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CUR Focus

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Multiple Contexts, Multiple Outcomes, One Conceptual Framework for Research Skill Development in the Undergraduate Curriculum

Undergraduate curricula in many disciplines may be re-engineered to develop the research skills of the majority of students. This paper explores the development of research skills embedded in regular curricula and the assessment of the resulting outcomes in numerous contexts, in order to contribute data allowing comparative analysis of the value of undergraduate research.

This paper considers research experiences designed for all students enrolled in any regular undergraduate course and provides an overview of faculty members' use of a particular conceptual framework, in multiple contexts, to incrementally, coherently and explicitly develop student research skills. This equitable student exposure to research experiences may enable more students to develop interest in, and the skills associated with, research than is possible with models based on mentoring, and may encourage more to continue on to graduate research. The use of one conceptual framework across numerous disciplines and institutions enables a comparative analysis that, over time, may provide evidence of the efficacy of the framework itself.

The conceptual model that informs this development and analysis is the Research Skill Development (RSD) framework (Willison, O'Regan, 2006), which incorporates six facets of research skills into a continuum of student autonomy in the conduct of research (Willison, O'Regan, 2007). The contexts drawing on the RSD framework vary widely, in courses from the freshman to senior years; in institutions ranging from research university to technology university to rural university; and from introductory academic programs to more advanced courses in science, health science, engineering, business, social science, and the humanities. Many of the faculty members involved in courses in all these contexts make up the team for the Research Skill Development and Assessment in the Curriculum project, funded by the Australian Learning and Teaching Council (ALTC, 2007).

The Research Skill Development Framework

It is not always the students who are rated as "academically able" who are most able to engage in research. Sometimes students who are successful taking exams are not able to pose questions or create appropriate research directions, whereas academically weaker students may excel (White, 2007). So providing research opportunities for as many students as possible is important to allow some of those with lower academic rankings to shine in a research atmosphere. Developing research skills in a whole cohort may add to their general academic environment by inspiring curiosity in studies generally and promote progression to graduate research (Bauer, Bennet, 2003).

However, a major difficulty with providing a greater number of students with research experiences is that unless students are specifically guided in investigation processes, they will often continue to operate in subsequent investigations at the level at which they entered the university (Chaplin, 2003). This means that care needs to be taken to incrementally develop students' research skills over a period of time to enable undergraduate students to take part in research. The role of the Research Skill Development framework is to enable faculty members to conceptualize incremental approaches to involving students in inquiry. The RSD presents six facets of research, in which students:

- embark on inquiry and thus determine a need for knowledge/understanding;
- find/generate needed information/data using appropriate methodology;
- critically evaluate this information or data and the process used to find or generate it;
- organize information collected or generated;
- synthesize and analyze and apply new knowledge; and
- communicate knowledge and understanding and the processes used to generate the advances, with an awareness of ethical, social and cultural issues (Willison, O'Regan, 2006).

In the RSD framework, these elements are elaborated in a continuum of five levels of student autonomy. The first three levels all describe "closed inquiry" in which the faculty members determine the starting point such as aim, purpose, or question; the processes to follow, such as methods and procedures; and the end point, such as the answer, resolution, intended audience, and style of presentation. A student who is considered to be working at Level 1 requires a high degree of structure and guidance, whereas a student working at Level 3 does so

independently within all the parameters that have been set. Levels 4 and 5 describe open inquiry, where the starting point, processes, and end points are determined by the students. At Level 4 this is scaffolded, so that, for example, students would still be limited in their scope and be given objectives to meet. At level 5 the open inquiry is determined by the student with reference to the discipline. For all of these levels, the degree of academic rigour required to fulfill them will vary according to academic level, disciplinary expectations, and so on (Willison, Schapper, Teo, 2009).

The RSD framework is used to assess the extent to which students improve their discipline-specific research skills as assessed by faculty members using assessment rubrics generated by the RSD framework; improve their discipline-specific research skills as measured through pre- and post-course student questionnaires; and change their regard for research processes and research outcomes, also as determined through pre- and post-course questionnaires given to students.

The framework is also currently being used to assess differences in plagiarism rates among cohorts of students involved and not involved in courses utilized explicit research skill development; the rates of progression of students into graduate research and completion of graduate-level research; and former students' evaluation of their research skills once employed.

Constructing, Validating Assessment Tools

The primary assessment tools utilized are diagnostic assessments provided early in a course, followed by summative assessments provided late in a course. Many disciplines' assessments are available for download on the RSD web site (see Willison, O'Regan, 2006). These are typically pre-existing assessment instruments that have subsequently been reframed by the RSD framework. This reframing is done in terms of the purpose of these instruments, that is, to explicitly and coherently develop and assess research skills; and in terms of the ways that faculty members assign grades using assessment rubrics shaped according to the six facets of the RSD and focused on discipline-specific research processes. This is an assessment-first orientation to curriculum redesign, which takes into account that assessments are often the point at which students begin to engage with the curriculum.

