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A vertically integrated, embedded curriculum enhances the information literacy skills of science undergraduates

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Information literacy is often cited as a key graduate attribute. The literature strongly suggests that embedding information literacy into the curriculum is the most effective means of supporting student learning. Within this framework, academics and librarians must share responsibility for teaching information literacy. The School of Zoology has worked in partnership with the Science Library to devise an embedded, vertically integrated Information Literacy curriculum. We used a longitudinal survey to assess the development of information literacy skills by a cohort of Zoology students exposed to overt teaching and assessment of information literacy through the three years of their undergraduate degree. The survey instruments were designed to assess students' skills and attitudes against the Australian and New Zealand Information Literacy Framework (ANZIL) Framework standards. Our results show that, in general, our students' skills did increase significantly from year 1 to year 2, with a trend for a further increase from year 2 to year 3, although that increase was not significant. These results demonstrate that embedding information literacy within the science curriculum is an effective strategy for improving the generic skills of science graduates, and preparing them as life-long learners.

Keywords: graduate attributes, information literacy, longitudinal survey

In today's increasingly competitive higher education environment, there is a growing need for universities to demonstrate that their teaching programs are geared towards graduating students who are well prepared as life long learners (Clanchy and Ballard, 1995;Parker, 2003). A fundamental assumption is that we are preparing our students for an unknown future and that students must be enabled to continue learning throughout their lives (Candy, Crebert and O'Leary, 1994). Most universities today have developed a statement of graduate, or generic, attributes that identify the characteristics their graduates should posses as a result of their university experience and information literacy is often cited as a cornerstone graduate attribute (Catts, 2004). Information literacy "enables learners to engage critically with content and extend their investigations, become more self-directed, and assume greater control over their own learning"(Council of Australian University Librarians, 2001: p. 2). Candy, Crebert and O'Leary (1994: p. 102) commented that: "a graduate cannot be considered to be, even embryonically, a 'well-rounded person', unless he or she possesses a degree of 'information literacy".

The literature strongly suggests that the most effective learning outcomes occur when generic skills are an integral part of teaching within the discipline and taught to students in a structured and progressive manner (Shapiro and Hughes, 1996). Rockman (2002) suggests that embedding information literacy into the curriculum is the most effective means of supporting student learning. In recent years, there has been a shift from "bibliographic instruction" (*sensu* Lupton, 2002) towards viewing information literacy as a comprehensive learning process. Within that conceptual framework, academics and librarians must share responsibility for teaching information literacy so that information literacy skills (ILS) are taught within the context of discipline-specific research paradigms (Asher, 2003; Grafstein, 2002). This facilitates a move from a library-based, skills-training environment to a learner-centered paradigm which fosters a deep learning approach to information literacy (Lupton, 2002) and fosters mechanisms for reinforcement and development of students' ILS over time (Rockman, 2002).

This paper describes an investigation of whether this theoretical approach translates into real learning outcomes for undergraduate students in science. Within the School of Zoology, University of Tasmania, we have worked in partnership with the Science Librarian over the last ten years to develop a vertically integrated information literacy curriculum embedded within core first, second and third year Zoology units. In doing so, we took account of the literature advocating such an approach (e.g. Rockman, 2002; Shapiro and Hughes, 1996). At each year level, information literacy workshops are geared to specific needs and linked to assessment items, and there is a clear progression based on the students' cognitive development and increasing skills base over the three years. For example, at first year level, students are given an overview of the library research process, and then complete a follow-up assignment in which they document the strategies they used to begin researching an essay topic. This Library Exercise is assessed by the Librarian, and handed in by the student with the essay to which it is linked. In one second year level exercise, students view a video and discuss a popular science documentary, and are then asked to critique its scientific accuracy. To support that assignment, the lecturer and librarian jointly run a workshop on how to find the science behind the story through analyzing the topic, then choosing and using data bases and library subject guides. Third year students are introduced to the power of EndNote® as a bibliographic tool, and use it in researching and presenting a review essay. To examine the efficacy of this teaching approach, we used previously trialed survey methods (Dearden et al. 2005; Jones et al., 2005) to assess the development of information literacy skills in a longitudinal study of a cohort of Zoology students.

