REVIEW OF AUSTRALIA'S RESEARCH TRAINING SYSTEM – CONSULTATION RESPONSE FORM

Please read the submission guidelines before completing and submitting this form. This form should be submitted through the consultation website. **Submissions should be evidence based, provide examples where possible, and address the consultation questions.**

YOUR DETAILS

Name	Professor Moses Tadé
Organisation	Australian Council of Engineering Deans (ACED)
Level in organisation at which submission has been authorised	President
Contact email	M.O.Tade@curtin.edu.au

EXECUTIVE SUMMARY

Please provide an executive summary of no more than 300 words of your submission

In Engineering, effective researchers need technical knowledge, analytical and practical skills for complex problem solving, initiative and creativity, independence matched with team skills, and communication ability. To succeed in a wide range of careers, HDR students and graduates need to develop leadership, project management and liaison skills, and be able to work effectively with other disciplines. Broader capabilities include networking, vision, business and professional skills, as well as the ability to deal with high degrees of complexity.

Engineering researchers contribute to Australia's prosperity and well-being through discipline-specific knowledge, transferable knowledge, generic skills and personal skills. Our research outputs are internationally competitive. These can be maintained by appropriate relevance and increased research funding. The value of our research-trained engineers will be enhanced by stronger and more flexible engagement with employers, and better-developed career pathways. Noting that relatively few of each year's 7,000 Australian engineering graduates from Bachelor (Honours) and Masters degrees progress to HDR candidature, the number of HDR scholarships for Australians in engineering should be increased. This will ensure that more Australian engineering research that is funded through government grants and industry is retained in Australia.

The Research Training Scheme, as it applies to Engineers, could be improved by funding students to enrol in courses in technical and non-technical areas. The former would enhance their technical research work; the latter, in areas such as innovation management and business processes, would enhance PhD graduates' career prospects. The overall funding duration of the post-AQF8 research candidature should be four years to maintain academic excellence. Scholarship funding should also allow for every candidate to spend at least one semester in an international laboratory.

RESPONSES TO CONSULTATION QUESTIONS

PRODUCING HIGH QUALITY RESEARCHERS

Question 1 - What are the research skills and experiences needed to be an effective researcher?

KNOWLEDGE. Fundamental knowledge of mathematics, natural and physical science, engineering science and computing relevant to the discipline. Specialised and advanced knowledge in the discipline. Awareness of relevant areas outside the discipline, understanding of research methods, knowledge of relevant contexts, including world and political events and the major challenges for prosperity, healthy living, security and safety.

ANALYTICAL SKILLS. Critical thinking. Mathematical skills. Programming skills. Statistical competency. Problem formulation.

PRACTICAL SKILLS. Experimental design in the research area. Ability to search and review relevant literature. Structured problem-solving. Project design and management skills.

INDEPENDENCE. An independent thinker. An enquiring mind. Ability to work independently. Ability to work systematically, thoroughly and punctually. Ability to see the gaps in current knowledge.

INITIATIVE. Driven. Proactive. A high level of initiative and preparedness to investigate problems unfamiliar to the student.

CREATIVITY. A creative approach to problem solving. Innovative and entrepreneurial spirit.

TEAM SKILLS. An effective team player. Ability and willingness to collaborate. Acceptance and utilisation of peer review. Utilise opportunities to work with persons other than their direct supervisors. Be open to new thinking. Able to nurture and guide junior members.

COMMUNICATION ABILITY. Able to communicate effectively, both orally and in writing, across a range of expert and non-expert audiences. Appreciation of and contribution to measurable research impact.

PROFESSIONAL AND ETHICAL PRACTICE. A knowledge and understanding of ethics as outlined in the Australian engineering and research codes.

Question 2 - What broader transferable qualities do HDR graduates need to develop to succeed in a wide range of career pathways? Should these skills be assessed, and if so, how?

LEADERSHIP. Ability to lead. Patience, perseverance and patience. Clear articulation of their contributions to society.

