Double or nothing! Clever thinking, double-degree frustration, and returns to Science

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Undergraduate double-degrees are 'a necessary disaster for science', in the experience of one Science Dean at a major university. Double-degrees bring timetabling and logistics problems, but 'more so students who have to study for so long then want to leave and work'. This is especially so for degrees with Law. The Dean reported difficulties attracting top students to pursue Honours and Doctorate research. His frustrations were reinforced by heads of science schools across institutions.

These interviews were conducted as part of a research series over 2005-2006 exploring issues in academic ways, course structures, teaching and learning at disciplinary interfaces, with a focus on Law:Science double-degrees. Among other findings, academic irritation was matched by frustration among some students with limited opportunity for integration during their double-degree study.

Escalating global, national, industry and student demand for integrative thinking is vital context to the research outlined in this paper. Gibbons, Limoges, Nowotny, Schwarzman, Scott and Trow signalled, in 1994, the need for new ways of thinking – in science, universities and graduates – to ensure useful engagement with an interlinked world. Mode 1 was 'pure, disciplinary, homogeneous, expert-led, supply-driven, hierarchical, peer-reviewed and almost exclusively university-based'. Their Mode 2 is 'applied, problem-centred, trans-disciplinary, heterogeneous, hybrid, demand-driven, entrepreneurial, network-embedded' (Watson 2003). Mode 2 knowledge generation is 'increasingly transdisciplinary … draws upon and integrates empirical and theoretical elements from a variety of fields', in universities, industry, centres, consultancies, think-tanks (Jasanoff 2003, p.234), by 'new types of non-subordinated researchers' whose work 'cannot be authoritatively encoded in traditional forms of scholarly publication' (Nowotny, Scott and Gibbons 2003, p.180).

This 'major, now canonic, theoretical intervention' (Watson 2003), has been promoted by some, who acknowledge the challenge to 'institutional science' and to traditions of structuring knowledge and universities into disciplines (e.g., Oliveira 2000), but disputed by others through words or silence. The contention that 'production of knowledge and the process of research [is] being radically transformed', (Nowotny et al. 2003) has generated a deal of academic debate (e.g., MacLeod 2003).

In reality, though, the world is not waiting for academia. Gibbons' 2001 warning that academics would increasingly need to accept sharing their territory with other knowledge generators, is ratified daily. We see knowledge and its power forming well beyond the walls of universities and professions, even now in the sciences. It is not surprising then, that 'today's students have a broad world view and are interested in social and global problems' (Tytler 2007, p.iv), and that these students, especially the gifted and talented, expect considerably 'more' of their universities.

Disciplines, for instance, are not the world of students before university, nor the essence of many careers beyond. Interdisciplinary issues are 'real', they are multi-dimensional, (Policansky 1999; UKRC 2000; Batterham 2001) with a complexity many citizens takes in their everyday stride. Approaching an issue with single discipline expertise is a more artificial, and slower, circumstance – and the impatience of Generation Y is now as legendary as their global outlook. And the pace is escalating. A Barnett discerned in 2004, students, employers and futurists are expecting universities to prepare clients to work with still greater complexity. Even as the simplicity of Mode 1 fades, life spills beyond Mode 2 and demands a Mode 3 – ways of 'knowing-in-and-with-uncertainty' (p.251).

In this dynamic environment, an associated and equally important context to this paper is the difficulty faced by the Sciences in enrolling students and graduating scientists – including future shining stars – for research, teaching and industrial enterprise.

Contraction of enrolments in 'enabling sciences', in contrast to some expansion in behavioural and biological sciences, and incursion of 'non-science' subjects through students taking double-degrees, are of particular concern (McInnis, Hartley and Anderson 2000; Dobson 2003). However, analysts are also intrigued by these trends and indicators about 'university science', given that regular media coverage shows 'Science is definitely on the [public] agenda' (Dobson 2007, p.3).

Investigating degree interfaces

Arguably, many bright, young students entering universities signal that they expect to boldly embracing 'worldly complexity' by choosing multiple-degree programs. Double-degrees are well-established in Australian undergraduate education, and on the rise for instance in Europe (Sursock 2007). Students are also likely well aware of career market expectations and need for competitive edge.

In contrast, even on the surface (e.g., websites), there are few signs that Australian universities have embraced double degrees. Indicators suggest double-degrees emerged as a way for universities way to cater for student/industry demand for wider study, even while bemused by the phenomenon. For instance, although undergraduate students have been long enrolling in multiple programs, such as Science and Law, there has been little research into their expectations, views and experiences.

My curiosity about degree interfaces sharpened as I founded a unique centre and new double-degree, balanced across two faculties and three schools. Even as enrolments began, there seemed no academic pathway for bringing together two lines of study so the university could deliver on promises of 'analysis at intersections' (integration). Deeper exploration showed this to be the general case across double-degrees and universities. In particular, behaviours at interfaces of Science and Law confirmed a clear 'stand-off', traceable in part to propensities in academia, and to compartmentalisation in learning (Welsman 2004, see also Faigman 2000).