Methodology

We assessed the information literacy skills (ILS) of undergraduate students of the School of Zoology, University of Tasmania using a multipart survey designed to test students' current knowledge, skills and practice against the *Australian and New Zealand Information Literacy Framework (ANZIL) Framework* Standards (Bundy,2004). The Standards provided learning outcomes that could be adapted to teaching and learning. Our survey instrument (Parts A and B) was modified from two surveys provided to us, respectively, by Ralph Catts (then at University of New England) and Judith Peacock (Queensland University of Technology). The survey probes students' knowledge of, and attitudes towards, information literacy using questions matched to the six Information Literacy Standards outlined in the ANZIIL Information Literacy Framework (Bundy, 2004), all questions being linked to specific standards (see below).

Standard One: the information literate person recognises the need for information and determines the nature and extent of the information needed.
Standard Two: the information literate person finds needed information effectively and efficiently.
Standard Three: the information literate person critically evaluates information and the information-seeking process.
Standard Four: the information literate person manages information collected or generated
Standard Five: the information literate person applies prior and new information to construct new concepts or create new understandings.
Standard Six: the information literate person uses information with understanding and acknowledges cultural, economic, legal and social issues regarding the use of information.

In 2004 and 2005, we surveyed Zoology students in first, second and third year classes, while in 2006 we surveyed third year Zoology students only. This strategy allowed us to compare the ILS of students across the three undergraduate levels within one calendar year, and, in particular, to follow one cohort of students as they progressed through the three years of their undergraduate degree (2004-2006): this is termed the longitudinal study. The surveys were anonymous and participation was voluntary. Surveys were administered during normal class time by the Science Librarian; academics teaching the unit were not present. All surveys were carried out during mid second semester so the students were near the end of that year of study, and had benefited from relevant learning experiences.

Part A of the survey (modified after Catts' survey) presents 20 statements and asks students to rate their responses on a numerical scale of zero (= never) to four (= always): each standard is associated with four statements/questions. Part B (modified after the QUT survey) is composed of multiple choice questions, each of which tests a particular attitude or behaviour linked to the exemplars for a particular Information Literacy Standard. Previous publications (Dearden et al., 2005; Jones et al., 2005) have demonstrated that Part B of our survey could highlight discipline-specific differences in the information literacy skills of students in Zoology, Computing and Engineering.

For Part A, survey responses were translated into numerical scores, and scores for all four questions matching each standard were pooled (maximum score = 12 for each of Standards 2 – 6 only). These data were analysed by one way Analysis of Variance (ANOVA) with post-hoc Ryan-Einot-Gabriel-Welsch Multiple range tests (REGW) to compare, first, the scores of the single cohort of students from 2004 (first year) to 2006 (third year) and, second, between year groups (2004, 2005, 2006) of third year students. For Part B, questions were matched to Standards 1, 2, 3, 4 or 6 only. The answers were scored as correct or incorrect, and the proportion of correct answers was calculated for each question. These data were analysed by logistic regression with log-linear modeling, except for Question 1, which asked students what sources of information they would use first in looking for information: those data are, instead, presented graphically

Results

We received 81, 36 and 14 surveys respectively from the year 1, 2 and 3 classes (in 2004, 2005 and 2006) of the cohort of students forming the longitudinal study: this represents approximately a 40-50 % return rate from each class, and most respondents completed all questions in the survey.

Survey part A

The analysis of Part A of the survey showed that there was a general trend for an increase in information literacy skills from year 1 to year 3. By year 3, students were scoring highly on all questions, reflecting a high level of information literacy skills in the pre-graduation class (Fig. 1).