TRANSFERABILITY. Ability to transfer research outcomes into practice. Be able to apply experience and skills gained in a narrow area to a wider area. Adaptability, that is multiple solutions to a problem may exist, the best solution depends on the situation. An appreciation of other disciplines and the wider world.

CROSS-DISCIPLINARY SKILLS. Awareness of other disciplines. Cross-disciplinary and interdisciplinary experience.

PROBLEM SOLVING. Creative approach to problem solving. Independent critical thinking. Analysis. Keenness to seek and answer difficult problems. Flexibility in approaching and solving problems.

PROJECT MANAGEMENT AND INNOVATION. Interpersonal skills. Time management. Financial basics, budget management. Complex project formulation and grant writing. Innovation and entrepreneurship skills.

INDUSTRY LIAISON. Collaboration and interaction between disciplines and industry is critical.

COMMUNICATION. Excellent communication skills, both oral and written.

Many of these aspects should be the subject of training during HDR candidature.

Many HDR students in engineering do not aspire to academia. The opportunities for employment with government, industry and research laboratories must be clearly articulated during their HDR program.

Question 3 - What other broader capabilities should HDR graduates develop during their research training?

NETWORKING. Personal networking. Ability to work with others in diverse roles. Understanding the global impacts of research. International experience.

DEALING WITH COMPLEXITY. Ability to identify gaps and formulate appropriate research questions. Ability to work in complex teams.

ADVANCED COMMUNICATION SKILLS. Across team members, across organisations, with the public. Ability to communicate effectively outside a niche area of research.

VISION. Understanding industry/community needs. Understanding research culture in an organisation. Understand impact of research. Being able to think outside the box.

BUSINESS SKILLS AND INNOVATION. Ability to work with available resources. Financial skills. Intellectual Property training as appropriate. Undertake consulting jobs - even as students, so as to become familiar with dealing with clients and working to Australian and international standards. Principles of entrepreneurship. Knowledge of start-ups.

PROFESSIONAL AND ETHICAL PRACTICE. Advanced knowledge and understanding of ethics as outlined in the Australian engineering and research codes.

CONTRIBUTING TO AUSTRALIA'S FUTURE PROSPERITY AND WELLBEING

Question 4 - What skills and capabilities do employers in Australia need from HDR graduates?

DISCIPLINE-SPECIFIC KNOWLEDGE: Deep knowledge of their discipline. Technical expertise.

TRANSFERABLE KNOWLEDGE: The ability to use knowledge and experience to resolve practical problems. The ability to teach/mentor others. The ability to transfer research findings into development leading to commercialisation. A broad knowledge of the wider community.

GENERIC SKILLS. Problem formulation and solving skills. Project planning, design and management skills. Team skills. Management skills. Financial skills. Communication skills. Interdisciplinary skills. Entrepreneurial skills.

PERSONAL SKILLS. Integrity, flexibility, reliability, attention to detail, timely delivery.

The Engineering PhD is seen principally the gateway to become an academic or researcher in CSIRO, DSTO or ANSTO. Sadly, most Australian employers do not think that they need HDR graduates at all. Systematic support to create more engineering-based start-ups from university research must be encouraged.

Question 5 - What research skills and capabilities are needed to ensure Australia's research system remains internationally competitive?

FUNDING. Much better funding support. We cannot compete unless research is properly funded.

KNOWLEDGE. Access to cutting-edge research knowledge. Know what is happening at the frontiers.

CONTINUE OUR EXCELLENT WORK. We have the skills and capabilities such as internationally competitive publication and citation rates. We need to continue to be involved in innovative research with high quality research outcomes disseminated internationally. Tangible outputs are vital, for example publications, patents or direct applications into industry, government or society. HDR graduates should be trained to focus on excellence; e.g. they must publish in top journals during their training.

RELEVANCE. Ability to undertake internationally relevant projects. Build capacity to offer projects of interest to international industries. Identify challenging, global problems where we can make an impact. Use our ability to innovate to identify and solve key problems of strategic importance to Australia.