From 2005, I progressed four pieces of research working with universities. Knowledge gained in each project informed the next, in overall pursuit of an unasked question: Are Australian universities able to ensure undergraduates who commit to double degrees can learn to their full potential? Especially, those choosing to study, say, science and law, or say, science and commerce with a sharp eye to events unfolding around them? The four projects explored 'interdisciplinary' and 'integration' within universities, courses and teaching:

a) *Interdisciplinary response in law curriculums* – examined law programs as represented in public materials vis-à-vis stated interdisciplinary directions at university and faculty levels.
b) *Teaching in a scholarly way* – tested a scenario involving a hypothetical multi-discipline subject (Law and Zoology) against five policy and academic measures of scholarly teaching (in: Prosser and Trigwell 1999; Chickering and Gamson 1999; Trigwell, Martin, Benjamin and Prosser 2000; Åkerlind 2003).
c) *Law:Science double-degrees: Student views on integration* – explored issues through focus groups with volunteer BSc/LLB undergraduates plus content and phenomenographic analysis.
d) *Academic leader-teacher views on integration* – investigated integrative thinking and intention through interviews and critical review of four published reports on course/program development.

Findings and deductions in relation to 'double-degree frustrations' included, in outline:

- Australian double-degrees involving law (and generally high entrance scores), even at leading institutions, are not interdisciplinary and are barely integrated. Most double-degrees 'bolt' one part to the other with little consideration of students or pedagogy (see also Johnstone and Vignaendra 2003). Students are challenged to progress two separate courses almost in spite of the system.
- multiple lecturers delivering and examining parts of a single subject, even in early undergraduate teaching, is a common if curious phenomenon in Australia. Universities, it seems, do not require an academic to master and teach all elements of a subject but expect undergraduates to integrate the knowledge, within or across disciplines.
- occasional subjects demonstrate elements of 'integrative intention' in the minds of lecturers. However, interest to grapple with this in building courses and to encourage leading edge thinking in students is constrained by university reward and resource systems and by discipline paradigms.

Overall, an important proportion of students entering universities appear bolder and braver than their education environment. I asked academics 'do you feel your university harnesses the capacity of young students enrolling in a double degree such as Science/Law?' The university 'in no way approaches this', said one. 'The university doesn't do much for these bright, integrative students' said another.

Through bright student eyes

A closer look at views expressed by BSc/LLB undergraduates should be useful to science educators. I conducted focus groups with first year and later year students. These students were young – from 18 to 23 years of age. Most had enrolled straight from school. Almost all had completed an impressive array of science and mathematical subjects at high school, contributing to their top line UAIs (a number had three sciences plus maths). Less than half had also studied legal or political subjects.

Among them, these students were enrolled in or planning to study: pure mathematics, theoretical physics, double major in genetics, medical science, chemistry and biochemistry, immunology, animal and human health, genetics and organic chemistry, cell and molecular biology, ecology, chemistry and molecular biology, computer science, mathematics and computer science. Deans of Science, scientists worldwide and Australian policymakers might despair at some of the influences, as well as 'worldly interest', that guided these students to also enrol in three years of Law.

'(S.1) … liked doing science, that's why I picked this, my Dad's a lawyer he persuaded me to do law, to lead to a career… (S.2) …I wanted to do something I was very interested in – the science – but then law should be more useful in the long run … '

That they elected to 'take-on' a complex Law-Science combination is a testimony to their personal drive and scientific and mathematical proclivity. While some said they had not decided on career lines, in the later year group it was evident that most would be taking the Law pathway.

'I did science in high school very interested, wanted to know more about law, now taking a lot of law but science still strong don't know yet what I'll do [later said he sees his career being in law]'

Yet there was some regret in the older group that the double degree demands precluded them from getting deeply into Science.

'(S.1) I actually find you end up doing few real science subjects because doing so many research projects … same with law … can't do a proper science degree with a law degree

(S.2) can't do more advanced science degrees a B Med Sc or B Biotech … clashes with timetables etc . A pity really. '

Demonstrating their global view, more first-year first-semester students were open-minded. Indeed two surmised they might use income from practicing law to finance their scientific research.

'I thought I might do law first just to fund my science research … science is always begging for funds … if I can earn the money myself …in the end I can do my science research without looking for funds.'

Expectations and experiences around integration, separation or linkage of their programs were explored. Inductive content analysis plus a basic application of phenomenography gave insights into views of these bright students.

- A number, not all, revealed an underlying search for points of intersect and integration in their Science and their Law. Later year students were more vocal and frustrated. The weight of expectation (hope) was that the faculties and teachers might move to integrate the lines of thinking behind two degrees offered as a combined set.

  '… becoming clearer after a few months, very interested now in biological and ecological sides of science, and the law, see that it can and should be integrated at points. The theory of law is becoming clearer. Can see myself applying the science to the law perhaps.'

  'Haven't had much opportunity to integrate yet … human genetics … we had a couple of lectures in science on intellectual property and I was the only person in the science class who stayed awake – right over their heads … I think the really good point of integration is in the biology degree … .'

- Later year participants showed a recognition that they, as students, would (and perhaps should) need to do much of the integrating themselves, to the extent that opportunities arise. With perseverance, a few had achieved honours level projects 'at interfaces'.

