Driving curriculum and technological change to support writing in the engineering disciplines

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***Abstract*— Written communication skills are essential for engineers in the workplace, yet developing these skills in undergraduate engineering continues to be an issue. Curriculum innovation can be increased through the use of online writing tools that are designed to support integration of written tasks in engineering courses, along with the appropriate leadership communication and integration in the faculty teaching culture. Moreover, research has shown that there is a need to incorporate writing activities to enhance both learning and communication. The overall aim of this project is to create an integration model in collaboration with leadership, learning support and academics at several Australian universities. The integration model is based on a risk communication framework, which will support the use of engineering-specific online writing tools and drive curriculum innovation in undergraduate engineering. To create this model data is being collected from academics and students on use of the online writing tools.**

Keywords*— *Communication skills, writing activity, online writing tools, integration model, risk communication framework.

I. INTRODUCTION

In today's workplace, it is essential that engineers possess strong written communication skills. There are differences between students' communication skills and those required in the workplace. However, innovation and development in undergraduate engineering to include these skills continues to be an issue. The difficulty is, while some academics will engage in curriculum development many will be 'reluctant' and 'resistant' to change. This reluctance is often a result of perceived organizational, disciplinary and individual risks relating to the use of written tasks in learning and teaching. There are ongoing concerns about the discrepancy between engineering students' communication skills and those identified as necessary by the Australian Government and professional bodies [1]. Professional faculties such as Engineering need to articulate their learning outcomes to insure graduates have the communication skills to fruitfully participate in the workforce and meet the standards of professional accreditation bodies (Engineers Australia 2008; Accreditation Board for Education and Technology ABET 2008).

A survey of actual work practices indicates that engineers spend 40-60% of their time communicating [2] and an increasing amount of their time writing. This issue has been acknowledged as a priority in universities and has been the focus of past projects related learning and teaching, yet innovation in this area has not been systematically addressed across engineering faculties in the universities.

While acknowledged as critically important, the actual integration of written tasks presents a number of concerns for academics. These concerns include: academics' ability to articulate how they assess student writing, their capacity to address issues of plagiarism and the provision of timely, the form of relevant and appropriate feedback on writing to bring about improvements, as well as the acceptance and value of written tasks in undergraduate engineering and the general sustainability of making this change in their curriculum. We propose that an integration model centered on the use of online writing tools can help university and faculty leadership to minimize academics' perceived risks related to the integration of written tasks and support students' development of written communication skills. To do this, we draw up on two bodies of research that provide the conceptual framework of the proposed model, on two levels: 1) academics conceptions of writing tasks in undergraduate engineering and 2) organizational and individual perceived risks related to curriculum development and innovation.

Research has shown that academics can see the need to incorporate writing activities in two ways: 'writing to learn' [3] where writing serves domain specific learning outcomes, and 'writing as communication' where its purpose is to develop generic skills. These conceptions coincide with beliefs students tend to have about the activities, and there is evidence that this affects the way they write [4]. However, academics conception of the role of writing in engineering may have impact on integration of these skills in their curriculum, particularly appraisal of risk and benefits related to writing activities. Therefore, in the process of deciding whether to integrate written tasks in curriculum, academics will weigh the risks, the 'cost and benefit,' of making this type of change. It is a given that something will be at risk, such as student learning, professional identify, time, effort, etc. If the risk is perceived to be too high, it is less likely an individual will make the change [5]. Studies have shown that perceived high risk limits engagement with, and adoption of, new teaching practices. Individuals perceiving high risks related to change will often seem 'reluctant' and 'resistant'. Perceived risks are socially constructed [6, 7] and individuals are likely to adopt the beliefs

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and practices valued in their group or culture [8]. In the case of educational change, teachers are likely to adopt the beliefs and practices of their disciplinary peers [9]. Therefore, the perception and evaluation of risks can be changed.

Curriculum development and innovation can be managed and supported through the organizational culture, as well as through the wider teaching discipline. Research has shown that effective risk communication can minimize individual's perceived risks; but, to develop effective risk communication, the perceived risks need to be identified [10]. Essentially, risk communication can be used to manage risk, drive curriculum change and innovation. Through the use of online writing tools, specifically designed to support integration of written tasks in engineering subjects, along with appropriate leadership communication and integration in the faculty teaching culture, these perceived risks can be minimized and curriculum innovation increased.

