Journal of Academic Language & Learning
Vol. 8, No. 2, 2014, A60-A71. ISSN 1835-5196

AALL
Association for Academic Language and Learning

Iterative writing programs may generate higher student confidence about their ability to write, but not necessarily improved writing ability

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(Received 3 January, 2014; Published online 10 June, 2014)

Student writing proficiency is considered to be a hallmark of educational excellence. This study reports on an iterated writing skills development program, incorporating elements of content, form and context, for science undergraduates. The program, which was initiated in first year biology and then iterated through a second year science unit, investigated student confidence about their writing and writing-related skills, and the correlation with actual writing ability in terms of an annotated bibliography and a literature review. Other things being equal, commencing second year students who had completed first year biology, which included scaffolded practice in essay writing, had significantly higher confidence regarding five of the seven skills examined in this study, compared to students who had not. Further, upon completion of the second year unit, the level of confidence was still significantly higher with regard to four of these seven skills. However, there was no significant difference in marks for both second year writing tasks between students who had or had not completed the first year subject. This study demonstrates the considerable value that iterated writing cycles, including feedback and opportunities for revision, have on student perceptions of their writing and writing-related skills. However, students may be overestimating their actual ability to write in a scientific domain, given an apparent disconnect between their self-perceived ability and their actual marks for the assignments. Different explanations of this disconnect suggest different remedies. If it occurred because students are not aware that markers' expectations increase each year, then clearer instruction about increasing task difficulty, together with assessment and writing guidelines from unit coordinators and ALL staff, are required to better inform students so that their perceptions and actual writing abilities are more strongly aligned. If it occurred because skills developed in writing one type of assignment do not necessarily transfer to writing a different type, both students and teaching staff need to treat each different type as a new writing challenge, to some extent. Either way, the results cast doubt on a common assumption that training in academic skills in first year is sufficient to carry students through their work in subsequent years.

Key Words: Assessment; feedback; scientific literacy; academic language and learning; graduate attributes.

1. Introduction

The quality of graduate attributes and their inculcation over the course of degree programs are highly debated contemporary issues in undergraduate science education. Of these many attributes, which include discipline knowledge, critical thinking, problem solving and teamwork skills, effective writing skills are among the most highly regarded (Patterson, 2001; Peat, Taylor, & Franklin, 2005). Indeed, employers rank written communication skills equally with, or more important than, quantitative or specific technical skills (Gray, Emerson, & MacKay, 2005). Effective writing is highly valued in science disciplines as it enhances critical thinking skills (Quitadamo & Kurtz, 2007) and enables students to actively reflect upon and integrate their science content knowledge (Keys, 2000). Further, writing has considerable value in enhancing student understanding of underlying scientific concepts, viz-a-viz the "writing to learn" approach (Singletary & Sampson, 2011) in which students organise and articulate their ideas, using scientific words and symbols, to create meaning and therefore reinforce their underlying knowledge. Alternatively, the "writing to communicate" approach, exemplified best by the student practical report, is more prescriptive in that it focuses on the method by which writing conveys a message (Balgopal & Wallace, 2013). Unfortunately, a high proportion of undergraduate students experience considerable difficulty researching, structuring and writing science essays (Rayner & Cridland, 2009) and practical reports (Cronje, Murray, Rohinger, & Wellnitz, 2013). This, together with the fact that writing ability has been reported as lacking in graduates from Australian universities (Neilsen, 2000; Oliver, Whelan, Hunt, & Hammer, 2011), demands that efforts be made to develop initiatives that will enhance student writing skills, which provides the underlying rationale for this study.

Semester-long writing exercises have considerable potential to improve students' writing skills (Holb, Longest, & Jensen 2013), both generally and in terms of Academic Language and Learning (ALL). In particular, text-specific feedback incorporating form, content and context has been shown to positively impact student writing (Freestone, 2009; Libarkin & Ording, 2012; Vardi, 2012). Nevertheless, it is possible that students may not clearly understand the need for a higher standard of writing on iterated writing assignments, both within and between year levels. This is important, as it may contribute to the potential disparity between student perceptions of a particular ability and their actual competency for that ability (Dunning, Johnson, Ehrlinger, & Kruger, 2003). This raises questions about the clarity of guided rubrics and/or associated assessment standards, and further suggests that there should be greater scrutiny of students' own perceptions of their skills.

