Central University of Technology

Teaching & Learning Conference 13-14 June 2016

The innovative use of a problem-solving research model to support academic work

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Abstract:

The challenges in 21st century Higher Education and managerialist initiatives to drive performance and throughput have place increasing pressure on staff to fulfil contradictory roles. This has led to significant levels of stress and ill-health. The research, teaching and community engagement duties expected of staff suggest constant paradigm-shifting, as these functions represent very different kinds of activities. Balancing these functions is comparable to multidisciplinary problem solving, which – literature and industry tell us – our students are increasingly less capable of demonstrating. Recent research into how graduates navigate between multiple disciplines in engineering problem-solving offers a number of findings which can be applied to the work of academic staff. Using a novel problem-solving model based on Legitimation Code Theory, this presentation is both a research-informed and practical guide to not only understanding our conflicting roles, but also easing the burden of academic work through the effective and innovative use of technologies.

Key words: Academic stress; multidisciplinary problem solving; Legitimation Code Theory; technology-enhanced work.

Introduction

Higher Education (HE) is in a state of flux, not only in South Africa (SA). Globally, nationally and locally, we are seeing increasing calls for ‘transformation’, for responsiveness to 21st century realities. This has meant – among many other things -- the restructuring and alignment of qualification frameworks, and the interrogation of what kind of graduates we need to produce, given the impact of globalisation and rapid technological developments. As HE practitioners, never have we had to juggle more balls! We are required to teach classes that get bigger and more diverse every year. We need to design or deliver curricula that are bulging at the seams as we try to bridge the articulation gap by 'stretching' backwards *and* make those curricula more relevant by 'weaving' forwards (Shay, Wolff & Clarence-Fincham, 2016), to face the world of work and increasingly complex societies. We are expected – like our students – to engage in lifelong learning, by increasing our own qualification levels, by conducting meaningful research and 'producing outputs'. These responsibilities mean engaging with various communities of practice, not the least of which is the very community in which our institutions are located. We are called on to reach out and engage with those around us, so as to contribute to socio-economic transformation.

Recent research on wellness in HE academics indicates 'alarming symptoms of burnout' (Bezuidenhout & Cilliers, 2010). Many of us here – I am sure – have felt or are feeling the effects of the stress. Maybe we are beginning to 'drop the ball'? What I would like to do today is to share with you a view of all those 'balls' we are juggling that can change the way we work. In talking about the diverse roles of HE institutions, Badat refers to the view of "teaching and learning, research and community engagement as related and intersecting activities". I would like to take that a step further and suggest that each of these functions can contribute to the others.

I am going to be doing three things: Firstly, we are going to take a brief look at HE in 21st century SA; secondly, I am going to give you an overview of my own PhD research on problem solving, and then demonstrate how the principles of the research are enacted in my daily work and supported by the effective use of a number of very practical tools!

HE in 21st century South Africa

I wonder how many of us sit in those endless departmental or faculty meetings thinking: ‘This is such a waste of my time – I have papers to mark, a class to prepare for, a proposal to write’. Just as many of us are engaged in redesigning ‘curricula that are appropriate to a supercomplex world’ (Barnett R. , 2000, p. 262) – as Barnett calls it – so too our institutions are battling to balance their own ‘super’ complexities. Badat describes the purpose of universities as the ‘production of knowledge’, its dissemination, the cultivation of the cognitive character of students, and to play a role in our communities (2009). So, we have duties with respect to the ‘knowledge, practices and values’ of the programmes in which we work, of our students, of our communities, and of our own development. These *epistemological*, *ontological* and *praxis* dimensions (*ibid.*: 258) of our work are very different in those different spaces. The knowledge in the subject I teach is totally different from the knowledge in my administrative role, or the knowledge required in a particular community project. So too the practices differ considerably. The rigour of doing a scientific experiment is not the same as opening up a space for creative community discussion. Manuel Castells (2001) tells us that:

> *Universities are subject to “the conflicts and contradictions of society” and need to be “solid and dynamic enough to stand the tensions that will necessarily trigger the simultaneous performance of somewhat contradictory functions.*

In our attempts to balance these contradictory functions, and in the face of consistent challenges with throughput, attrition and retention, our institutions have resorted to increasingly ‘managerialist’ approaches to managing what it is we do (Ntshoe, 2004). This is a form of top-down management. Now, while these approaches – drawn from the private sector - may be intended to guide or ‘quality assure’ practices in the sector (Teelken, 2012), I am sure that everyone in this room has experienced that sinking feeling when yet another checklist or audit-type document has popped into your inbox. They represent yet another ‘duty’ in our already full workloads – the first of four occupational stressors among SA academics. We often feel these processes rob us of the little time we have to do meaningful work, and it is no wonder that we just ‘tick the boxes’ to keep someone ‘up there’ happy. Another key contributor to occupational stress among SA academics is ‘job control’ (Barkhuizen & Rothman, 2008), in addition to lack of resources, poor communication systems, and the actual characteristics of our jobs.

And yet, ironically, we are still expected to be ‘innovative’. Let’s just take a look at innovation. One of my mentors on my PG journey, Dr Keith Jacobs, looked at what it took for engineering enterprises to be innovative and to develop viable new products in SA. At the heart of his model is the ‘innovation engine’, and for this to exist, staff need to be empowered, they need to be trusted to have responsibility, they need to work in an organisation that is flexible, adaptable and with open communication channels (Jacobs, 2010). Working under such conditions boosts morale and improves productivity and creativity. The low morale and state of staff health at many of our institutions (Bezuidenhout & Cilliers, 2010) suggests that the conditions required for innovation and success simply do not exist. I would hazard a guess that my colleagues here feel they are constantly walking a tightrope between conflicting paradigms. What seems to be missing in our contradictory roles is “a guiding conceptual framework” (Mthembu, Orkin & Gering, 2012) which your own Vice Chancellor alludes to in his collaborative paper on the Strategic Transformation of Education Programmes at CUT.

The good news is that this is exactly what we expect of our students – this balancing act. This is the nature of balancing different kinds of knowledge, practices and values that characterise their lives as students preparing for legitimate socioeconomic participation. But that does not make it any easier to accomplish. So I am going to take you on a research detour to demonstrate what such a 'balancing act' looks like in real world engineering practice.