In collaboration with leadership, learning support and academics at The University of Sydney, University of New South Wales (UNSW), and the University of Western Sydney, the overall project described in this paper aims to create an integration model, based on a risk communication framework, which will support the use of engineering-specific online writing tools and drive curriculum innovation in undergraduate engineering. The model will have a particular focus on academics 'reluctant' and 'resistant' to engage in curriculum innovation.

The specific aims are to:

1. Identify academics conceptions of written tasks in undergraduate engineering.
2. Identify academics perceived risks related to the integration of writing tasks in undergraduate engineering.
3. Assess the impact of disciplinary conventions and organizational policy on innovation in undergraduate engineering.
4. Analyze academics interactions with, and use of, online writing tools in relation to undergraduate engineering.

The expected outcomes are:

1. Develop an integration model supporting the use of online writing tools to develop written communication skills in undergraduate engineering in line with University graduate attributes, the needs of employers and accrediting bodies.
2. Create a framework guiding organizational leadership support implementation of the integration model in undergraduate engineering.
3. Improve engineering academics knowledge of, and capacities to, integrate written tasks in undergraduate subjects.
4. Improve undergraduate students' written communication skills.
5. Dissemination of the model and related best practices in the integration of written tasks in undergraduate engineering.

Section two presents the justification of study based on a previous experiment and the risk factors, section three describes the integration framework. Finally, the evaluation process for the framework is presented in section four.

II. Data Analysis and Rationale

Using a risk communication framework, the proposed integration model is based on the use of online writing tools to support academics to incorporate written tasks in their curricula, particularly targeting academics exhibiting reluctance to the use of written tasks. Online writing tools can be designed to minimize risks, such as managing feedback and plagiarism, and support academics to integrate written tasks in their curriculum, while serving a diverse student body with differing levels of need. Recent studies in this area have shown that the use of these tools provides a comprehensive and systematic approach to the integration of writing in undergraduate engineering. Over 1,800 students from the University of Sydney and UNSW used an online writing tool and online e-tutorials (iWrite aka. Online Writing Centre)[1] designed to support writing in engineering, in Semester 1 2012 (~250 unique users each day; [11]. Figure 1 shows the daily number of unique student users of the system. The figure illustrates that students' use of the online writing tools has increased over the last year. A similar level of engagement is expected in future.

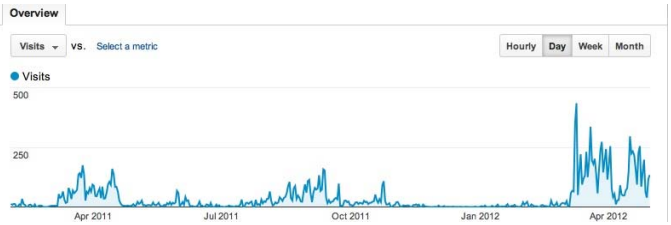

Fig. 1. Student use of online writing tools 2011-2012

Over the course of Semester 1 2012 students received computer feedback and human feedback through iWrite and used the online e-tutorials. Their written work showed significant improvement, with the average marks of a class of 60 students using the tools improving from 54% in the first draft, to 57% in the second draft, to 65% on final submission. This indicates a significant 11% improvement in the writing outcomes of a very diverse group of students. Moreover, student feedback from subjects integrating the online writing tools and e-tutorials show positive student experience. The students express agreement significantly above average (M = 4.10, subject integrating online writing tools; M = 3.70, average of engineering subjects).

While use of online writing tools resulted in promising gains in students' skills and development of graduate attributes, findings show that integration of the tools was most successful with academics that were likely to adopt new practices and

[1]http://iwrite.sydney.edu.au

technologies [11]. For all students to benefit from the increased support and learning opportunities available with the use online writing tools, and to provide systematic integration written tasks in Engineering, it is necessary to provide appropriate and targeted support for academics who are more reluctant to change. This can be done through identification of perceived risk and targeted risk communication. Research has shown that there are several key risk factors to address when forming risk communications [12], which will form the basis of an integration model:

- **Disciplinary culture**. Conflicts between curriculum development and innovation and conventions of the discipline, e.g. writing task are not typically used as a form of assessment in undergraduate engineering.
- **Organizational culture**. Conflicts between explicit (policy) and implicit (traditions) values and beliefs of the faculty and university.
- **Sustainability**. Concerns about the frequency and life-expectancy of change and innovation, e.g. a new eLearning platform is introduced every two years
- **Technological.** Concerns about curriculum development and innovation related to personal efficacy and capacity to participate e.g. ability to use new technologies or to support development of written communication skills
- **Student profile**. Concerns about the quality of student learning and experience as a result of engaging in curriculum development and innovation, e.g. student assessment performance, student evaluation scores.

