, graduates from India and China. They have a shortage and the salaries for graduate entry in IT are really high because they can't work it out ideally either. I agree with what Renee's saying, we do have a lot of communication between the university faculties and industry partners, but I think there might be a philosophical problem of trying to teach what industry needs despite the fact that it's not possible in such a rapidly changing industry or area.

What they should be doing I think is more teaching of core software engineering skills rather than the tools that engineers are using out in the workplace at the moment. Because if you teach the core skills, a graduate who's done it and done it hard will get out there and have no problem learning to use the latest techniques and the latest tools that are de rigueur in that industry.

JIM MINIFIE: So quite an agenda to fix IT and presumably there are opportunities in other disciplines as well. I want to touch on policy and then open up to questions. As you mentioned Andrew, we've had a "demand-driven" system for some years now, at least at the undergrad level, so what is the role for policymakers in this area?

ANDREW NORTON: Well, one of the reasons for the demand-driven system was that nobody thought the government could do a good job of forecasting what courses or what graduates we would need and that just letting universities and students work it out between themselves would work more effectively. I think you can say it has actually dealt with a lot of the skills shortages, but the question is now do we have too many graduates and what are they going to do?

JIM MINIFIE: So are there funding model changes that need to be considered?

ANDREW NORTON: Probably not, but it means that if you're going to steer the system it has to be via market means - advertising, persuasion - rather than sitting in Canberra and saying, "This university will have X thousand engineers, X thousand IT students" etc.

RENEE HINDMARSH: I think government is trying to address that through things like the QILT (Quality Indicators for Learning and Teaching) survey, so committing additional resources and saying we want students to have all the information possible when it comes to making a decision about what it is that they study. I think also having a longer term view of what's going on would be really beneficial as well. We have the four month snapshot in time, but perhaps linking things like tax file data would really give us a much clearer picture of what's happening than what we have now. Some of what we're talking about is speculation.

ALAN FINKEL: At the risk of repeating what I said before, I do think we've got to start actively decoupling our thinking, our mindset about chasing a match between the degrees that young people do at university and the jobs that are out there, because it's just a snapshot, a moment in time, and it will change. What we should be focusing on is the quality of the degrees that are being offered by the universities. In the main they're very, very good, but there are lapses and we shouldn't have any lapses because wherever there's a lapse there are young people who are not getting the quality of training that they should get.

One of the things that I and many other people have been talking about and expressing significant concern about is the fact that most of the science degrees around the country don't require mathematics and nearly half of the engineering degrees around the country don't require the level of mathematics that includes calculus. The reality is you can't do engineering properly unless you can deal with calculus and vector algebra and things like that, so if we lower the standards for entry and then commensurately lower the standards during the course we are doing disservice to those students. If we keep the standards high and train them well then they will be flexible in the workforce. I think that's a significant mindset shift that we need to get our heads around.

RENEE HINDMARSH: Can I just make one more point around policy? I think it's great to see that we do have NISA (National Innovation and Science Agenda), but it would be really good to see a bipartisan approach to policy in this space. It's very Pollyanna of me I know, but I think having a longer term commitment to the STEM agenda would be helpful for all of us.

JIM MINIFIE: Andrew, parting shots, final words?

ANDREW NORTON: It looks like Senator Kim Carr is not going to be the shadow so Labor might change their policy, but I think hoping for bipartisanship is hoping for too much.

JIM MINIFIE: It'd take all the fun out of it. So if we now move to questions, don't hold back because the time runs by.

AUDIENCE: Thank you for a very engaging and insightful discussion. You've talked about how graduates leave the university, enter the workforce and take STEM with them. What role is there for universities to engage more directly with the economy for collaboration between universities and entrepreneurs to really bring STEM into the Australian economy that way?

RENEE HINDMARSH: It's a great question and certainly something that we are and I personally am really passionate about. I think it's great to see that we are changing some of the incentives around engagement and collaboration to try and drive that meeting of the minds, but I think we can do more from universities' perspective. Earlier this year we announced that we would take a national approach to IP, for example, to say, "We're open for business, come and work with us". It also needs to come from industry too though. At the moment I think a lot of the drivers have been around universities and what we can do better. There needs to be a conversation about how can we encourage industry to want to do that, and having people with STEM skills really will help solve that because you need people that can communicate to both sides and understand the problem.

ALAN FINKEL: There are a lot of things, Renee mentioned new incentives, so the ARC has been asked under NISA to develop a new metric that will go alongside the existing metric for research quality which is currently called the ERA. This will be a new metric that measures industry engagement or end-user engagement and impact, and I think that's a big help. We need to do things to encourage companies to reach back into the universities and there are tax measures that could be done, but one of the problems that industry sometimes expresses is they see the university system as too complex and they don't know how to get started.