Engineering problem-solving research

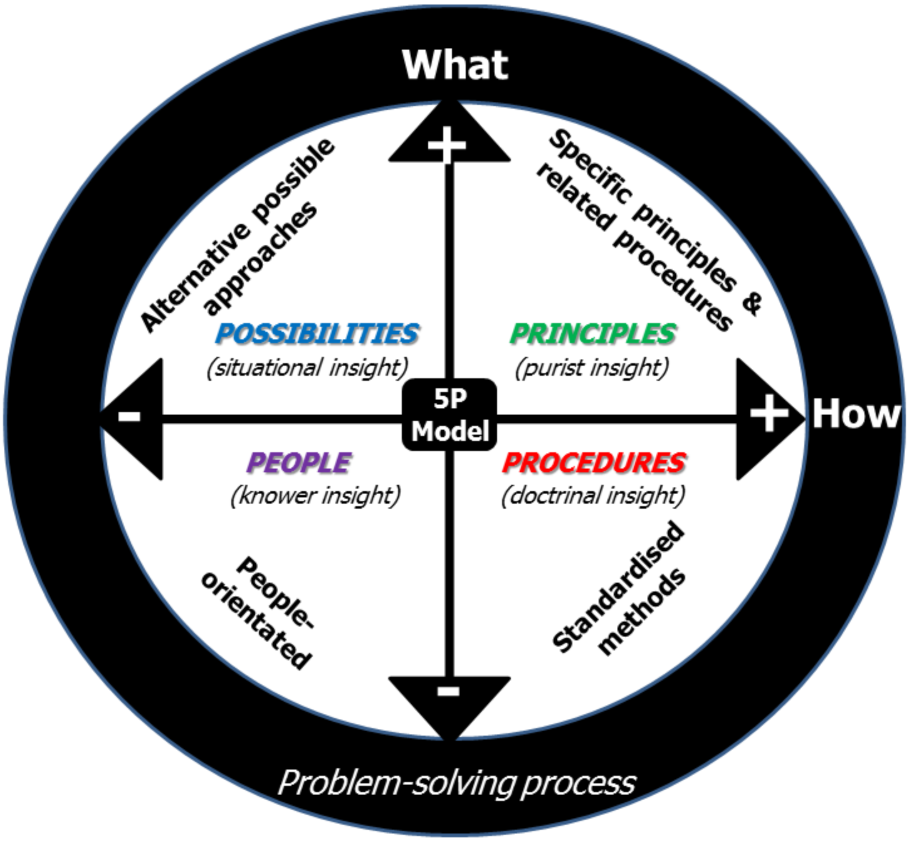
The impetus for my research was the observation that UoT engineering students struggle to bridge the theory-practice divide, and that this is particularly evident in the design or project subjects, and even more acute when they are trainees in industry. As a WIL coordinator at the time, I kept hearing industry partners talking about students not 'knowing the principles' and 'not being hands-on'. The original contention in my research was that we do not fully understand the complexity of a 'problem-solving situation' in the 21^{st} century, particularly in the face of dynamic and evolving technologies in relation to a relatively stable body of science-based knowledge. So, I set out to look at how engineering practitioners apply the different engineering disciplines in a real world problem in different industrial contexts. The aim was to understand what this 'disciplinary navigation' looked like so that we are able to look back at the curriculum (and our teaching) and shape it more appropriately for the 21st century.

The research is theoretically located in the sociology of education, and draws on the work of two key social realists: Basil Bernstein and Karl Maton's Legitimation Code Theory. I looked at the relationship between the different core disciplines underpinning multidisciplinary engineering – their different knowledge structures or organising principles, the fact that on their own, these disciplines require different ways of thinking - and what this means when they come together in a problem-solving moment.

Let us just take a look at some aspects of these ‘organising principles’. The engineering region at the heart of this research is mechatronics engineering – which is the computer control of electromechanical systems, the kind of engineering you find in manufacturing. Its core disciplines are physics, mathematics and logic. I have arranged the key elements of a mechatronics curriculum as a Venn diagram to demonstrate the disciplinary spread. In Bernsteinian terms, here on the right we have the traditional physics-based engineering regions – mechanical & electrical. These regions are underpinned by physics - what Bernstein terms a hierarchical knowledge structure - we have specific concepts, strongly sequenced, that absorb lower concepts. Ohm’sLaw is an example, or force. In the centre, and applying across the spectrum is Mathematics - a strong ‘horizontal’ knowledge structure. This simply means there are different mathematical languages which you could apply to the same phenomenon. Each language has strong concepts or rules that are not necessarily applicable to a different mathematical language. The upper left regions are underpinned by Logic – the disciplinary basis of programming and control systems. This is a ‘weak’ horizontal structure – weak meaning there are choices that are context dependent. Like languages themselves, or social science. In other words, the phenomenon itself does not dictate the knowledge form – in the way that motion is governed by Newton’s Laws or voltage is governed by Ohm’s Law. These kinds of knowledge are weak in that they borrow concepts and rules across families of the same type; they’re constantly changing; things become redundant. Each of these structural knowledge types requires an entirely different way of thinking, they represent a different kind of ‘code’. We tend to teach them in ‘silos’. But the question is: how do engineering practitioners work with such different forms of knowledge at the same time?

The analytical tool used to look at the problem solving moment comes from one of the LCT dimensions - ‘Specialisation’: specifically, the concept of epistemic relations – this is about the *what* and *how* of knowledge. The vertical-axis is about the phenomenon in question –

how strongly it is bounded by recognisable and ‘legitimate’ principles. The horizontal-axis is about ways of approaching the phenomenon. The stronger the rules, the stronger the so-called ‘discursive’ relations.