In order to form these risk factors into an integration model, it is essential that we understand how academics experience each of these areas and how perceived risks can be managed and minimalized to support the sustainable development of written communication skills across engineering faculties. The development of the integration model is of value because it addresses two critical areas need in higher education: 1) the development of written communication skills in undergraduate engineering and 2) an integration model to support all academics to engage in curriculum innovation.

First, it becomes increasingly important that Australian graduates demonstrate a high level of written communication skills. In today's globalized knowledge industries, particularly Australian professionals who are often working at a distance from centers of engineering innovation, professionals need to have superior written communication skills. In the field of Engineering, they will be required to write proposals to overseas clients, manage distributed teams over several countries and multiple time zones, deliver products and documentation that can be easily understood by multiple audiences. It is not an overstatement to say that communication skills are an essential component of Australian industry and, therefore, our graduates. Online writing tools provide a systematic approach to developing students' written communication skills, although for students to benefit from this approach it must be integrated into teaching. The expected outcomes of this project will provide an integration model that will support all academics, those engaged in use of these tools and more reluctant users, with the confidence and capacity to facilitate written tasks in undergraduate engineering, thus providing an environment for sustained development of students' written communication skills.

Second, the Engineering faculties, academics and students directly involved in this project will benefit from development of the integration model. More importantly, outcomes from this project will provide a disciplinary-sensitive approach to managing risk and supporting engagement in curriculum and technology innovation. This integration model will provide a method of integrating written tasks and developing students' written communication skills in engineering faculties across Australia. Moreover, the integration model can act as a framework for supporting other types of technology-related curriculum development and innovation.

III. The Integration Model

As part of the integration model, the following subsections explain the online writing tools, implementation phases, key deliverables, and the evaluation process. For the purpose of this study, we will group academics into the three 'usage groups', such as use of online writing tools, use of university Learning Management Systems (LMS) and paper-based approaches.

A. Online Writing Tools

The online writing tools used in this project are part of the Online Writing Centre (OWC) project. They are as follows:

E-tutorials: Digital content that students access to learn about the different genres of writing in engineering. These materials are designed to complement support provided in face to face in university learning centres. These tools provide the additional affordances of anytime/anywhere learning and personalization to support students' particular needs.

Assignment Manager: This is the component that manages the documents students submit assignments, receive genre-specific and generic feedback and they can engage in a peer-review process.

Word processing platforms supported by the OWC are Google Docs and Microsoft Word. The online writing tools provide tutorial support, writing development and the provision for students to engage in peer review.

B. Implementation Phases

The project design includes two major phases: Design and Implementation. The Design phase is a systematic assessment of perceived risks, based on the risk factors, to develop and pilot the integration model. The Implementation phase is the deployment and full evaluation of the integration model in the engineering at the three Australian universities. Administrators, academics and students will be included in the project:

- **Administrators:** University/faculty/school level administrators responsible for policy development

- **Academics:** Unit Coordinators/ Lecturers responsible for curriculum (unit of study) development at the subject level, including lecture content and assessments.
- **Learning support/ literacy coordinator:** Responsible for student learning support and genre-specific writing development support
- **Students:** Engaging directly with online writing tools and curriculum, influence curriculum development through formal university evaluations and indirectly through performance on assessments

The Design phase (Phase 1) includes input from multiple stakeholder perspectives, to inform development of the integration model: 1) identification of academics conceptions of writing and perceived risks through interview and a questionnaire, 2) consultation with university and faculty leadership in the three universities, and 3) baseline evaluation of students' beliefs about written tasks and writing in the field of Engineering.

Step 1 of the project, identifying academics' conceptions of writing and perceived risks, is based on a Repertory Grid Technique (RGT) [13]. This method is designed to use interviews to capture individuals' perceptions. This requires in-depth investigation, and therefore a method that works with a small number of academics to deliver the necessary rich data for informing subsequent design decisions, as well as with larger number of participants, necessary for generalizing findings. RGT has a long and productive history in social psychology and clinical psychology. A major advantage of this approach, compared to traditional survey methods, is that RGT does not only elicit peoples' ratings but also the dimensions of these ratings. Importantly, the constructs, or dimensions for comparison, are not given to the participants, but generated by them during the interview.

