Research-Based Education in Computer Science at the ANU: Challenges and Opportunities

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THE AUSTRALIAN NATIONAL UNIVERSITY

1 Overview

- about the Graduate Certificate in Higher Education
- research-based education: concepts and objectives; ANU's vision
- research-oriented undergraduate degrees at the ANU
  - the PhB (Science) program: mentoring and advanced study courses
  - the Bachelor of Computer Science program
    - student perceptions of research-based education, approaches to learning, experiences of the BCS
- some examples of research-based education in Computer Science
  - in normal courses (1st to 4th year) and research project courses
- academics' perceptions of research-based education
  - what it is, own practices, relationship to the BCS, SWOT
- visions for a way forward, discussion, and conclusions

2 About the Graduate Certificate in Higher Education

- College-Based Program of the GHCE first introduced in 2006
  - emphasis on underlying principles in education, rather than techniques of practice
  - that year, emphasis on research-based education
  - six from CECS 'invited', one still standing . . .
- experiential- based curriculum; courses covered include:
  - EDUC8003: *Curriculum Design and Innovation* S1
  - EDUC8002: *Learning and Teaching in Higher Education* S2
  - EDUC8006: *Action Research Project* S1/S2
    - combination of projects undertaken with EDUC8003 & EDUC8002
  - EDUC8001: *Enhancing Your Academic Practice* S3
    - capstone review
- portfolio-based; *flexible*; pass/fail/deferred only

3 The GCHE – My Portfolios

- Integrated Reflection Portfolio (EDUC8003)
- Applying the Community of Practice Approach to Postgraduate IT Projects (EDUC8003/8006)
- Goals for Teaching and Student Learning (EDUC8002)
- Analysis of Different Approaches to Learning in First Year Students of the BCS (EDUC8002/8006)
- Analysis of Different Intentions, Approaches and Experiences of Of Computer Science Teachers (EDUC8002/8006)
- Integrated Review: A Survey of 'Best Practice' in Computer Science Teaching (EDUC8001)
- Professional Enquiry: Research-Based Education in Computer Science at the ANU: Challenges and Opportunities (EDUC8001)

4 The GCHE – My Experience

- *lots* of reading – textbook chapters and research papers
  - a few paradigms, each with a close community
  - (arguably) some of the research could have more rigor?
- a different mindset required, e.g. qualitative research methods
- opportunity to follow own interests, do some research in education
  - eScience Projects CoP (2006) was a highlight! So is this!
  - some confusion over what, where, end when
- really good teachers ($\approx$ colleagues)
- some interesting contact with fellow students
- but finding the time would have been really heard without OSP in S2...
- will I be a better teacher?
- should everyone be doing this?

5 Research-Based Education: Concepts

- ways in which research may be introduced into university teaching:
  - research-led: curriculum dominated by staff research interests
  - research-oriented: learn about research processes, how knowledge gets created, and the 'mind-set' of a researcher
  - research-based: students act as researchers, learn associated skills, curriculum dominated by inquiry-based activities

  (hereon, 'research-based education' can mean any/all of the above)
- "teaching should be directed towards helping students understand phenomena in the way that experts do"
- (problem) inquiry-based learning: engages student learning in the context of a (broad) problem
  - potentially fosters closer engagement, deeper understanding and generic, long-term skills

6 Research-Based Education: Views in the Literature

- e.g. the Boyer Report (1998) strongly advocates this for research-intensive universities
  - students engage in research in as many courses as possible from the first year, learn how to communicate research results, take inquiry-based courses with collaborative projects, are given a mentor, join a research team, participate at seminars and take internships
  - students participate in research conducted by their lecturers
- other studies are more cautionary, e.g.:
  - extrinsically (vocationally) oriented students may not respond well
  - many academics believe basic knowledge must be acquired first
- the teaching-research nexus: views from symbiotic to incompatible
- potential student benefits found to be dominantly positive:
  - teachers: 'enhanced knowledge currency, credibility, competence in supervision and enthusiasm/motivation"
    (perceived drawbacks: reduced availability & effort put into teaching)

7 ANU's Vision for Research in Education

- 2004: 'education informed by recent research" through a range of "research-led degree programs based on interactive enquiry"

  (ANU: university with a difference)

  - key elements: critical enquiry, deep approaches to learning, reflective practice and research experience early in the degree
- 2005: position strengthened, proposing students be integrated into a research community (ANU Educational Development Group: working paper)
- 2006: the terms discovery and curiosity displace research and inquiry; emphasis on flexibility (ANU by 2010)
- 2007?