A modified and annotated schematic based on the epistemic plane (Maton, 2014, p. 177)

The epistemic plane gives us four ‘codes’ – four ways of thinking. The top right is purist – recognised principles and associated procedures, precisely like Ohm’s Law – it does not matter what language you speak or where you live, the principle of the relationship between current, voltage and resistance is consensually accepted. The bottom right is recognised methodologies – it does not matter what the phenomenon is (this is like following a formula – the structure of an experiment, applying lean manufacturing rules, maths, economics). The top left is called situational insight – there are many possibilities for addressing the same, strongly bounded phenomenon (choosing a new cell phone, for example). What I want it to do is fixed, but how I do it is variable. The lower left quadrant is where there isn’t a strongly bounded phenomenon or any fixed ways to do things – this could either be because we are now focused not on knowledge but on knowers (where other things count) or because there is no legitimate or recognisable practice.

Each knowledge structure and each insight represents a kind of 'code', a way of thinking. Each 'code' or 'insight' is significantly different. Now, how did I use this in my research? Very briefly, I had 50 volunteers working as mechatronics technicians or technologists in three different types of automation environments. They completed a questionnaire describing context, the most recent problem faced, and a technical description of how they solved the problem. I then selected 18 of 27 responses and conducted a re-enactment interview. This meant they took me through the problem with the actual artefacts. The third phase involved getting their supervisors and my industry experts to verify my analysis.

I used the epistemic plane to 'map' their approach to and analysis of the problem and the subsequent synthesis of a solution. In other words, I tried to 'surface' the disciplinary basis of their problem-solving process. I am going to share a few key findings with you (Wolff, 2015):

- The scale of the environment, for example, dictated a preferred insight (way of thinking). The larger the company, the more doctrinal the insight.
- The more holistic problem-solvers in the different environments displayed an anomalous high achievement in both Maths and the Logic-based subjects.
- Each of the environmental types revealed a different PS process pattern.
- In all cases, there was a multi-layered cause-effect relationship between the disciplines in the actual problem structure in relation to a particular context.

What emerges from the research is that successful problem-solvers recognise the different disciplines and aspects of the problem, and use explicit code shifting techniques. The technical language they use changes depending on the context – whether it is for a report, or verbal update to their managers or a discussion between colleagues on a production line, for example. These successful problem-solvers appear to take a 'macro' view – taking into account the people, situation, principles and procedures of each aspect of the problem. This means that for every problem-solving situation, there are too many contextual variables for us to prepare our students. I do suggest in the research that we need to enable two things in our teaching: the recognition that the differences between disciplines are essential – they mean different ways of thinking; secondly, we need to enable a more conceptual grasp of the reality and principles of different practice contexts. We cannot hope to mimic or simulate all the possibilities our students will encounter.

Now, what does this mean for us as academics in our conflicting paradigms and contradictory roles? Bernstein talks about the 'relational idea', a golden thread, as it were, visible to all in the field, and requiring relations across disciplinary areas. This 'relational idea' is what underpins a 'guiding conceptual framework'.

Academic role code shifting

Let us look at how we can use this guiding conceptual framework in our work – how it can help to shape our own code-shifting practices between our different roles. Each of our roles (teaching & learning, research and community engagement) is underpinned by different principles, procedures, people and possibilities. But first and foremost, there is one overarching principle: all of these take time. I have seen far too many academics drowning because of a lack of consciousness about time itself, how much is needed for what, when, where and how. The first step is to realistically allocate time to absolutely everything you need to do: Classes you teach, material preparation, consultation, departmental meetings, research time, personal obligations. We all have access to an electronic calendar – and it is a valuable resource which too many of us waste. The two benefits of allocating time to specific types of work are 1) these are like 'appointments with yourself' during which that particular task is all you need to worry about – in other words, it helps you focus and not worry about the chaotic imaginary or notebook 'to do list'; and 2) it helps you identify what you do not have enough time for. When you have populated an entire month, and semester, and you then see you have still not allocated a realistic period for 'that paper' or seminar, you need to question your priorities or others' expectations.