The immediate problem for Australia to remain internationally competitive does not fundamentally lie with research skills and capabilities. It lies with the lack of funding and commitment, especially by private industry, and the lack of career structures. The Chief Scientist's recent paper on the vision for Australia as a STEM [Science Technology Engineering and Mathematics] based nation provides a longer term picture of what Australia needs to remain internationally competitive. There must be a pipeline of STEM education beginning at primary school and progressing through all levels of secondary and tertiary education and thereby providing fundamental skills for researchers.

Question 6 - What research skills and capabilities are needed from HDR graduates to ensure Australia is ready to meet current and future social, economic and environmental challenges?

FLEXIBILITY. Ability to adapt to changing environments. Ability to change research focus to new directions. Broader training to understand the implication of their research in those challenges.

CONNECTIVITY. Interdisciplinary experience. Linkages to industry – part of the project carried out in Industry, or with an Industry focus. Linkages to government. Forums for international collaboration and exchanges. Ability to draw information from a range of sources (political, policy, public, media, as well as research data).

INNOVATION. Innovative ideas and practices. Innovation in both research and development.

CAREER PATHWAYS. Better support of HDR students after they have graduated. There is currently massive difficulty in finding appropriate employment.

The development of broad capabilities could be via short graduate courses on relevant theory, on the environment, basic accounting, innovation, constitution and contract law. Substantially more funding would be needed as a 4 year PhD would be needed in this model.

Question 7 - What features of the research training system should be retained to ensure our graduates are internationally competitive?

SCHOLARSHIPS: At least retain, preferably increase. Ensure equity for domestic and international applicants.

BLOCK FUNDING: At least retain, preferably increase.

PROFESSIONAL DEVELOPMENT ACTIVITIES. At least retain, preferably increase; for example, participating and delivering seminars in the particular field. Professional development programs are also required to introduce new and developing methods and studies.

ACADEMIC EXCELLENCE. It is imperative an emphasis on academic excellence be maintained. Increased interest in research impact should not be at the expense of academic standards of excellence. Publications must continue to be in top journals.

FUNDAMENTAL RESEARCH. Desired increases in industry exposure and participation must not be allowed morph research work into development. High-risk and/or fundamental research should be maintained.

Question 8 - How should the research training system be structured to produce high quality researchers who can contribute to Australia's future prosperity and wellbeing?

MORE MONEY. Double the HDR budget. The PhD scholarship is relatively small compared to their counterparts working in the industry. Therefore it is essential to increase the scholarship to match the industry standards and also essential to create better job opportunities. Engineering HDRs should be treated as 'engineering professionals' in engineering research practice. Their graduate peers are earning typically $75,000 pa in industry and many are on excellent career paths.

BETTER USE OF TIME. Encourage completion in timely manner by limiting the maximum number of years supported. But introduce more graduate training. For example, first year provide short course graduate training plus broad courses in environment, accounting, constitution, and contracts. Years 2 to 4 - research project, with 3 months break to either teach or work in industry.

IMPROVE PROCESSES. Less bureaucracy, but more insightful and thorough auditing of supervision. Quality assurance/benchmarking requirements for the whole HDR process from intake to examination process. There should be some significant review of the intake and overall doctoral training pathway.

BETTER CAREER PATHS. Currently in Engineering many HDR candidates find it difficult to find a job after finishing the PhD, whereas an undergraduate can easily walk into a job. Competitive start up grants for PhD students who want to spin off their research. HDR students should be encouraged and supported to interact with industry. More industry focus, similar to German system.

Question 9 - How can entry and exit pathways to and from research training be better structured?

ENTRY and EARLY PREPARATION. The formative professional engineering degree (Australian Bachelor of Engineering (Hons) and Masters ('entry to practice' coursework) or equivalent) invariably includes a capstone research project and a unit of study on research methods. This is a proven sound basis for admission. Further induction into research training at the commencement of HDR study, would give students additional skills to tackle the challenges that will appear throughout the candidature. During candidature, develop of management and personal skills to improve career readiness on departure. Prepare PhD students in advance for the differences between research in academic and commercial (industry) settings.