8 The PhB Program: The Flagship Research-led Degree

- PhB (Science) program a “research-focused” Honours program
  - requires six advanced study courses (ASCs) over the first three years
  - often in form of research projects with an academic instructor
  - each student is also supplied a ‘mentor’ throughout
- assessment by Wilson, Wilson & Howitt (2006, GCHE project)
  - 1st years saw challenge and flexibility the main virtue; older students cited the opportunities for research.
  - majority of students were neutral on benefits from their mentor
  - most had more +ve relationships with their ASC instructor
  - students: perceived benefit of ASCs mainly learning generic research skills & the resulting personal development
  - drawbacks was high workload; need more enthusiastic instructors
  - staff: few mentors had ever been instructors; many did not envisage any kind of educational outcome; lack of focus on generic skills; lack of consistency with assessment

9 Our Answer: the Bachelor of Computer Science

- the BCS is a “research-oriented” degree of a similar nature
  - COMP1130 / COMP1140: use of problem seminars seeded by an academic in their research area
  - project courses only in third year
- 4 (/10) students interviewed August 2006
- predominantly used deep approaches to learning: satisfaction at solving complex problems, extensive seeking of relevant references
  - with their high scholastic aptitude, ideal profile for RBE!
  - two however needed structure and guidance in their learning
- chose the BCS because its eliteness, seemed more interesting/faster
- perceived ‘research-oriented program’ as advertising, being an RA, learning about research methods
  - research as end in itself attractive only to 1

10 The Bachelor of Computer Science: Student Experiences

- only 1 student highly +ve relationship with mentor (research enthusiasm!)
- socially, stratified into 2 groups (α-geeks & others);
  little purely social interaction or with other CS students
- views on the term RBE encompassed all of the main meanings
  - felt COMP1130/40 only to a small extent had RBE; theory dominated!
  - the COMP2300 memory hierarchy assignment was the most prominent example so far
    - very challenging: had build a deep understanding first
  - felt in future, RBE would mainly be in projects courses
    - "it should be curiosity-driven, and solvable and relevant"
    - two preferred the PhB model
  - perceived benefits: broader persecutive and deeper understanding, valuable mind-set even for industry

11 Current Examples of RBE at ANU: Non-Project Courses

- elements of research brought into advanced courses,
  e.g. COMP3320, COMP3620, COMP3300/10 (guest lectures)
- course content deriving from lecturer's research interests: COMP6444 (design patterns), COMP3110 (executable specs, aspect-oriented)
- teaching the process of discovery: Max-Profit Scheduling algorithm and associated proof
- teaching research skills / methodology: COMP2300 memory hierarchy expts.
- problem-based learning: COMP1110: group SE project,
  COMP3320: cluster middleware group project,
  COMP3110: real-world examples of systems
- 4000-level programming language implementation: papers reviewed, class projects based on current research problems (contagious enthusiasm!)
- HCI course more strongly RBE: studying key older research papers, then recent; also projects mirror research practice

12 Current Examples of RBE at ANU: Project Courses

- large variety, from 3000 to 8000 level (implementation and/or research emphasis, 6 to 24 units)
- teaching research-related skills:
  - COMP4200 Milestone Papers: literature searching, critical evaluation of key research, and presentation
  - associated series of short seminars on generic skills (e.g. presentations) from an ASLC guest speaker (2006)
  - formation of a Community of Practice for generic skills (e.g. presentations, writing, etc) in the eScience projects (2006)
    - students benefited from each other's and the facilitators expertise
    - learned in the context of their own and other student's project: strong benefits in terms of motivation and experiential learning
- *aside*: in general, how systematic are our ideas of learning objectives, and how consistent is the quality of teaching and assessment across these courses?