One of the best ways that's been shown around the world to break down that feeling of not understanding how it works to get PhDs working in those companies is a system that the French use

where 10% of their PhD cohort are funded to do their PhDs while full-time employed in a company, but supervised properly through a university. That has not only the benefit of graduating somebody who has industry experience, but it's giving those companies the comfort and the knowledge of how to reach back into the university system. So there are many, many things we can do. You mentioned entrepreneurial training and accelerator hubs on campus. It's happening. Is it happening as fast as we want? No, but the Vice-Chancellors are aware of it and things are moving in the right direction.

AUDIENCE: You mentioned earlier that our 14 and 15 year olds have become less competitive on a world scale, what do we need to do at primary school and secondary school to change this course of events so that Australia's number one?

ALAN FINKEL: A lot of studies have been done on the "why" and you could point your finger at many, many things. The fact that we don't have across the board performance pay and the right kind of professional development training for teachers and many of them, not through any fault of their own, are left teaching in subjects for which they did not have tertiary training. It depends on which survey you look at, but between 23% and 40% of secondary school maths teachers didn't do mathematics at university, so that makes it very difficult for them if they're using modern pedagogies such as inquiry-based learning for them to respond to the questions that those young people have. It's resourcing at schools. It's probably not class sizes, there have been a lot of studies that have been published recently that show that smaller classes, which have been driven over the last 20 to 25 years where class size has gone down a lot, have not led to any improved outcomes. Pre-requisites that I was talking about before, if universities brought back maths pre-requisites, Principals at schools would respond by improving their maths education delivery all the way down to primary school because they know that you can't pick up maths in Years 11 and 12 and do well and meet the pre-requisite requirements.

So there are many, many things. One of the things that I'm hoping to encourage through my office working with State Education Departments and Principals and others is an achievement award system or reward system for schools that develop their own plans for how they're going to improve what they're going to do in maths and science, because there is no one-size-fits-all model that will work for all schools.

JIM MINIFIE: I would add that we've got a recording of an entire session that Grattan ran last year on this topic on our website.

AUDIENCE: I have a two-part question and the second depends on the first. I've been exploring mentoring PhD students across 12 different disciplines and they tell me that after six months they stop talking across each other and they start working rather productively and the outcome's been rather good. Unfortunately this process is not generally repeated, although everybody I brought in to deal with it said what a wonderful idea, we should do it. Structurally the university seemed almost incapable of handling it, so I resigned from that particular university because it was a voluntary activity. It is however one I would comment. The second part depends where do you get the resources to do that? Well, I'm 75 and I'm on my fifth round through different disciplines. I've heard much about the first round, I've heard little about the one-and-a-half round, I've heard nothing about the huge resources that we have from those who are deemed to be beyond ages. I didn't start my academic career until 50 and I've been through three subjects already.

Can we please have a more balanced discussion? There are different things that different age groups can deliver. The mentoring processes are critical, the cross-disciplinary areas are absolutely critical. I worked in many EU projects where it's a skill that that was developing. We need universities to start seriously looking at these things, and by cross-disciplines I do not mean biology to medicine with maths. I mean philosophy, zoology, management and engineering all in the same group, which is what I had. I would commend this. The perspective shifts are visible, the effectiveness is large, and it's something that you can expect from those in their second round in their career as well to have gained other ways, so we still ought to value these things.

JIM MINIFIE: Can I just interpret, is the question is there more that can be done for people who are not straight out of school in their first round of university?

AUDIENCE: Why are we not doing more of the cross-disciplinary education to enable even the first round to be twice as productive?

RENEE HINDMARSH: I think one of the advantages of being a university is that we do have strength across disciplines and I think that that is something that is changing. Certainly when we engage with industry and we look at research problems, bringing in people from different faculties really strengthens the offering that we have and having multidisciplinary teams. We see it in action where you might have someone who has the technical expertise to develop a widget, but it might be someone from behavioural sciences, for example, who comes in and says, "Yes, but people won't buy that widget if it's red" or whatever example you want to use. Having that cross-disciplinary approach to very complex problems is beneficial and I think that universities have traditionally been quite siloed, but we are seeing a shift, certainly at the ATN University, towards embracing cross-disciplinary teams.

ALAN FINKEL: I don't think that the situation is as dire as you point out, certainly in industry. Let's move away from universities for a moment. Industry puts together multidisciplinary teams all the time. You don't have a marketing success just by developing the technology, you have to understand behaviour, you've got to do art and design, and you've got to look at the economics, and good companies put together experts in those fields. We do have examples in universities where that happens and it happens very well, but there is a bit of a challenge with the current funding model through the ARC (Australian Research Council) and the NHMRC (National Health and Medical Research Council) and that tends to be discipline-specific. There is new funding coming down the line through the MRFF (Medical Research Future Fund), but the rules for that haven't been designed let alone announced. Most people I speak to, and I would agree with this, hope that there will be some commitment to multidisciplinary project funding and to pre-commercialisation project funding.

