

## THE VALUING OF CREATIVITY IN THE WORKPLACE ROLES OF ENGINEERING RESEARCH GRADUATES

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**Abstract:** This paper reports on a study that explored the beliefs of twenty-two industry-based employers of Mechanical and Chemical Engineering Higher Degree Research (EHDR) graduates about the value of these graduates to the engineering workplace. Once the commonly known generic employability attributes were set aside, the findings revealed that creativity was an essential factor in employers' decisions to accommodate these graduates. The employers' comments suggested that they valued knowledge and creative problem-solving skills gained in HDR candidature but feared that EHDR graduates would display attributes popularly associated with creative genius, and this concern reduced their willingness to accommodate these graduates. This highlights the value of creative skills and attributes, the hallmarks of HDR activity, to the overall employability of EHDR graduates in innovative enterprises, but reveals a barrier to industry engagement that is based on myth.

*Keywords; Doctoral education, employability, graduate attributes, creativity.*

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### 1. INTRODUCTION

Higher degree by research (HDR) qualified engineers are rare in Australia, with 2.6% of the engineering workforce qualified at the engineering doctorate level (Engineers Australia 2008). However, 24% of all doctoral graduates stated that they were employed in engineering-related industries (Neumann et al., 2007). Despite their industry destinations, Engineering HDR graduates have been commonly painted by employers as poorly prepared for industry work, lacking key professional capabilities including teamwork, communication, managerial, time management and problem-solving skills (Akay, 2008; Mann et al., 1994; Tyler, 1998).

The present study looked beyond employer demands for generic professional skills to explore the beliefs and experiences of employers who have successfully engaged EHDR graduates. Creativity was found to be a valued employability attribute, yet one that the employers feared.

*1.1 Creativity at work*

Creativity is manifest as a quality of a person, product, and cognitive process. It is evident in the achievement, by the use of creative cognitive processes, of an original product, process or idea that is fit for purpose (Amabile, 1983; Torrance, 1988; Woodman et al., 1993). Amabile (1983) defined the notion of originality as both the outcome and the process by which it is achieved: ‘A product or response will be judged as creative to the extent that (a) it is both a novel and appropriate, useful, correct or valuable response to the task at hand, and (b) the task is heuristic rather than algorithmic’ (Amabile, 1983, p. 33). Innovation is defined as ‘the successful implementation of creative ideas within an organisation’ (Amabile et al., 1993; Amabile et al., 1996), including the implementation of creative ideas generated elsewhere (Amabile et al., 1996; Woodman et al. 1993).

Amabile (1983) presented a model for the production of creative outcomes that integrates three essential components. Domain-relevant skills form the pool of knowledge a person draws upon when undertaking a problem-solving task; in the case of EHDR graduates these are the engineering knowledge and skills honed in HDR candidature. Knowledge of this type is frequently unrecognised as essential to creative outcomes (Woodman et al., 1993). Creativity-relevant skills form the thinking processes that control decisions about the way the search unfolds. Task motivation consists of the interests and drive a person has to persevere in a task. Figure 1 lists the elements of each component and the variables on which each element is dependent.

<b>Domain-relevant skills</b>	<b>Creativity-relevant skills</b>	<b>Task Motivation</b>
<u>Includes:</u> <ul style="list-style-type: none"> <li>• Knowledge about the domain</li> <li>• Technical skills required</li> <li>• Special domain-relevant “talent”</li> </ul>	<u>Includes:</u> <ul style="list-style-type: none"> <li>• Appropriate cognitive style</li> <li>• Implicit or explicit knowledge of heuristics for generating novel ideas</li> <li>• Conducive work style</li> </ul>	<u>Includes:</u> <ul style="list-style-type: none"> <li>• Attitudes toward the task</li> <li>• Perceptions of own motivation for undertaking the task</li> </ul>
<u>Depends on:</u> <ul style="list-style-type: none"> <li>• Innate cognitive abilities</li> <li>• Innate perceptual and motor skills</li> <li>• Formal and informal education</li> </ul>	<u>Depends on:</u> <ul style="list-style-type: none"> <li>• Training</li> <li>• Experience in idea generation</li> <li>• Personality characteristics</li> </ul>	<u>Depends on:</u> <ul style="list-style-type: none"> <li>• Initial level of intrinsic motivation toward the task</li> <li>• Presence or absence of salient extrinsic constraints in the social environment</li> <li>• Individual ability to cognitively minimize extrinsic constraints</li> </ul>

**Figure 1: Components of creative performance** (Amabile 1983, p. 68)

*1.2 Notions about the creative individual*

The notion persists that creativity is a flash of insight or special, mysterious, irrational and difficult to manage quality (Becker, 1992; Rickards, 1999). At its extreme, this view of creativity was explained as a form of divine mania or as a psychopathological state.