13 Academics' Perceptions of Research-based Education

- 8 academics from DCS/CSL interviewed over Nov'06 – Jan'07
- views on the term RBE encompassed all of the main meanings; only a few deeming teaching of research skills an important part of RBE differences in broadness (e.g. is PBL part RBE?). Quotes:
  - *Research means generating new knowledge, so [RBE] means teaching students how to generate new knowledge.*
  - *[RBE] should include research that is of practical use to practising engineers in the next 0 – 5 years. [It] must be appropriate to the student groups – engineers or scientists.*
- evaluation of own RBE practices:
  - PBL & HCI: worked well, elsewhere student reaction polarized
- awareness of others' RBE practices: very little
- skill level required for RBE: depends on sub-field (e.g. HCI easier); consensus is a good 3rd–4th year level but:
  clear thinking is the main thing; the need for specifics often over-rated

14 Academics' Perceptions of the BCS and RBE

- marketing the BCS as a "research-oriented program":
  - may draw good students (build on ANU's reputation)
  - but may put off potential employees or vocationally-oriented students
- goals of the BCS: get good PhD students; but important to give a good grounding in basics and not to specialize too early
- should PhB-style projects be introduced: yes, although some only from 2nd year or optional on student background
- should the BCS have a stronger research orientation: yes, (mentoring, attach to a research group)
- should this extend to other programs: reservation (danger of dropping-out), although *the BCS will bring*RBE *into rest of curriculum by osmosis*

15 SWOT: Strengths and Weaknesses

- strengths:
  - recruit research students; can increase research output; raise the standard in industry
  - can improve quality of teaching (enthusiasm, 'cutting edge', uniqueness) forms broader & better thinkers (instead of tradesmen).

    Especially important to:
    - know that the discipline is evolving, that research is driving it
    - nurture a lifelong learning ability
- weaknesses:
  - for large course assignments: hard to make it work/unclear objectives/ higher staff workload
  - not for everyone, especially at lower undergraduate level
  - project courses: our research interests too specialized; unrewarding if students are sub-standard

16 SWOT: Opportunities and Threats

- opportunities:
  - general consensus it is greater at the upper levels
  - give ANU a niche; it is what a research-intensive university should be doing!
  - take advantage of recent identification of research groups within CS
  - can link in NICTA/RSISE and move CECS forward
  - may work if we (ANU) do this systematically
- threats:
  - antipathy from some academics (RBE needs the right academics - active researchers)
  - ANU might be seen just as for top-end research
  - high teaching loads may preclude extra effort needed for RBE
  - the research schools may get the (good) research students instead

17 Visions for a Way Forward and Discussion

- should rethink our courses for RBE and set assignments accordingly, e.g. in an AI course:

  We could give a vision of 2050 with a World Cup class robot soccer team [the frontiers of the field]. Then we show them where the current state-of-the-art differs. And then work back to a problem that can be tackled today, e.g. planning using current soccer robot prototypes, and get them to work on this.

- "*have an audit of RBE and curriculum design. Courses without synergy with our research can be axed - unless they have strong professional requirements*"
- form a (CS-based) Community of Practice to exchange ideas and experiences
  - an ANU-wide CoP is already operating!
- to make it work: need attractive, high quality research programs and develop good rapport with u/g students (retention)
- discussion: to what extent, and where and how should we do this?

18 Conclusions

- in the literature, there are plenty of studies and relevant ideas
  - but as yet no direct comparison of traditional vs. RBE u/g degrees
- ANU's vision: seems appropriate for a research-intensive university
- important lessons can be learned from the PhB and BCS experiences
  - more nurturing, better objectives / standards needed for project courses
- variation in the broadness and value of RBE in the academics
- already have a wide range of practices that can be considered RBE
  - but we need to have a more systematic and integrated approach
  - formalizing it in curriculum & mission statement: to what extent?
- acknowledgements:
  - the GCHE lecturers (facilitators) and fellow students
  - the interviewees: BCS students and DCS/CSL academics
  - the College, for sponsoring me (if I pass!)