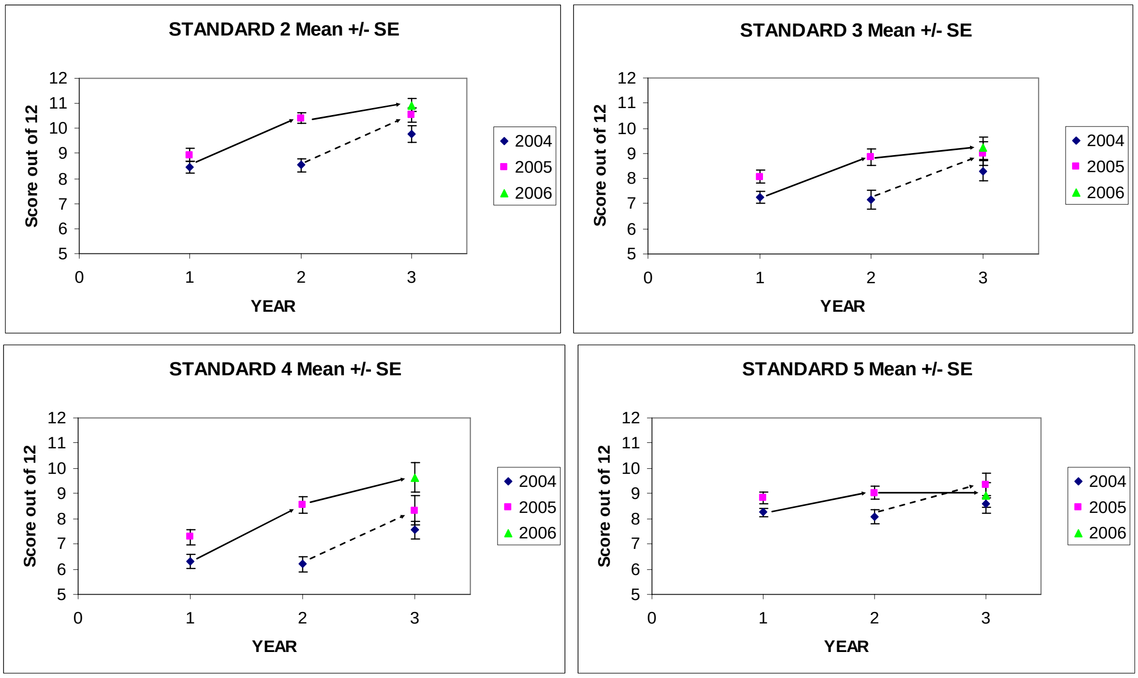

Figure 1: Changes in scores (Survey Part A) for Standards 2, 3, 4, and 5 in students surveyed during years 1, 2 and 3 of their undergraduate degree. The maximum score for each standard is 12. Arrows indicate the progress of one cohort of students between years; the solid arrows indicate the longitudinal cohort followed through all three years of their degree.

Statistical analysis of the results for Part A of the survey demonstrated that for Standards 2, 3, 4, and 5, there were significant differences amongst the responses of the same cohort of students sampled in different years. Post hoc tests showed that the significant changes were, in all cases, increase in skills between years 1 and 2 (Table 1).

Table1: Results of Analysis of Variance tests comparing scores for Standards 2 to 6 for one cohort of students surveyed during years 1, 2 and 3 of their undergraduate degree

Standard	F statistic	P	Comments on post-hoc REGW tests
2	$F_{2,123} = 21.57$	< 0.0001	Mean score increased Year 1 to 2, but not Year 2 to 3
3	$F_{2,124} = 11.26$	< 0.0001	Mean score increased Year 1 to 2, but not Year 2 to 3
4	$F_{2,124} = 20.48$	< 0.0001	Mean score increased Year 1 to 2, but not Year 2 to 3
5	$F_{2,122} = 3.43$	0.036	Insufficient power to indicate where difference lies
6	$F_{2,122} = 0.07$	0.93	(Not applicable)

Although the graphs do show a clear trend for improvement in skills, the smaller sample size at year 3 (2006) meant that, within the longitudinal study, the differences in skills between years 2 and 3 were not statistically significant. For Standard 6 (reflecting attitudes to academic honesty and plagiarism), there were no significant differences between years of study, with scores beginning and remaining high.

Survey part B

Question 1, which allowed students to choose amongst five options, demonstrated a developmental change in students' perception of where one should begin a literature search when researching an essay topic (Fig. 2). As first year students, they were more likely to use books, but by the time these students were in third year, they were more likely to be searching journals or, in particular, review articles. The use of simple search engines (e.g. Google) on the world-wide web rather than literature-based data bases was highest amongst students in their first year of study.