Biographical studies into the lives and mental states of eminent creative geniuses, usually artists and writers, revealed problematic personal attributes such as eccentricity, isolationism, obsession, and madness that still form a popular stereotype of the highly creative genius.

Since the 1950s, research both moved away from biographical study and focused on the correlates of scientific creativity, which were identified as broad interests, attraction to complexity, high energy, independence of judgement, autonomy, intuition, self-confidence, persistence, curiosity, intellectual honesty, and an internal locus of control (Woodman et al., 1993), and openness and flexibility, arrogance and hostility (Feist, 1999). No empirical evidence supports a hypothesis that personality characteristics are predictors of creativity, and according to Feist (1999), only openness and flexibility are strongly associated with scientific creativity.

As well as extensive domain knowledge, the cognitive factors associated with the creative process (Woodman et al., 1993) include the capability

- to generate many and varied ideas, combined with divergent thinking to generate fluent, flexible, original and elaborated ideas by transforming knowledge and re-envisioning situations;
- for convergent thinking to produce not only original, but useful and appropriate outcomes;
- to tolerate ambiguity so that the creative person is not tempted to resort to conventional, and previously unsuccessful, patterns in frustrating problem-solving situations.

## 2. THE STUDY

The views of twenty-two industry employers of Mechanical and Chemical Engineering research Masters and PhD graduates in two Australian cities were explored using Grounded Theory methodology (Glaser and Strauss, 1967). Interview participants covered a broad range of roles in organisations ranging in size from 25 employees to several thousand and engaged in a variety of principal activities. The following six questions were used as prompts to discussion:

- Why do you decide to employ a postgraduate engineer for some positions? (What sorts of positions require postgraduate education and training?)
- What attributes do you believe postgraduate engineers should bring to a position?
- What attributes do you believe postgraduate engineers actually do bring to a position?
- Are you ever surprised by what a postgraduate is or is not able to do?
- If you had the opportunity to provide feedback to a university about their postgraduates' abilities, what would you say?
- If you had the opportunity to provide feedback to postgraduate candidates about their value to employers, what would you say?

Participants were encouraged to comment, from their experiences, on anything they believed relevant to the topic. This paper presents interesting observations made from the interview data.

### 2.1 *Innovator role types*

The roles the employers believed suitable for EHDR graduates in their organisations were distinguished by the degree of originality required in their performance outcomes (Table 1), ranging from the innovative adaptation of existing, imported products or processes (innovative adapter role) to the envisioning of potential future developments with no possibility for

immediate implementation (visionary innovator role). An intermediate role, niche innovator, required an original outcome but employers of these engineers emphasised the need for constraint imposed by limited availability of resources (Adams et al., 2008). Niche innovators typically worked in manufacturing and consulting engineering firms.

**Table 1: Key advanced engineering innovator role types, their purposes and tasks, ranging from least creative (innovative adaptor) to most creative (visionary innovator)**

Increasing demand for originality in innovative process and outcome	Innovator type	Purpose	Engineering HDR graduate tasks
	Innovative adapters	To maintain product or service relevance	Search for, identify, assess and adapt readymade products
	Niche innovators	May include the above, plus... To provide competitive advantage in the marketplace	Devise and develop new to world products or processes Adapt and maintain new products
	Visionary innovators	Some or all of above, plus... To predict future scenarios and anticipate developments	Some or all of above, plus... Anticipate future development scenarios Build knowledge base for potential future developments

### 2.2 The value of knowledge and creativity skills

The employers entertained two notions of creativity in parallel. Firstly, much as modelled by Amabile (1983), they identified the value of EHDR graduates' domain and creativity-relevant skills to production of original outcomes. Secondly, they associated EHDR graduates' creativity with personal characteristics popularly linked to creative genius. The quotes below are a sample of many comments made by the employers associating EHDR graduates with domain-relevant and creativity skills.