Stepping out of that, the learned academies, who represent the various disciplines of social sciences and humanities, science and technology, and engineering, come together on a regular basis to do multidisciplinary reports looking at the really challenging problems for society. Take something like coal seam gas: if you look at that purely from a technological point of view you get a certain way forward, but if you look at it from a multidisciplinary point of view you get an approach that is much more likely to deliver some outcomes. So nothing's perfect, but I don't think the situation is as dire as painted.

ANDREW NORTON: It's quite interesting that undergraduates are quite good at this, lots of people do double degrees with multiple disciplines, but as postgrad it becomes more and more specialised, and I think that's the challenge that the question was referring to.

ALAN FINKEL: But that's a good thing. I run a lot of complex engineering projects and we put ten people on a team and never once have we looked for ten multidisciplinary people. We get ten people, each of whom has some extraordinary expertise, and we put them together so that we've got the best of the best in each of the disciplines and we manage it as a multidisciplinary project. So you've got to be very careful what we're looking for. There's nothing wrong with people being specialists, even experts are worth respecting.

AUDIENCE: I'm a STEM graduate, I lasted only three years in the laboratory doing analytical chemistry because way back in 1971 some amazing innovation was displayed: the same computer that was used on Apollo 13 was married up to a piece of analytical equipment and, hey presto, the era of automated analytical chemistry well and truly got underway in this country. I went on and did other things. One of those is that I'm at the last stage of being an external member of a panel to review the BSC Honours degree at a university here in Melbourne and I'd like to make a number of propositions and hear replies or comments please from the panel.

Firstly, the students don't know what they don't know. They fall into doing degrees and it's only at about year three or even in the Honours year that they start to ask themselves, "What am I going to do?" Some go into research after the Honours degree, but about only 20%. 80% go on and do other things, usually in industry or in government. Secondly, I fully support what Alan Finkel has said, quality is essential. If I go back to when I was in my employment era many decades ago and employing new people, I could get a Year 12 graduate who had better literacy and numeracy skills than many of the graduates I'm meeting today for the reasons that have just been spelled out. Thirdly, because we are overproducing graduates, can we not look at policy being developed which will not so much marry up the numbers of graduates with the perception of the jobs that are likely to be available, but rather look at tertiary education becoming a very good general education which teaches problem skills, analytical skills and communication skills?

ANDREW NORTON: I think every course should teach those general skills, whether it's aimed at a particular vocation or not, and that's one of the claims that universities make that distinguishes them from technical education. I think one of the issues has been that even though universities have long said that they do these things, they haven't been very good at testing how good they are at doing these things and a lot of unis are thinking about this, but it's not really happening yet.

ALAN FINKEL: Can I go back to the first of the three comments, I don't think there's anything wrong, and I'm not suggesting that you meant that there was something wrong, in somebody being in the second or third year of their degree and really not having a vision yet for what their future is. The most important thing is that the students are doing it with quality, learning some skills and keeping the doors of opportunity open.

Your last point relates to that where you said we might be entering a new era where having a tertiary education is the expectation. We've seen in the last hundred years that it was expected that all kids did primary school and not that many did secondary school, then we had what was called Form 4 which was the Year 10 intermediate as the expectation and Year 11 leaving, and then HSC and we

expected the vast majority of students would do HSC. We are now entering an era where we expect that the vast majority of students will do tertiary studies of some kind. The obligation on the system is to give them the opportunity to do that properly where they get deep discipline skills, they're challenged, they're taught a lot, and they get the discipline and all those quality attributes that we've been talking about on the panel tonight. They should get it all because there is very little chance for the majority of them that they'll be working for a particularly long period of time at all in the exact discipline that they studied.

AUDIENCE: I read that a child born today will live to 105. So I come back to the earlier question, why is this conversation only focused at the beginning or the front end of the lifespan? This is really an ongoing learning discussion and, given that we are expecting people to have multiple careers, surely we do expect them to have multiple learning disciplines. Where are the universities in that conversation? I haven't heard anything about that today.

RENEE HINDMARSH: I think it's really important to have that conversation about lifelong learning and that is something that the universities try and instil in the graduates, so it's not just that you get your qualification and you graduate and you go into a job for life, but that you do have the ability to adapt. Some of that may be through technical qualifications or going back to university and to study later on, but also maybe just experience in the workforce and that you are constantly are looking at the skills that you have and ensuring that you're up-to-date and working. That's something that I think as a sector we're all committed to and we try and instil in our graduates that this isn't just, "Okay, you're done now, thanks for coming" but that it is absolutely about lifelong learning and a passion and a curiosity.