The primary aim of this study was to investigate whether iterative writing in first year biology, incorporating feedback and resubmission of essay assignments, generated higher quality writing skills in second year science students. Our study, which used a framework incorporating both online survey and direct assessment tools, also investigated whether student confidence in their writing and writing-related skills increased following a subsequent, second year iterative writing program, and whether these levels of confidence correlated with assignment marks in their second year writing assignments.

2. Research methodology

2.1. Writing program structure

As part of their studies in first year biology, students completed two essays, each focussed on an aspect of science or medicine and requiring research, the integration of published material and conventions regarding attribution. The writing program, based on an iterative cycle (see Figure 1), was scaffolded through provision of guidelines, exemplars of well- and poorly-written essays, an online referencing tutorial, and a range of workshops conducted by ALL staff. The ALL staff collaborated with the unit coordinator to develop marking guidelines and assessment rubrics. The iterative cycle for each essay involved submission of an initial full draft, for which students were provided with substantial feedback, including comments, annotations, suggestions and corrections and a mark, weighted at 30% of the overall mark. This mark was generated from an assessment rubric which reflected student performance for their mechanical aspects of

writing, such as grammar, spelling, syntax, structure and organization, as well as synthetic elements such as evidence, attribution and referencing. Students were then given two weeks to make required corrections and improvements, before submitting the final essay for further feedback and final assessment (see Figure 1). For the period 2010-2012, the mean mark for each first year biology essay was 78.5 ± 0.5% (first essay) and 78.3 ± 0.5% (second essay).

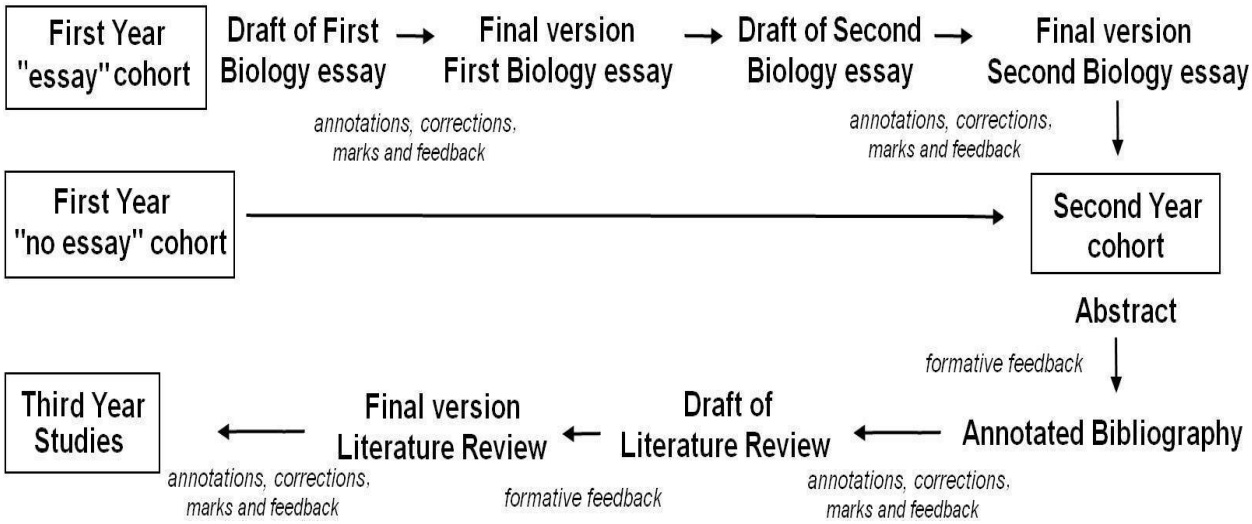

Figure 1. Schematic of the writing program structure used in this study. The first year iterative writing program involved sequential essays over the course of a calendar year, and the second year program an Annotated Bibliography and Literature Review, over the course of one semester.

The iterative writing cycles in first year biology were built upon in SCI2010 (see Figure 1), a compulsory second year unit in Science and associated degrees at Monash University. Students who took this unit, including those who had completed first year biology and those who entered from other discipline areas, undertook as their primary assessment task a scientific Literature Review (LR), which was developed in a series of stages (see Figure 1). Students started with a summary of a peer-reviewed scientific paper (Abstract), which was then built upon in an Annotated Bibliography (AB) comprising five such summaries, through to a full LR, involving critical evaluation and synthesis of information from a range of primary peer-reviewed scientific papers (see Figure 1). Students used Turnitin® plagiarism-detection software prior to submitting their AB and LR, with a 10% similarity index set as the maximum allowable threshold. The AB and LR were marked using the same four general criteria, namely content, structure, style and referencing. At this level, the iterative writing cycle was scaffolded by considerable formative feedback on the initial Abstract, with further formative assessment via anonymous peer review of an LR draft (see Figure 1), using a standardised rubric based on the above-stated criteria. As with the first year essays, student skills development was supported through provision of guidelines, exemplars of well- and poorly-written reviews, and ALL-conducted workshops.