INCREASED FLEXIBILITY. Transferability between PhD and Professional Doctorates where appropriate. Pathways from Research Masters to PhD and vice versa. It would be beneficial for industry-sponsored HDR positions to have flexibility and opportunities for subsequent employment. Including coursework within the HDR candidature would be desirable, in both technical and non-technical areas. Combined postgraduate coursework awards with the PhD, or Professional Doctorate models could be considered.

INCREASED INTERACTION WITH EMPLOYERS. The problem with exit pathways is the restricted range of employment opportunities and the frequent absence of career structures. Government support (e.g. employer tax incentives, salary compensation, leave entitlement scheme) for graduates already in the workforce to undertake HDR whilst remaining in their current employment. Candidates being aware of the range of employment opportunities (commercial, research, government) exist once they have completed. Educate industry of the value of employing PhD graduates, that is dispel outdated notions of narrowly focussed, commercially-inept graduates.

EXIT PATHWAYS. Career prospects for HDR graduates in Australia are not strong. The examination process should have tighter time limits. More end options may entice more students to start. Also need intermediate exit and re-entry to allow for teaching training or industry placement.

Question 10 - How can barriers to participation in HDR programs be overcome so that more candidates from non-traditional backgrounds, including indigenous students, undertake research training?

STARTING AT HIGH SCHOOL. Prospective Engineering students need a strong basis in mathematics and science.

ENCOURAGED AT UNDERGRADUATE LEVEL. This is primarily a job for undergraduate and other first degree (integrated BEng/MEng) degree programs; we should promote research more widely at this level. Regardless of opportunity, many undergraduates do not understand that university academics engage in research. Engagement at high school, undergraduate and postgraduate level with research activities is very important. Excellent employment outcomes and the emphasis on contributions to society (their culture, their communities etc.) is very important.

MORE AND TARGETED SCHOLARSHIPS. Scholarships for PhD preliminary programmes so that more students are supported in taking a safe stepping stone towards a PhD. Expand APA and IPRS programmes. Currently these are highly competitive and only top students are successful in obtaining them. If the scholarship schemes were broader, there would be more scope to assess students based on past opportunity rather than just past performance. Scholarships for candidates from non-traditional backgrounds

DURING CANDIDATURE. First year of skills training to get all students up to an equivalent level. Promoting an inclusive research culture in Universities. Providing appropriate supervisory team from relevant cultural background who could provide relevant guidance. A stronger sensitivity around learning approaches across different cultures and how that can be applied to indigenous and other non-traditional backgrounds.Different approaches to acquiring and communicating knowledge may be highly valuable, but can currently be penalised through the traditional research and thesis/dissertation approach. Working in research projects relevant to candidates' needs and background. Formal government or institutional support for language development programmes to be undertaken in parallel with commencement of a PhD.

Barriers into programme are not difficult: the hard part is after graduation.

OTHER SUPPORTING INFORMATION

Further supporting information not covered in your answers to the consultation questions should be provided here

An Appendix provides data on HDR commencements and completions to from 1996 to 2013. The trends are clear, with strong international enrolments and better female participation than for undergraduate programs (about 15%).

Appendix: Higher Degree by Research: Completions and Commencements in Engineering & Related Technologies 1996 - 2014

Note: these are compiled from the Higher Education statistics purchased annually by ACED