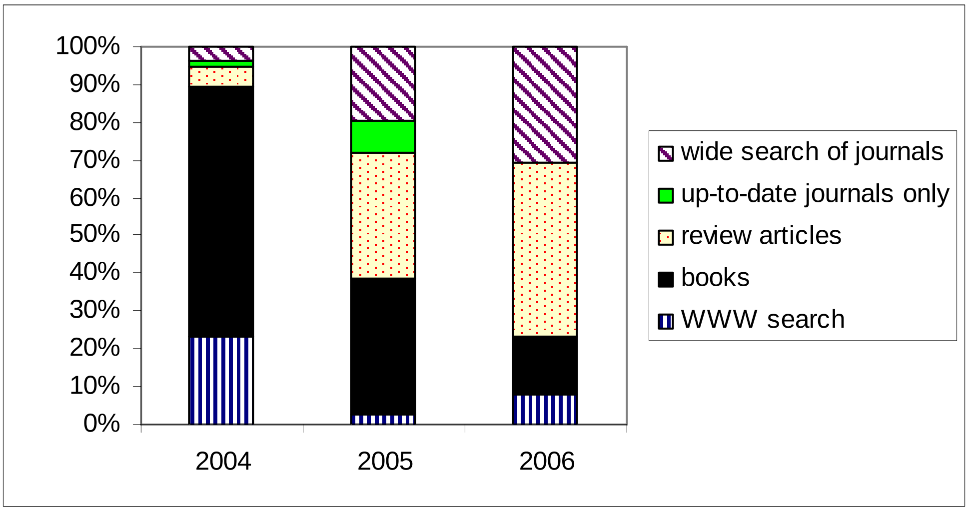

Figure 2: A cohort of students demonstrates a change in their conception of what resources they should use to begin a literature research for an essay topic from 2004, when they were in first year, to 2006, when they were third year students (Survey Part B: question 1).

Part B of the survey was less able to discriminate between the year groups and those results are not therefore, presented in detail. Unlike Part A, it was not statistically appropriate to pool scores for individual questions as each question specifically tested a particular aspect of the standard. For five questions, nearly all students, regardless of year group, chose the correct answers. Again, there was a general trend for the proportion of correct responses to increase from first to third year, but there was considerable variation in pattern between questions (see examples presented in Fig. 3), making it difficult to elucidate overall trends.

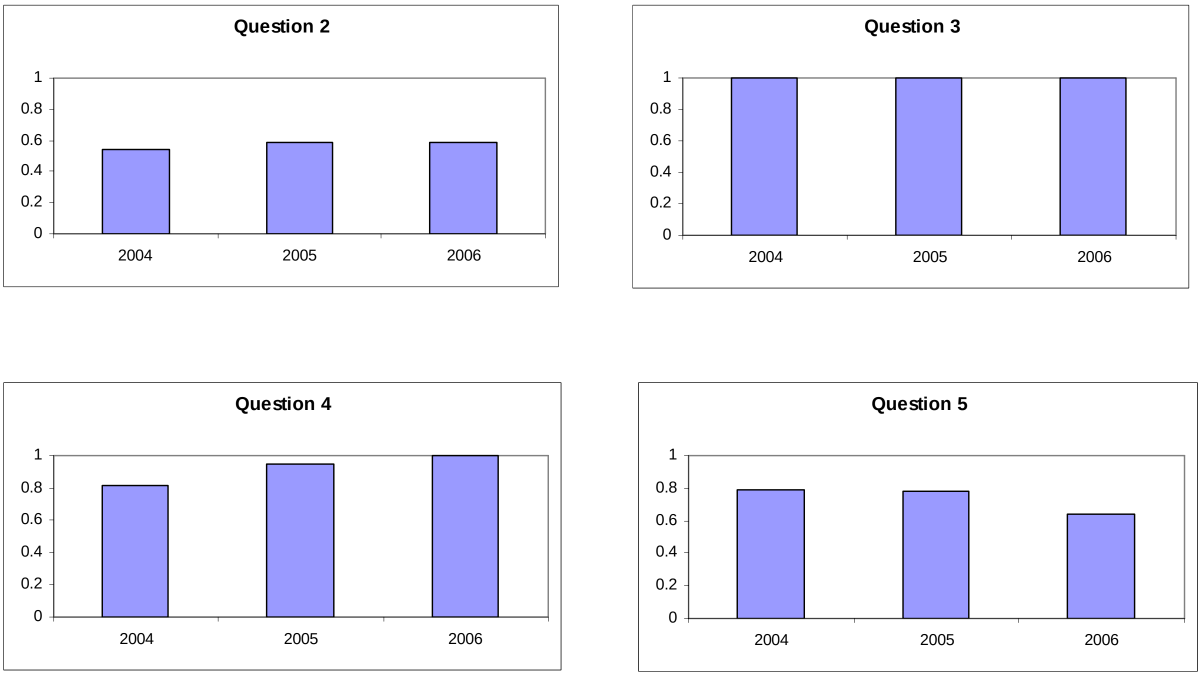

Figure 3: Proportion of correct answers in response to four questions from Part B by one cohort of students surveyed in 2004 (first year), 2005 and 2006 (third year).