  'Was interested in both at high school. But did think from first up that I would mesh the two, and set out … to make sure I did. Did science units assignments that included ethics based, communications etc.'

  'I tried to move as soon as I could into the science in context, theoretical type classes .. would be a good way of getting integration in courses, more than just a law student and through assignments … on cross-topics … but hard with group projects … .'

Most saw conceptual, procedural, presentation (referencing) and 'ways of thinking' as obstacles. Later year students were conscious of philosophical and thinking gaps among academics and professionals practising science and those practising law.

'(S.1) I tried to discuss some science in a presentation about regulations … difficult people in room not so interested … both a discussion on technical standards … food etc. (S.2) … wanted to do a project for law honours that was relevant to science and law but law said had to have two law supervisors … .'

Q. Would you discuss a law case in a science assignment? or include science in a law essay?
A. No I can't see that happening, most science assessments are compulsory subjects they just

do the questions and you answer them. Haven't done more general science courses [yet].
Q. What about in law – would you discuss variations in science when considering facts at law.
A. More likely, would discuss applying the science in the law … but can't really see …

To most, this gap was a challenge but also a possible opportunity, especially as they saw their careers taking the law pathway, bringing in science – with some lingering regret they did not more deeply pursue their fascination with scientific inquiry.

'90% of the law people I come across have no technical or practical knowledge at all. We had a lecture in law with a lead case involving semi-conductors – someone asked what is it – the lecturer didn't even know – he said we'll just call them widgets. Even outside university … I have done work with law firms, and their mindset for the technical stuff. Its just not there. '

Applying a phenomenographic technique (Åkerlind 2005; Bowden and Green 2005), I could discern four qualitatively distinct student ways of thinking about integration of science and law: Accepting, Forming, Utilising, and Questioning.

1. Accepting. *See little or no integration*. Two lines of personal study interest, or one real interest and pressure to do the other. Keeping career options open.

2. Forming. *See limited integration in practice or careers*, but benefits personally in developing thinking capacities and analysis skills.

3. Utilising. *See potential for practical career integration*, by themselves, bringing together separate Science and Law elements, and advancing their careers.

4. Questioning. *See need and potential for integration of thinking*, externally and personally. Urging themselves, faculties, professions, policy-makers to think more at interfaces. Personally questioning along interfaces, building perspectives.

Interestingly, level 4 could be situated in Biggs' SOLO Taxonomy (2003) as *high relational* edging to *extended abstract*. These are theoretically desirable orders of thinking to be achieved from teaching and learning. Levels 3, 2, 1 align with relational, multistructural and unistructural.

Some students were clearly seeking higher-level integration and intellectual leadership that would extend them into *arguing* and *testing* – daily essentials in industry, policy and community enterprise (and in my terms, 'interdisciplinary thinking'). Overall, there are multiple reasons (not the least being the great capacity of these students) to develop strategies in Law:Science double-degrees to lift student thinking into the integrative, high-level questioning and critical thinking, realm of level 4.

Clever thinking may pay-off for Science

Science is readily dominated in double-degree dynamics. The conceptual demands and commercial promise of programs such as law, finance or economics can overbear the time-hungry Science courses. Many of these brightest of students are pulled/pushed away from Science after a string of base units; their worldly interests unfuelled by 'lame labs', multiple-choice 'fact exams' and discipline-bound feedback.

In 2007, after decades of exhortation (see OECD 1972), modes of inquiry 'characteristic of the discipline' still dominate academic structures and teaching (Neumann 2001; Dearn 2006). With limited efforts at university level to deter compartmenting pressures on double-degree takers, there is

opportunity for inventive Science faculties to take a lead in genuinely integrative learning – and in doing so, to open and maintain paths 'in Science' for these gifted students.

Some approaches may 'just' involve lateral thinking by faculties and academics. For instance:

- *Questioning, argument and testing across and well-into disciplines.* Building interdisciplinary decision-making (using models from all-around - business, government, judges, parents) into curriculums through issue, theme or problem based seminars, debates or courses.
- *Linking subjects through one skilled course leader who demonstrates integration potential and issues* by working resolutely across discipline, skill, and knowledge generation boundaries.
- *Matrix assessment* – rewarding some students for synthesis, issue identification, argument and ideas, as much as others for data recall and interpretation – in the one assessment exercise.

Having facilitated interdisciplinary, integrative thinking and kept double-degree student interest, faculties might leverage returns to Science by changing 'the way things are done'. Some ideas:

- *Serious interdisciplinary honours, masters and doctorate pathways* – encouraging the advance of 'arguing' and 'testing' and integrative knowledge generation at discipline interfaces.
- *Science-based professional doctorates* – connected to workplaces and competitive incomes.
- *New doctorate and research fast-tracks* for double-degree graduates returning to their love of Science after a frantic period in the commercial world earning the funds to enable their research.

While the Honours-PhD-PostDoc path inspired and groomed scientists in the past it appears ill-aligned to today's brilliant, multiple capacity, young super-integrators. Their influences are global, industrial, social, community and economic, and they mix all these into their 'scientific frontiers'.

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