RGT interviews will be designed to capture perceptions of online writing tools, use of university LMS and paper-based approaches for written assignments, as well as the risk factors. Interviews will take approximately 40-50 minutes. Analysis of these interviews will provide RGT factors from which questionnaires will be designed. The questionnaires will also address academics conceptions of written communication skills in learning and teaching, details about their technology use and perceptions of organizational and educational change in their faculty and university.

After completing the questionnaire, academics that have not previously used the online writing tools, will be introduced to the suite through writing workshops at each of the universities, conducted by the learning specialists. A selection of academics will be asked to trial the online writing tools in their subjects. Participants in the study will receive a packet containing informational material about the OWC suite of online tools, details to contact support and the project.

In Step 2, using results from the RGT questionnaire, collaborating administrators, learning specialists and the project leaders will design a preliminary integration model addressing the risk factors, use of online tools in the faculties, and perceived organizational risk related to curriculum development and innovation. A primary component of this collaboration will be team input, driven by academics' interview and questionnaire responses, to improve how OWC address specific perceived risks and writing in engineering subjects. This design will have a strong focus on approaches necessary to engage academics identified as 'reluctant' to change. In conjunction with creation of the model, a framework for sustainable organizational support and resources necessary to implement the model will be identified. A key component of this framework will be the replicability of support structures, such as access to teaching and learning resources and addressing graduate attributes.

In Stage 3, the preliminary integration model will be reviewed by academics in the three user groups. These may include those who had participated in the Stage 1 interviews. In this stage, they will also be asked provide feedback on how the preliminary model addresses use of the online writing tools, alignment with teaching expectations and practice, minimization of perceived risks and student experiences. Academics will be asked to provide structured written or verbal feedback, which will be coordinated by the research assistant. Student feedback on usability of the online writing tools, perceptions of how the tools support their writing and overall experience will be collected by the learning support staff through short student interviews (n = ~10 at each university, depending on up-take in the subjects). Academic and student feedback will be used to evaluate the preliminary model and online writing tools, for the Implementation phase.

Key deliverables: 1) A preliminary integration model supporting the use written tasks, through the use of online writing tools, in undergraduate engineering, informed through thorough data collection and collaboration between stakeholders; 2) a framework of organizational support needed for implementation of the model in undergraduate engineering; and 3) development of academics understanding of written tasks in engineering, as well as their understanding of, and confidence using, online writing tools.

The Implementation phase (Phase 2) includes deployment of the integration model in the three universities and invitation for all academics to take-up the OWC tools in their subjects. Implementation includes: 1) focused modeling and leadership around the integration of written tasks in engineering subjects; 2) workshops specifically addressing risk factors related to disciplinary and student factors, as well as building reluctant users' capacity to integrate OWC and support written tasks; 3) upgraded OWC with attention to feedback on academic and student experiences and use.

The Implementation phase will be independently evaluated, but the project team will also conduct follow-up RGT interviews with the same academic cohort from the phase 1 collection. The interviews will capture possible changes in perceptions of the OWC tools, use of university LMS and paper-based approaches for written assignments, as well as the risk factors after a year of opportunity and support to integrate the online writing tools in their subjects. Each interview will be 40-50 minutes. As in phase 1, analysis will provide factors from which a questionnaire will be designed and made available to all engineering academics in the three universities.

Results from these questionnaires, in collaboration with administrators and learning specialists, will be used to address improvements and finalize the integration model.

Student writing will be collected and analyzed by the learning specialists at each university. The number of subjects integrating the tools will determine size of this sample. This process will provide summative evaluation of students' written communication skills, determination if they are fulfilling university graduate attributes, as well as professional expectations. This analysis will be triangulated with academics use of online writing tools and beliefs about written tasks in engineering.

Key deliverables: 1) A final integration model supporting the use of written tasks, through the use of online writing tools, in undergraduate engineering, to be deployed to other Australian universities; 2) tested and refined framework of how organizational leadership can best support the integration model in undergraduate engineering; 3) Academics' improved skills and knowledge of using written tasks to support the development of written communication skills in undergraduate subjects; 4) results of undergraduate students' written communication skill development through the use of online writing tools in engineering subjects.

C. Evaluation Framework

Following best practices for this type of projects, the evaluation is being carried out both by an independent team in collaboration with the project team and by the project team members themselves. The project team will conduct formative evaluation in each phase of the project and at each university, as milestones are achieved according to the project timeline.