Teaching & Learning

I am going to apply the model to one example from each of the core roles. Let's start with teaching and learning. If we used the 5P model to examine our T&L contexts, we might identify key elements of each aspect as follows:

Table 1 Epistemic Plane applied to Teaching & Learning

Aspect	**Principles**	**Procedures**	**People**	**Possibilities**
Features/ **Problem (constraint)**	• Conceptions of learning • Disciplinary basis • Curriculum coherence • **Student engagement**	• **Timetable** • Assessment • Materials • Reporting	• Students (level) • Colleagues • **Tutors** • Mentors • Management	• **Class size** • Venue • Tutorials • Practicals • Resources
Possible Affordance			*Students as peer mentors*	*Additional resources*

Here is one scenario: the class is large, and curriculum is packed. There is not enough time to enable the kind of deep learning you wish to encourage. Students do not have time to ask questions, and when you do make time, they do not engage. But you may be overlooking a key resource: your students themselves. What about getting them to do some of your work? Help each other, answer questions, explain concepts, clarify procedures? One way to do this is to set up a group for your subject – some lecturers use WhatsApp, others use Google Groups. Here's an example of real student engagement in a group forum where they are not afraid of asking for help or being judged for language. Setting up a group like this is easy – all it takes is asking the class for a volunteer to set it up. Trust me, there is nothing more empowering for a student than to be in a position to help someone else. And this is the first step towards building a community of practice.

Community Engagement

Let us take a look at our second role: Community Engagement. Everything we do is located within a community. If that 'community' has a shared purpose and there are defined deliverables, then it is more than likely that we are busy with 'community engagement' – despite the narrow way in which many of our institutions prefer to refer to this activity. One of the key challenges here is time – finding the time to get all the stakeholders together – and then when you have managed that, there is the question of information sharing. The number of emails that go back and forth trying to align people's schedules or circulate information can be debilitating. Using the same principle with the 5P model one can identify the need for more effective information sharing that people can manage in their own time. Using a shared resource platform – such as a website with access to shared folders – not only effectively distributes information, but becomes a central repository for purposes of accountability.

Table 2 Epistemic Plane applied to Community Engagement

Aspect	**Principles**	**Procedures**	**People**	**Possibilities**
Features/ **Problem (constraint)**	• 'Community purpose' • Research • Deliverables • **Accountability**	• Meetings • **Information** • Reporting	• **Colleagues** • **External stakeholders** • **Students (UG/PG)** • **Management**	• Formal/ informal • **Time** • Resources
Possible Affordance			*Shared accountability*	*Shared resources*

And now to move on to my particular favourite – Research – because it was in this role that I discovered the wealth of tools available to make my life a little easier.

Research

Given our collective ‘lifelong-learning’ ethic – whether we like it or not, we are always learning – ‘research moments’ are always present, if we want to improve our teaching, our communities, our lives. We are going to focus for today on formal research. Again, we take our tool to unpack the features we want to consider:

Table 3 Epistemic Plane applied to Research

Aspect	**Principles**	**Procedures**	**People**	**Possibilities**
Features/ **Problem (constraint)**	• **Research focus** • Methodology • Deliverables • Ethics	• Proposal • **Literature Review** • Data collection • Data analysis • Writing	• **Other researchers** • Participants • Supervisor • Family • Management	• Research time • **Research tools** • Resources • Support
Possible Affordance			*Online accessibility*	*Using a search engine productively*

There are so many possibilities when conducting research, and although we seem to have such standard methodologies, I have seen post-graduate students really struggling with accessing appropriate literature and navigating their online library systems – particularly when they are researching off campus and the network is down.