ANDREW NORTON: The big trend over the last 25 years has been the rise of post-graduate education, so lots of people are studying at later times in their life to either advance or renew their skills. I think there is an issue though around the length of time it gets to a degree relative to people's other obligations in their life around work and family and whether you need more sharply defined added learning than another three year Bachelor degree or two year post-graduate degree.

ALAN FINKEL: I think there's also a very different requirement. So there's been this onslaught of MOOCs (Massive Open Online Courses) and they've been singularly unsuccessful at transforming education for young people. Young people vote with their feet, they want to go to bricks and mortar universities because they want the social experience, they need the peer pressure, they need adult supervision, if you like, from their lecturers, and it works really well. Where the MOOCs have been successful, when they go in and analyse the demographic of the people who actually finish and do the exam and do well, they're typically 35 or 40 years or older with a family and a job and adult self-discipline and the willingness to apply themselves and run the course through to conclusion. Universities across Australia and around the world are offering online courses, full courses, and you see the same demographic distribution, it's mostly second degrees for 35 and 40 year olds, that's where the enrolments come from.

The last thing I would say is that it's a different kind of problem also because, as I said before, once you've done a degree and you've gone deeply into the discipline you've become what's called the carrot, you've got deep knowledge and you top that up with a little bit of growth on the surface. Once you've done it once it's not that hard to do it again driving yourself, but it's really hard to do it the first time. So the focus tonight on the first degree I think is appropriate, but not for a second would I

suggest that ongoing training and re-training for adults isn't critically important, especially as the nature of the job market changes.

AUDIENCE: I'm a senior member at ACS (Australian Computer Society) and I've seen that organisation go through a lot of metamorphoses. It has introduced recently a professional year compulsory for the graduate students which they had to undergo as part of their degree certification and they must attend a monthly program at the ACS sponsored events. So that initiative that they have taken to bring industry closer to the graduates I thought would be a really good thing. I attended most of it and was disappointed with a couple of things. There is nothing to take away from the ACS, but the way that the graduate students perceived what those programs were, they were not interested even to understand the complexities that industries are facing when hiring graduates. At the end of the talks and the sessions I had to interact with them and let them understand that they need to really have a diversified skillset other than just knowing technology and how to communicate what it is that they've learned.

Then when I went to the ACS chairman and tried to understand and find out from him why this program has failed and what needs to be done, they said that it has to come from the government, that a lot of initiatives have to be discussed with the government about what can be done and it has to be taken down to school level. They don't know what will be the driving force for them to interact at lower levels than the graduate, like primary schools and middle schools, so what kind of policies should the government develop to help the whole process to make sure that it is filtered all the way down to primary schools?

JIM MINIFIE: Any response, this is really getting an example of STEM, so in this case computer science filtering down into high schools and primary schools?

ANDREW NORTON: It's one of my colleagues' areas. I think there is an issue that we found in our research of perceptions around IT in particular which means that people start not thinking about it when they should and they don't do the subjects that they need to do to get into it. So I'm just repeating your problem, but this is quite difficult in getting this change of attitude over time.

AUDIENCE: I studied engineering and science but I work in business - so as you can see, people can work in broad areas - and one of the things that I hear a lot about, and Andrew commenced on this, he said we're a net importer of STEM, but then I also hear we're having a brain drain and we're losing people. I'd love to hear how the numbers are really working around that, is there a brain drain? And then Alan, if there is a brain drain, what sort of policies could be encouraging the next boom to bring these people back and to increase employment in interesting STEM areas?

ALAN FINKEL: My experience is that, first of all, the brain drain sometimes converts back into a brain gain. So a lot of the people who go away for three, four or five years do come back and we also get a lot of immigrants, so it's a two-way street. We do gain people from overseas who are not Australian who are contributing to our society, so I don't think that one can just look at who we're losing without looking at what's coming back. The most important thing is to have an economy that's thriving so that there are job opportunities and challenges, because the people that go overseas in the first place are the ones who are chasing opportunity and we have to provide that back home. So that comes from policies around not only education, but innovation and commercialisation, getting the right tax policy

drivers so that small companies and start-ups can thrive. It's very, very complex, there's no single solution.

ANDREW NORTON: Also what Alan says, I think it's great that people are going overseas and getting experience from other countries. The work we've done related to repaying HELP is that the vast majority of them do eventually return, so I think it's to their benefit and Australia's benefit that they see what people are doing in other countries.

JIM MINIFIE: Thank you so much, I think that's all the time that we can devote to questions. I've found this a most stimulating discussion. Thank you so much Alan Finkel, Renee Hindmarsh and Andrew Norton, and thank you for a very engaged participation from the audience as well, On behalf of Grattan and the State Library, thank you and good evening.

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