The approach to evaluation during the life of the project is integrated into the feedback cycle to improve the design and development of the integration model and online writing tools, so in this sense the results will also be able to inform software development. Therefore, the project team themselves will carry out this part of the evaluation process since they will directly implement any necessary changes related to integration and support of the online writing tools. Of particular importance during this time are formative evaluations from all stakeholder groups on the integration model. This is built into the project design. Academics and learning support staff in the project provide critical feedback on how it is affecting their work practices and whether there have been improvements in terms of the assessment feedback cycle. Administrators are asked to provide critical feedback as organizational frameworks are developed. The learning specialists at each university collect site-specific data on this and report to the reference group, as well as students' written tasks and reflections in the Implementation phase.

Typical evaluation practices include student and staff questionnaires, pre and posttest performance data, pre and post analysis of student writing, focus group interviews and/or individual interviews with students and staff, software tracking, observation and audio recordings of student interactions with online learning modules, and think aloud protocols.

IV. Conclusions

This paper presents a theoretical framework and a methodological approach to improve our understanding about what drives engineering academics to introduce new learning technologies and practices. We have focused specifically on those practices that develop students' writing and communication skills. Materials, now freely available at the iWrite portal, are being provided in customized format to other institutions (if required), and to as many lecturers as possible. The activity management tool used in OCW, are being made available to other institutions by implementing an authentication module using the framework provided by the Australian Access Federation (AAF)[2]. This provides support infrastructure to facilitate trusted electronic communications and collaboration within and between universities and research institutions in Australia. We have already completed the AAF integration into the iWrite system (part of the OWC) in order to give access to other universities that are members of the federation.

The three participating universities are currently using iWrite (E-Tutorials and Assignment Manager) in some of their Engineering courses. Data is being collected from academics based on the three 'usage groups'. Samples of writing tasks by students using the online writing tools will be analyzed. We are also tracking the daily number of unique users of the system through Google analytics[3]. The findings from this information will be reported in the future.

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References

[1] C. S. Nair, A. Patil, and P. Mertova, "Re-engineering graduate skills – a case study," *European Journal of Engineering Education,* vol. 34, pp. 131-139, 2009/05/01 2009.

[2] C. Tenopir and D. W. King, *Communication patterns of engineers*. Hoboken, NJ: Wiley-IEEE Press, 2004.

[3] J. Emig, "Writing as a mode of learning," *College Composition and Communication,* vol. 28, pp. 122-128, 1977.

[4] C. Bereiter and M. Scardamalia, *The psychology of written composition*. Hillsdale, NJ: Lawrence Erlbaum Associates 1987.

[5] P. Slovic, M. L. Finucane, E. Peters, and D. G. MacGregor, "Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality," *Risk Analysis,* vol. 24, pp. 311-322, 2004.

[6] M. Douglas, *Risk and blame: essays in cultural theory*. London: Routledge, 1992.

[7] O. Renn, "Perception of risks," *Toxicology Letters,* vol. 149, pp. 405-413, 2004.

[8] G. H. Hofstede, *Culture's consequences: Comparing values, behaviors, institutions and organizations across nations*. Thousand Oaks: Sage Publications, 2001.

[9] Y. Zhao and K. A. Frank, "Factors affecting technology uses in schools: An ecological perspective," *American Educational Research Journal,* vol. 40, pp. 807-840, 2003.

[2] http://www.aaf.edu.au/about

[3] http://www.google.com/analytics

[10] C. J. Atman, A. Bostrom, B. Fischhoff, and M. G. Morgan, "Designing risk communications: completing and correcting mental models of hazardous processes, Part I," *Risk Analysis,* vol. 14, pp. 779-788, 1994.

[11] P. Mort, H. Drury, R. A. Calvo, I. Skinner, A. McEwan, D. Levy*, et al.*, "An online writing centre for engineering students," in *8th International CDIO Annual Conference* Brisbane, Australia, 2012.

[12] S. K. Howard, "Risk-aversion: understanding teachers' resistance to technology integration," *Technology, Pedagogy and Education,* pp. 1-16, 2013.

[13] A. Aditomo, R. Calvo, and P. Reimann, "Collaborative writing: too much of a good thing? Exploring engineering students' perceptions using the Repertory Grid," in *9th International Conference on Computer Supported Collaborative Learning (CSCL2011)*, Hong Kong, China., 2011.