One secret weapon is indeed Google Scholar. You can use Google Scholar to locate just about every article or text ever written on the various aspects of your research question, and simply add these to your online ‘library’. This is excellent for a 1st phase literature review search! As you refine your search terms, you can create an ‘alert’ so that you are alerted to every article written or uploaded to the internet. And these alerts are sent straight to your inbox for when you have time to review them. Articles that you find useful can be downloaded – preferably with a standardised file-naming system so that you can keep track of your literature. I used an online spreadsheet system when I initially started reading, to make notes and colour code key themes. What is really useful about using such online systems is that you can share them with your supervisors and even refer to them collectively during remote supervision discussions!

Concluding remarks

The aim of this talk is not to 'sell' Google – there are many alternatives. The point is that by applying the very conceptual framework from my research to my own life and activities, I found I had an organising framework that helped to alleviate the constant stress of feeling that I had no control over my work, that there was simply too much to do. By setting aside specific blocks of time for specific activities and identifying the key elements – the principles, procedures, people and possibilities – implied in each activity, I could shift my thinking appropriately and remain focussed. Reading the literature for your study, or meeting with a particular community, or marking assessments are fundamentally different kinds of activities requiring different approaches, tools and forms of literacy. When we become more conscious of these differences and navigate between them productively, then we open up the space for innovation, the space to truly make a difference to the world in which we live.

References

Badat, S., (2009) *The role of Higher Education in society: valuing Higher Education*. Keynote address HERS-SA, GSB, University of Cape Town

Barnett, R. (2000). Supercomplexity and curriculum. *Studies in Higher Education, 25*(3).

Barkhuizen, E. N. (2005). *Work wellness of academic staff in South African higher education institutions* (Doctoral dissertation, North-West University).

Barkhuizen, N., & Rothmann, S. (2008). Occupational stress of academic staff in South African higher education institutions. *South African Journal of Psychology*, *38*(2), 321-336.

Bernstein, B., 1975. *Class, codes & control.* London: Routledge.

Bernstein, B., 2000. *Pedagogy, symbolic control and identity: Theory, research, critique, rev. edn.*. London: Rowman & Littlefield.

Bezuidenhout, A., & Cilliers, F. V. (2010). Burnout, work engagement and sense of coherence in female academics in higher-education institutions in South Africa. *SA Journal of Industrial Psychology*, *36*(1), 10-pages.

Castells, M. (2001) 'Universities as Dynamic Systems of Contradictory Functions', in Müller, J., Cloete, N, & Badat, S. (eds.) *Challenges of Globalisation: South African Debates with Manuel Castells*. Cape Town: Maskew Miller Longman

Jacobs, K.I., (2010) *A new product development practices model for small and medium engineering enterprises* (Unpublished doctoral thesis). University of Cape Town

Jarvis, D. S. (2014). Regulating higher education: Quality assurance and neo-liberal managerialism in higher education—A critical introduction. *Policy and Society*, *33*(3), 155-166.

Maton, K., 2014. *Knowledge and Knowers: Towards a realist sociology of education.* London and New York: Routledge.

Mthembu, T. Z., Orkin, M., & Gering, M. (2012). Towards distinctive and developmental curricula at UoT's: The STEPS process at CUT. *South African Journal of Higher Education*, *26*(2), 214-231.

Ntshoe, I. M. (2004). Higher education and training policy and practice in South Africa: impacts of global privatisation, quasi-marketisation and new managerialism. *International Journal of Educational Development*, *24*(2), 137-154

Shay, S., Wolff, K., & Clarence-Fincham, J. (2016). Curriculum reform in South Africa: more time for what? *Critical Studies in Teaching & Learning, 4*(1), 74-88. doi:10.14426/cristal.v4i1.61

Teelken, C. (2012). Compliance or pragmatism: how do academics deal with managerialism in higher education? A comparative study in three countries.*Studies in Higher Education*, *37*(3), 271-290.

Wolff, K. (2015). Insights into conceptual and contextual engineering problem-solving practices in the 21st century: some implications for curriculum redesign. *Proceedings of the 3rd Biennial Conference of the South African Society for Engineering Education* (pp. 189-198). Durban: SASEE.