The ability to generate many and varied ideas and use extensive domain knowledge was important to problem-solving:

*Specialists are thinkers ... in the areas of scenario planning ... helping management to think hard and you know, sort of put plans in place for contingencies or issues or a resource drying up for example. [...] bringing a lot of research based knowledge of what has been done before. (Emp 9C)*

*And I know they have the skills and power to drill into those problems more so than others, and solve it. [A PhD employee] because he's had research experience, his maths skills are honed to a greater detail and his use of a particular software or software types was actually more honed. [...] he can think outside the square and think about the broader issues. (17)*

They valued EHDR graduates' creative skills of divergent thinking and tolerance of ambiguity:

*A lot of the time you do need to think a little bit left of field and maybe try for a while and it doesn't work out, ..., you might learn something else in the process. ... it's not really a clear science, there's a lot of theory of how to get something ... but getting something that works most effectively, it's a little bit of a black art... You've got to be able to think a little bit laterally. (3)*

Creative skills in problem formation and re-envisioning were acknowledged, including an ability to move beyond conventional engineering approaches:

*But certainly in attitude it was preparedness to attack problems that they'd not seen before, cause most of the problems we were dealing with we hadn't seen before. Willingness to learn, an open-minded approach, ability*

*to think, preparedness to think. We didn't want someone whose views were 'this is the only way to do something'. (8)*

They sought EHDR graduates who were able to think heuristically and achieve original outcomes:

*I suppose novel means in that sense thinking outside the box. ... What we're talking about is coming up with a novel idea or a different approach to a problem which is not the norm and that's different. (19)*

EHDR graduates were viewed as able to transfer deep knowledge from one problem-solving area to another, and had confidence (task motivation) to think differently from traditional engineering problem-solving approaches:

*I think he [EHDR graduate] got that through that experience doing post graduate work. So you don't have the time when you're doing normal engineering as a graduate employee to develop a broad enough perspective to be able to take the knowledge in one field and being able to flop it across to another...and also to be able to dig down deeper' (Emp 2A).*

Some employers also recognised Amabile's third component of creative performance: task motivation displayed in an intrinsic drive to discovery. This is evidenced in the following character descriptions of attitude to problem-solving activity:

*a postgraduate degree program, has shown that he or she can exhibit the sort of skills and attributes that we're looking for, which includes primarily a rampant curiosity and an ability to go where others haven't gone...(10D)*

### *2.3 Fear of misfits*

Despite their recognition that EHDR graduates possess education, knowledge and skills of use in the abovementioned roles, all the employers harboured reservations about EHDR graduates' personal suitability for their workplaces. They provided many comments about the personal characteristics of graduates that revealed understandings and opinions about Engineering HDR candidates, the HDR experience and academia that suggest the employers entertained popular notions of stereotypical creative genius.

While some employers viewed EHDR graduates as systematic and procedural, others viewed them as obsessed, driven and unusual, with allusions to madness:

*... a 'mad professor', you know – a little bit autistic... Tendencies to zoom in on things in great detail – perhaps put the blinkers on and drill into a problem. [...] And that mad professor part comes from getting too caught up in a particular topic, and to the detriment of everything else.*

The persistence and determination needed to pursue isolated study on a narrow topic served as evidence that HDR graduates were driven by perfectionism ('Rolls Royce solution', Emp 5A) and self-interest. Furthermore, the image of a solitary research student, colourfully described by one employer as 'sitting in a back room somewhere for five years under a 40 watt light bulb' (Emp 18E), was feared as evidence of a non-collaborative approach in problem-solving and an attitude of secrecy and individual ownership of knowledge and problem solutions. These suspected characteristics underpinned the employers' concern that extended commitment to HDR study deprived an engineer of valuable work and life-enhancing experiences, particularly those that would engender workplace-relevant pro-social attitudes:

*...someone who is comfortable with staying in a laboratory for 4-5 years and perhaps, ... they're dealing with a relatively smaller number of people in a fairly protected academic environment... (7)*

Engineering researchers were characterised as quirky and self-absorbed, and unlike regular engineers:

*It seems to be viewed by the rest of the organisation with a deal of amusement, I guess, that they [researchers] are so focused on the academia and papers published and when they have any presentations or whatever they put letters after their names, whereas in the engineering field we tend not to. (22CHR)*

Employers suspected EHDR graduates are arrogant or egotistical:

*If they come in thinking I've got a PhD so everybody is going to listen to what I say, I think they've got a big surprise coming because sometimes a tradesperson has got more knowledge... but if they are just, you know because they are PhD's thinking 'Well I'm so good, people want to come and talk to me', I think people wouldn't bother. (9C)*

Their intelligence was also associated with egocentrism that impacted on co-workers, suggesting an image of the mad genius as social misfit:

*Because it is day to day stuff very often, it is day to day. And as a manager of people, which is my job, you know, if you have got two or three people who are sort of prima donnas and stuff like that, oh gee. And for such a marginal, they might be brilliant, by such a marginal improvement to the job that we do, to the distraction and the lack of everything else that goes with it. It is just not worth it. (15D)*

The social difficulties were partially hypothesised as a preference for ideas over people, and this was inferred as particularly problematic in consulting work:

*If you put them out of their comfort zone a little bit, they find in themselves that they may struggle and they think, 'I don't want to do it – not interested. I don't want to talk to clients; don't want to deal with them – they annoy me. I just want to do my work. I want to solve problems.' The relationship is all fluffy – they want to deal with the hard core engineering issues. (Emp 17)*

Exposure to the hard-driving, 'cutting-edge' real world of work was viewed as a socially maturing process, and EHDR graduates were viewed as potentially socially underdeveloped, and vulnerable people:

*For instance I did an interview yesterday where we interviewed a guy with a PhD and we determined that he was not fit for the project work. ... What I'm saying, what we, if you're going to put someone in that role, we wouldn't expect them to necessarily have it but we have to make a judgment about whether we think they would cope with it.[...] (Emp 4)*

The vulnerability of EHDR graduates was explained by their preference for and exposure to university life. Industry was seen as the 'real world' and engineering academics were seen as out of touch with not just industry, but society at large:

*Engineering is about, if you like, helping the community and to help the community, you've got to understand what the community needs and particularly if the people that are lecturing and providing guidance to the students have themselves not spent much time in industry [voice pause]; I know that [organization] has been trying to get a situation where academics have a certain mandated number of hours of industry time. (Emp 4)*

Not only was the university environment seen as removed from real life, but the employers also suspected engineering academics of being refugees from the pressures and challenges of industry who fled to the relative safety of the academic environment:

*I think probably in chemical engineering most academics have got a small amount of industrial experience but equally I suspect most of that experience is not good for them or wasn't a good experience, which is why they return to academia. So I think the great majority would be biased against industry and would attempt to keep the students in academia. (Emp 8)*

In all, thirteen employers commented on the value of knowledge and creativity skills, and eighteen employers expressed concern about difficult personal and social attributes.

#### 2.4 Accommodating

Accommodating creativity refers to a willingness to accept, to some extent, difficult social attributes implicitly associated with creative people in order to gain the knowledge and skills that result in creative outcomes. If an employer seeks creative skills as a means to achieving novel outcomes, the employer is more likely to accommodate some perceived problematic social attributes. This willingness to accept such a person creates a tension in the employer's decision-making process, due to the perceived risk associated with an EHDR graduate who possesses difficult characteristics.

*So you know, if they have got the normal set of life interests, it is really great....But that is not to say that if someone came along and was absolutely brilliant and there were just a few little funnies about them, you might make, you would say, 'gee you know, they really are brilliant' and you could probably accommodate one or two unusualls per twenty-five....But you know, you wouldn't want a whole team of them...But you are really looking, sometimes you do get someone who is quite brilliant, who is a bit unusual and you say, 'well yeah, we will take a risk here' and it ends up that they are probably going to be okay. (15D)*

Employers who seek innovative adaptors do not require an engineer with the level of creativity to produce original outcomes. These employers viewed EHDR graduates as creative, as defined by Amabile (1983), and many associated creativity with undesirable personal characteristics. It would seem likely, therefore, that these employers would be less inclined to engage an EHDR graduate, and that an EHDR qualification would hinder a graduate's chances of employment.

#### 2.5 Employers' suggestions for solution

Suggestions for improving the employability of EHDR graduates in industry focused on the benefits of increased industry contact and influence on the HDR candidate:

- Pre-candidature industry work experience
- Shared academic/industry supervision
- Industry relevant research topics
- Joint university/industry projects
- Industry-based professional development for engineering academics

These suggestions are not new, nor do they adequately address concerns. For example, despite the anticipation that university-government-industry linked Cooperative Research Centres (CRCs) would enhance industry readiness of PhD graduates in Australia (Harman, 2004), a recent comparison of employability outcomes of PhD graduates in CRCs found remarkably few differences in post-candidature employment success between CRC and non-CRC graduates (Pitt et al. 2009). None of the employers' suggestions in the current study directly addressed their concerns about perceived troublesome personal characteristics of EHDR graduates, and thus ignored 'the elephant in the room' they revealed during their discussion about EHDR graduates' employability.

### 3. DISCUSSION

Employers clearly value the knowledge and creativity skills gained in engineering research training, but their willingness to engage graduates in industry work is coloured by concerns about personal characteristics that appear to reflect outmoded notions of the creative genius. It was not an assumption of this study that the aim of the research education process is to prepare

workers for industry. Nevertheless, many EHDR graduates are interested in pursuing industry-based work, and the knowledge that employers maintain prejudices about personal characteristics of EHDR graduates should concern the engineering profession both within and beyond the academic environment. Along with efforts to promote generic employability attributes in EHDR graduates, this study suggests the need to actively promote an image to the larger community of creative engineering research training that dispels the myths of boffinism and mad genius.

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