One type of validation of RSD-based grading rubrics is demonstrated by a freshman human biology course that has used RSD-based grading criteria for four years. There has been a

Human Biology Students in their Freshman year gather data from the field for their Level 4, open-ended research

trend in the correlation between marks given for a literature-research task conducted in the middle of the first semester and the grades students receive for a field-based research task completed at the end of the second semester. Before the RSD was used to inform the grading criteria, the correlation of the two marks was 0.2. With RSD, this correlation significantly increased, to 0.57, ($p < 0.05$) in 2007 (Willison, Peirce, Ricci, *under review*).

The most likely explanation is that, as the skills associated with the literature research were explicitly and incrementally developed, some of the skills associated with field research were also developed even before students went out into the field (Willison, et al, *under review*). This is one piece of evidence toward the validation of the specific assessment rubrics. In most disciplines and year levels, students typically improve by an average of one level of autonomy during a semester. However, this average masks the differential improvement among students. Some students assessed as stronger at the beginning of the course do not develop skills as quickly as others, and the strongest students at the end of the course sometimes are those who started out as average or weaker.

The second set of assessment tools is pre-course questionnaires and post-course questionnaires. Both contain the same fifteen Likert-scale questions and two open-ended questions. The first nine Likert-scale questions ask students to assess their discipline-based research through such statements as, "My ability to ask rigorous research questions in Business Law is good." The remaining six questions ask about attitudes to research, such as, "Research has trustworthy outcomes." Students in RSD courses are consistently demonstrating statistically and educationally significant increases in specific research skills in the

Human Biology Students in their Freshman year involved in a Level 2, closed research task

content of the discipline they are studying. For example, business law students emphatically indicated significant increases in "ability to generate procedures to produce information" in the discipline during the semester. Questionnaires in themselves cannot be classed as reliable, as reliability is a function of specific questionnaire data (Cohen, 1988), but results from the pre- and post-course questionnaires in different contexts are showing consistently high reliability measures, as determined by a Chronbach's Alpha score of greater than 0.8 (Willison, et al, 2009). This is also an oblique justification of the RSD itself, as half of the questions are directly related to the RSD facets.

With the use of a conceptual model that informs faculty members' assessment of students, their construction of the questionnaire, and their efforts playing a substantial part in determining success in achieving the outcomes sought, there is always the danger of promoting a "self-fulfilling prophecy." To minimise this peril, another dataset is gathered that is substantially different in type and timeframe from the others mentioned above. This dataset is transcripts of interviews with students one year after completing a course that has embedded RSD-based assessments. From these interviews, more considered, longer-term aspects of the use of the RSD emerge. This triangulation of data gives substantial multiple perspectives on the benefits and detriments of explicit attempts to develop research skills. In addition, the 2005 cohort of students taking human biology is being tracked to determine long-term benefits, if any, of an explicit focus on development of research skills.

Evaluation can only determine the success of the implementation of a conceptual model. However, if the model is useful, this will show over time. Overall, the justification for the RSD framework would be substantial positive student outcomes and minimal negative outcomes in a variety, but not necessarily all, contexts. Other forms of evaluation, including students' rates of progression to and completion of graduate research, and employers' assessments of the research skills of former students they have hired are currently being implemented.

Outcomes and Scalability

Students' discipline-specific research skills are, on average, measurably increased in courses incorporating RSD-based grading rubrics. Students in the year-later interviews frequently state that the research skills they learned help them with subsequent university studies and with their employment. As noted, freshmen in human biology courses who do well in their first-semester literature research tend to do well with the second semester field research (but not necessarily the second-semester exam). Due to students' differential development, some students develop minimal research skills, but they can be identified as "at risk" of performing badly in the field research, based on their grade on the literature research, meaning support can be targeted at them. Moreover, many of these "weaker" students, when interviewed later, still appreciate that the attempt to explicitly develop their skills was, in hindsight, very useful for them in subsequent studies, employment, or both.

A minority of students have indicated that the process was not helpful for them and that other disciplines assisted them more. In an intensive Introductory Academic Program for international students who are new to an English-speaking university, students indicated in interviews that, while the RSD was informative at the time, its longer-term usefulness was low because the skills learned were not used in their subsequent courses. This highlights the need for students' research skills to be developed in discipline-specific, content-rich contexts, as opposed to general courses attempting to develop transferable research skills.

