



Australian Council of Deans of ICT

ACDICT Learning & Teaching Academy (ALTA) Grant Scheme

Final Project Report

Investigating the nature and design of computer programming examinations

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1. Project outcomes and deliverables against specified aims

The aims of this project were:

1. Investigation of the nature and composition of formal examination instruments used in summative assessment of programming students (Phase 1); and
2. Investigation of the pedagogical intentions of the educators who construct programming examination instruments (Phase 2).

To achieve these aims the project was conducted in two separate and overlapping phases. An outline of the project activities is presented in Table 1.

Project outcomes from Phase 1

Phase 1 involved analysis of a set of introductory programming examination papers to determine the complexity and difficulty of the questions. This required the development of a set of complexity and difficulty measures (domain references, explicitness, linguistic complexity, code length, conceptual complexity, intellectual complexity and perceived difficulty). The measures were sourced from an extensive literature search and further refined by the project team members. The measures were incorporated into an existing exam question classification scheme developed previously by members of the team. Accompanying the description of the measures, the team developed a comprehensive classification guide (see Appendix).

The classification scheme for complexity and difficulty was presented at a workshop at the Australasian Computing Education conference (ACE2012) in Melbourne in January 2012, led by the project team. At the end of the workshop participants were invited to join in the work of classifying a set of introductory programming exam papers. The scheme was refined and questions from 20 exam papers were classified for complexity and difficulty by a team of 12 classifiers. The classification was a multistage process with reliability measures calculated after several trials. The results of this work have been presented in papers to be submitted to the Australasian Computing Education conference (ACE 2013) [1] and the Annual Conference of the Australian Association for Engineering Education (AAEE 2012) [2].

The planned outcomes for this phase of the project were achieved:

- a. Development of a trialled and tested classification scheme for investigating the complexity and difficulty of programming exam questions.
- b. Knowledge of the composition of introductory programming examination papers in terms of the complexity and difficulty of the questions.
- c. A set of programming assessment questions classified according to a set of complexity and difficulty measures.

Project outcomes from Phase 2

Phase 2 involved interviews with eleven educators who constructed and used introductory programming exams. This phase required the development of an interview script by the project team. The interview script was piloted by a team member and the interviews were then conducted by four team members. The audio files of the interviews were transcribed. A thematic analysis was conducted on one interview script individually by all team members. Using the set of themes as a basis, a thematic analysis was then conducted on the remainder of the interviews by two team members using the qualitative software tool NVivo. The results of this work will be presented in a paper to be submitted to the Innovation and Technology in Computer Science Education conference (ITICSE2013) [3].

The planned outcome for this phase of the project, which was understanding the process of developing examination instruments was achieved.

2. Project activities

Table 1: Project activities and participants

Date	Project phase	Activity description	Participants
23 Aug 2011	Phases 1&2	Project meeting 1: - development of interview questions - ACE 2012 workshop planning	Judy, Simon, Angela, Daryl
Sept-Nov	Phase 2	Interviews conducted with eleven academics from six institutions. Transcriptions of interview audio files.	Judy, Angela, Simon, Daryl
10 Nov	Phase 1	Project meeting 2: - refinement of exam classification scheme - development of exam classification guide for the ACE 2012 workshop	Judy, Angela, Simon, Raymond, Daryl
11 Nov	Phase 2	Project meeting 3: - preliminary analysis of interviews	Judy, Simon, Angela, Raymond, James, Daryl
30 Jan 2012	Phase 1	Exam Classification workshop at ACE 2012. Eight Australian institutions were represented (Monash, QUT, USQ, UQ, RMIT, ANU, UTS, Newcastle) plus three international institutions. The workshop was advertised on the ACE 2012 website and the Australasian Chapter of ACM SIGCSE newsgroup. http://www.sci.usq.edu.au/conferences/ace2012/workshops.html#taxonomy	Project team (in total 16 participants from 11 institutions)
Feb-Apr	Phase 1	Classification of 20 papers using the Exam Classification scheme	Simon, Judy, Angela, James, Daryl and seven other participants from the ACE 2012 workshop
May-June	Phase 1	Preparation of paper for ACE 2013	Simon and Judy
Feb-May	Phase 2	Analysis of interview data using NVivo software.	Judy and Margaret
12-13 Apr	Phases 1&2	Presentation of project at the ACDICT Forum, QUT	Judy and Simon
19 Jun	Phase 2	Project meeting 4: - Analysis of interview data - Plan paper for ITiCSE 2013	Judy, Simon, Angela, Raymond, Daryl, Margaret
Jun-Jul	Phases 1&2	Preparation of papers for ITiCSE 2013 and AAEE 2012	Simon and Judy