ENGINEERING COMPLETIONS

	1996	1998	2000	2002	2003	2004	2005	2006	2007	2008	2009
DOCTORATES	**413**	**438**	**474**	**480**	**528**	**570**	**637**	**695**	**772**	**697**	**705**
domestic total	291	325	355	381	420	421	452	487	519	513	479
% domestic female	14.8%	19.1%	18.9%	17.1%	21.2%	20.9%	21.2%	20.1%	21.4%	24.2%	21.1%
international total	122	113	119	99	108	149	185	208	253	184	226
% international female	7.4%	9.7%	8.4%	15.2%	20.4%	14.8%	16.8%	16.8%	18.2%	17.4%	19.9%
% international	29.5%	25.8%	25.1%	20.6%	20.5%	26.1%	29.0%	29.9%	32.8%	26.4%	32.1%
RESEARCH MASTER'S	**237**	**230**	**189**	**185**	**194**	**220**	**208**	**264**	**230**	**228**	**185**
domestic total	178	164	143	144	148	147	133	139	135	127	99
% domestic female	23.6%	15.2%	27.3%	22.9%	18.9%	17.0%	23.3%	24.5%	25.9%	19.7%	18.2%
international total	59	66	46	41	46	73	75	125	95	101	86
% international female	10.2%	19.7%	23.9%	12.2%	23.9%	19.2%	21.3%	17.6%	21.1%	24.8%	25.6%
% international	24.9%	28.7%	24.3%	22.2%	23.7%	33.2%	36.1%	47.3%	41.3%	44.3%	46.5%

ENGINEERING COMMENCEMENTS

	1996	1998	2000	2002	2003	2004	2005	2006	2007	2008	2009
DOCTORATES	**592**	**655**	**732**	**840**	**872**	**951**	**822**	**847**	**950**	**1,039**	**1,390**
domestic number	449	491	556	614	615	687	550	486	519	498	586
% domestic female	20.3%	23.4%	24.6%	23.1%	20.0%	21.8%	20.5%	22.2%	19.5%	23.7%	24.4%
international number	143	164	176	226	257	264	272	361	431	541	804
% international female	20.3%	17.7%	21.6%	17.7%	19.5%	19.3%	18.4%	24.7%	22.0%	27.5%	28.0%
% international	24.2%	25.0%	24.0%	26.9%	29.5%	27.8%	33.1%	42.6%	45.4%	52.1%	57.8%
RESEARCH MASTER'S	**499**	**450**	**421**	**483**	**454**	**519**	**429**	**392**	**369**	**320**	**506**
domestic number	395	362	330	366	321	346	292	257	234	187	298
% domestic female	17.0%	17.7%	14.2%	20.2%	23.7%	22.5%	20.5%	17.9%	23.5%	23.5%	17.1%
international number	104	88	91	117	133	173	137	135	135	133	208
% international female	19.4%	22.8%	18.8%	16.4%	15.8%	14.8%	22.6%	24.2%	27.3%	27.2%	30.8%
% international	20.8%	19.6%	21.6%	24.2%	29.3%	33.3%	31.9%	34.4%	36.6%	41.6%	41.1%

ENGINEERING COMPLETIONS

	2010	2011	2012	2013	2014
DOCTORATES	**792**	**782**	**953**	**1,113**	**1,267**
domestic total	474	399	496	536	571
% domestic female	22.0%	23.3%	23.2%	24.8%	
international total	318	383	457	577	696
% international female	19.9%	23.0%	25.2%	27.0%	
% international	40.2%	49.0%	48.0%	51.8%	54.9%
RESEARCH MASTER'S	**196**	**235**	**212**	**245**	**218**
domestic total	99	115	100	132	103
% domestic female	23.2%	26.1%	15.0%	22.0%	
international total	97	120	112	113	115
% international female	33.0%	22.5%	**31.3%**	26.5%	
% international	49.5%	51.1%	52.8%	46.1%	52.7%

ENGINEERING COMMENCEMENTS

	2010	2011	2012	2013	2014
DOCTORATES	**1,476**	**1,528**	**1,629**	**1,789**	**1,834**
domestic number	678	621	601	662	
% domestic female	24.2%	22.7%	27.6%	25.1%	
international number	798	907	1028	1127	
% international female	24.8%	27.9%	24.8%	26.4%	
% international	54.1%	59.4%	63.1%	63.0%	
RESEARCH MASTER'S	**521**	**451**	**456**	**433**	**469**
domestic number	303	219	231	234	
% domestic female	19.5%	21.9%	24.7%	23.5%	
international number	218	232	225	199	
% international female	24.8%	28.9%	28.9%	27.6%	
% international	41.8%	51.4%	49.3%	46.0%	

Note: the ‘Year’ is the calendar year of commencement or completion of studies for the award; full data for 2014 is not yet finalised