Another type of useful outcome has been the steady increase in faculty members' use of RSD-based approaches. Faculty members teaching freshman human biology began to use an early version of the RSD (Willison, O'Regan, 2005) in 2005, and in 2006 were joined by faculty members teaching masters coursework in electronic engineering. In 2007, faculty members in nursing, agricultural science, petroleum engineering, business

and psychology began to utilise the RSD in four additional universities. In 2008 faculty also adopted the framework in their classes in English, dentistry, veterinary science, computing science, education, human resource management, and tourism. An external review of the Research Skill Development and Assessment in the Curriculum project stated that the RSD is a very useful conceptual framework if it is fully adapted to the context in which it is used; therefore it requires time to be correctly set up (Nightingale, 2008). Outside disciplinary boundaries, programs that prepare students to gain entry to university are also utilising the RSD. At present, eight universities are known to be using the RSD in at least one discipline or context.

A high degree of cross-pollination of RSD-based ideas has been found across disciplines, first suggested by the move from human-biology classrooms to electronic engineering. Disciplines that may otherwise be unrelated may have similarities in how courses are taught and so prove useful to informing faculty members about how to structure research-skill-building activities and assessments. For example, business law uses scenarios, an idea familiar to dentistry faculty members who utilise problem-based learning scenarios. The RSD-informed grading criteria used by business law inspired dentistry faculty members to incorporate RSD approaches; (Snelling and Karanicolas, 2008) they subsequently have inspired at least three other disciplines with their use of Wikis to develop and assess student research skills. The RSD Web site provides access to the assessment rubrics of many disciplines' assessments, so that these may be downloaded, adapted, and used in new contexts. Multiple users in multiple contexts over time, each engaging in formal evaluation procedures, will provide substantial understanding about the benefits and limitations of the RSD framework and the approaches that it has inspired.

Programmatic Changes Based on Assessment

The most common change that faculty members indicate that they have made through the use of RSD-informed assessment tasks is they way they talk to their students. For example, class readings are more clearly framed as engagement with others' research agendas, which may both inform students about discipline-appropriate processes and provoke discussion about the veracity of each instance of research. Many disciplines are just completing their first semester of experimenting with RSD-inspired approaches and are still analysing pre- and post-course questionnaire results, as well as diagnostic and summative assessment results.

Further, faculty members in the disciplines that are into their second or subsequent years of RSD have responded to analyses of assessments, questionnaire results, and follow-up student interviews. Changes they have undertaken have included formally including RSD-based ideas in course literature, descriptions of course purposes, and in online environments; making development of research skills even more explicit to students in subsequent years; factoring in ways to help students make the most of RSD-rubric feedback; expanding the number of assessments utilising RSD-based rubrics in a course; expanding RSD approaches to other courses under the control of these faculty members; and involving additional faculty members in RSD processes.

Five different major approaches to implementing the RSD have been used so far, all of which have emerged in specific contexts and influenced other contexts. The first and most common is the use of RSD-informed assessment rubrics, pitched at an appropriate level of autonomy, to determine a student profile of performance for each assessment, and to track changes over the duration of the course. The second approach is more "lockstep," in which students are expected to demonstrate Level 1 autonomy with the required degree of rigour, before proceeding to Level 2, and so on. The third approach is to assess the six facets of RSD via student utilization of Wikis as a team research process and then to present their final research product as a poster or presentation. The fourth use of the RSD is to evaluate existing assessment tasks, to determine their strengths and weaknesses. Commonly the requirement for students to evaluate information or data is missing or underdeveloped. The fifth emerging use of the RSD is by faculty members considering how the framework may be used in the supervision of graduate research students. This last approach raises the importance of the segue between undergraduate and graduate study, as students who move on to further study may be more ready to conduct research due the explicit focus on developing research skills they have encountered in their earlier studies.

Conclusion

Explicit and coherent development of research skills in the curriculum is one way of enabling undergraduate students to participate in the benefits of undergraduate research. Only a few of these students may be developing knowledge new to humankind, but potentially all will be developing the skills associated with discipline-specific research. RSD-based approaches can overcome some of the difficulties associated

with mentored research models, such as cost, the necessity of criteria to determine who may (and may not) participate, and the capacity to evaluate the success of programs.

An external reviewer of the RSD project stated, however, that the framework is not a silver bullet for courses; each context requires thoughtful adaptation of the framework to fit the university, discipline, course, and faculty personalities concerned, and this requires time and effort. Not all undergraduate students are prepared or willing to engage in more open-ended inquiry and may resist, resent, or find fault in RSD-based curricula. While early findings have been in general positive, these results should be approached tentatively, and trials and evaluation in each context must precede any policy about RSD implementation.

The Research Skill Development framework, used as a conceptual model to inform the explicit and incremental development of student research skills in the curriculum, has proven to be highly flexible, allowing faculty members to adapt it to their disciplinary contexts and enabling communication among disciplines and universities to inform and inspire a multiplicity of approaches. It has enabled the modification of standard assessments so that these fit into the one major agenda of developing students' research skills. Substantial gains have been recorded for most students involved in courses with RSD-based approaches. The RSD has enabled gathering of common data, allowed faculty members to measure changes in students' research skills over time, and allowed students to assess their own programs—all providing information that should help provide a basis for comparative analysis of the value of undergraduate research.

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