Discussion and Conclusions

Hoban et al. (2004: p.12) comment that: “more emphasis needs to be placed on how graduate attributes are acquired or developed by students and the role of teaching strategies used by academics to foster such attitudes”. We set out to test whether an integrated approach towards embedding the teaching of information literacy into a science curriculum resulted in positive learning outcomes for our students. Like Grafstein (2002), we advocate a discipline-based approach to teaching information literacy, and here we present evidence for the success of such an approach.

Rockman (2002) points out that many systems of assessment of information literacy skills provide only a “snapshot” of performance at a certain stage of a student’s career. Our survey instrument and the longitudinal study allowed us to track the progress of one cohort of students through all three years of their degree program. The results of Part A demonstrate clearly that our students do increase their information literacy skills during the three years of the undergraduate curriculum. There is also evidence of an improvement in our students’ ability to critically evaluate their sources of information. This contrasts with observations by Dunn (2002) that students at California State University showed an over- reliance on web-based resources and did not make distinctions between scholarly and general works. However Dunn (2002) did find that later year undergraduates were better able to choose resources most appropriate to a research strategy. Likewise, our students shifted their preferred starting point for research as they moved from first to third year, reflecting an increased ability to engage with the primary literature.

Part B of our survey was less easy to interpret. This was surprising because the same survey had indicated some significant differences in information literacy skills between students across the disciplines of Zoology, Computing and Engineering (Dearden et al. 2005; Jones et al., 2005). This contrast may reflect the greater emphasis on information literacy in Zoology: are our students already at a relatively high skills level by the end of first year? Variation in the proportion of students' choosing a correct answer could also reflect the particular focus of their most recent, relevant learning experience. It was unfortunate that the power of the analyses for Part B was compromised by the low sample size at third year level, but we were constrained by the voluntary nature of the survey. Furthermore, it has been argued that it may be difficult to fit concepts expressed in information literacy standards to precise measures of competency (Dunn, 2002; Rockman 2002). However, responses to individual survey questions can help us tease out where students have specific misconceptions or problems that could be better addressed in our teaching. For example, Question 2 showed that a common mistake was that the search term 'conservation of the environment' would retrieve the most citations in an electronic data base (the correct answer is, of course, 'conservation OR environment'). Like Dunn (2002), we have not yet explored the full extent of what our data set can tell us.

This study also highlights the importance of the partnership between librarians and academics in designing curricula with learning outcomes expressed in terms of information literacy. In our model, information literacy teaching is closely aligned with the disciplinary curriculum, and linked with current assessment. Assessment, as well as teaching, is generally shared between librarian and academic, and information literacy is taught and assessed in a problem-solving context. This strategy fosters the development of higher level cognitive skills such as critical thinking (Stubbings and Franklin, 2006). It contrasts with the model of "bibliographic instruction" (Asher, 2003; Lupton, 2002) in which information seeking skills are taught outside the context of the discipline, and within the paradigm of 'library as provider' (Catts, 2004). Lupton (2002) lobbies strongly for the librarian-academic partnership, and suggest that librarians should see themselves as teachers rather than trainers. She also suggests that information literacy learning outcomes should be explicitly stated in unit outlines, that there should be a developmental sequence of learning through a degree program, and that the teaching librarian should be able to assess learning outcomes by viewing students' work. We have independently come to similar conclusions during the development of our information literacy curriculum. Asher (2003) takes issue with this notion, arguing that the two areas of expertise (academic versus librarian) should be clearly delineated, with their *interdependence* rather than their merging best serving students' needs. However this appears to be a lone voice in the current literature, with most writers strongly supporting the concept of partnership (e.g. Stubbings and Franklin, 2006).

In conclusion, our study demonstrates the value of a partnership between academics and librarians in designing, delivering and assessing an information literacy curriculum that is vertically integrated across the years of an undergraduate science degree in improving learning outcomes for students. This curricular framework supports students' development ínto information literate graduates equipped to be lifelong learners (Shapiro and Hughes, 1996).

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