3. Changes to project

During the course of the project there were couple of changes to the project team and task responsibilities set out in the original project plan.

- Dr Daryl D'Souza, Senior Lecturer from RMIT, joined the project team from the first meeting of the project and has been involved in all project activities.
- Dr Margaret Hamilton, Senior Lecturer from RMIT, joined the project team in May 2012 and has been involved in the analysis of the data in NVivo.
- Dropbox was used as a repository for project resources rather than VILLE.

4. Lessons learnt and challenges met

- Face to face meetings were invaluable for progressing this project.
- Obtaining an acceptable level of reliability for the complexity measures required workshopping and several iterative improvements to the classifying guide.
- Obtaining the papers for analysis was achieved through advertising on the SIGCSE email group and the participants who attended the workshops.

5. Benefits to the ICT learning and teaching community

There are several potential benefits to the ICT learning and teaching community:

- a. The set of classified programming assessment questions may be explored to gain ideas for novel examination questions and find examination questions that are commonly used and could be shared.
- b. The Exam Classification scheme provides a universal language in which academics can discuss examination instruments and the questions they are composed of in a meaningful and unambiguous way.
- c. The Exam Classification Scheme could be used to investigate the complexity and difficulty of examinations in higher level programming units.
- d. The interviews of academics have provided insights into the process of developing examination instruments and information about the suitability of different examination questions for particular contexts (e.g. large classes vs. small classes).

There is potential interest in our work from the quality organisations within institutions for its relevance to the development and measurement of assessment standards.

There is potential interest in our work from other disciplines, particularly the STEM disciplines.

This project has formed the foundation for a future project which would build a searchable repository of exam questions classified according to the classification scheme, and a tool to enable construction of programming exam papers according to the requirements of the examiner.

6. Project dissemination

The outcomes of the project will be reported in four publications. These are planned to be submitted to the following venues.

[1] Simon, Sheard, J., Carbone, A., Chinn, D., Clear, T., Corney, M., D'Souza, D., Fenwick, J., Harland, J., Laakso, M.-J. and Teague, D. Exploring the complexity of exam questions: How difficult are introductory programming exams? To be submitted to the *Australasian Computing Education conference*, Adelaide, 2013.

[2] Simon and Sheard, J. Exams in computer programming: What do they examine and how complex are they? Submitted to the *Australian Association of Engineering Education*, Melbourne, Australia, 2012.

- [3] Sheard, J., Simon, Carbone, A., D'Souza, D., Hamilton, M., Harland, J. and Lister, R. Pedagogical foundations of introductory programming exams. To be submitted to the *Innovation and Technology in Computer Science Education* conference, Canterbury, UK, 2013.
- [4] Simon, Sheard, J, Carbone, A., D'Souza, D., Harland, J., Laakso, M., and Fenwick, J. Can computing academics really assess the difficulty of programming examination questions? To be submitted to the *Koli Calling conference*, Finland, 2012.

The outcomes of the project have also been disseminated through involvement of academics in the project. In total there were 18 academics from 11 institutions involved in the various stages of the project.

7. Acknowledgements

The project team would like to express their gratitude to the ACDICT Learning and Teaching Academy (ALTA) for their support of this project.

The project team would also like to acknowledge the contributions of the other academics who participated in the classification of the 20 examination papers: Donald Chinn, Tony Clear, Malcolm Corney, Joel Fenwick, Daryl D'Souza, Michael de Raadt, Mikko Laakso, Donna Teague.