As an ALL writing activity, the second year LR strongly aligned with the first year biology essays. This alignment included broad similarities in structure (Introduction, Body and Conclusion), word count, conventions in referencing and attribution, and modes of assessment. Those students who had completed first year biology were, for the purposes of this analysis, designated the “essay” cohort (75.3%); the remaining students, who completed only the LR and did not undertake first year biology (24.7%), were designated the “no essay” cohort (see Figure 1). Students who had completed similar writing tasks (n = 102) in other science degree units were excluded from analyses.

2.2. Self-assessment survey

Students undertaking SCI2010 during 2010-2012 completed an online survey in which they assessed their own ability to undertake a range of science- and writing-related tasks (n = 1295, 49.8% of total enrolled students). The survey comprised 19 volunteer-response, Likert-scale questions, many of which are strongly ALL-related (see Table 1). The entire question set aimed to investigate the range of pedagogical and societal issues related to science knowledge and application; however, for the scope of this study, analysis was restricted to the seven writing and writing-related questions (bolded in Table 1).

Table 1. Monash University SCI2010 self-assessment survey questions for 2010-2012 (student responses for bolded questions were analysed with Student's *t*-test).

What is your self-assessed ability to:

- understand current major topics in science?
- be aware of cutting-edge scientific research?
- form opinions on current scientific debates?
- **ask and refine questions on scientific topics?**
- **find relevant scientific literature?**
- **quickly read and summarise scientific papers?**
- be aware of ethical issues relating to scientific research?
- be aware of OHS issues relating to scientific research?
- **prepare written summaries of scientific papers?**
- **prepare a written scientific literature review?**
- give an oral presentation?
- prepare a scientific poster presentation?
- **be able to avoid plagiarism?**
- **understand scientific referencing requirements?**
- be familiar with presentation software packages?
- be aware of how science relates to management?
- be aware of how science can be commercialised?
- understand the political impact of scientific research?
- be aware of the broader social implications of science?

Data pertaining to these seven questions were collated across six semesters (two semesters in each calendar year). Each of these questions was subsequently filtered for matched pair responses, generating data only for those students who had completed surveys both at the start and end of semester ($n_{initial}$ = 910, 35.0% of total enrolled students). The mean scores for each question for the "essay" cohort and the "no essay" cohort, together with overall means, were determined at the start and end of semester. To avoid bias, the surveys of 57 students who had completed only one biology essay and/or had received a zero mark for one or both of the first year essays were excluded from all analyses ($n_{intermediate}$ = 853, 32.8% of total enrolled students).

2.3. Validation of student grades for Annotated Bibliographies and Literature Reviews

Marking of second year AB and LR assignments was carried out by sessional tutors, comprising a mix of graduates and postgraduate students. To enhance consistency and reliability in marking LRs, prior to grading the student assignments, markers assessed two practice LRs, and discussed their interpretations in order to generate agreement around the grading of the four assessment criteria (see above). To ensure that only completed assignments were assessed, 132 assignments with marks of zero for either the AB or the LR were omitted from analyses, along with corresponding survey data (n_{final} = 723, 27.8% of total enrolled students). All AB marks

were pooled across the six semesters, and the mean determined. This method was repeated for the LR assignment. Overall means for the period 2010-2012 were 72.5 ± 0.6% for the AB, and 69.9 ± 0.6% for the LR.

2.4. Statistical analysis

Means and standard error measurements (SEMs) of data from student self-assessment surveys were calculated using a modified Likert-type scale from 0.0-1.0 (Likert, 1932). One-tailed *t*-tests (Gosset, 1908) were applied to derived means, with differences considered significant if $p < 0.05$. Cohen's (1988) *d* values of effect size were calculated using Excel®.

3. Research Findings

3.1. Effects of first year biology essay writing on SCI2010 self-assessment survey data

Students who completed the two first year biology essays, prior to undertaking the second year assignments, had significantly higher self-assessed ability for five of the seven writing and writing-related competencies, than students who did not undertake the essays (see Figure 2). Competencies for which there was no significant difference between the cohorts were (i) the ability to ask and refine questions on scientific topics, and (ii) the capacity to avoid plagiarism (see Figure 2).

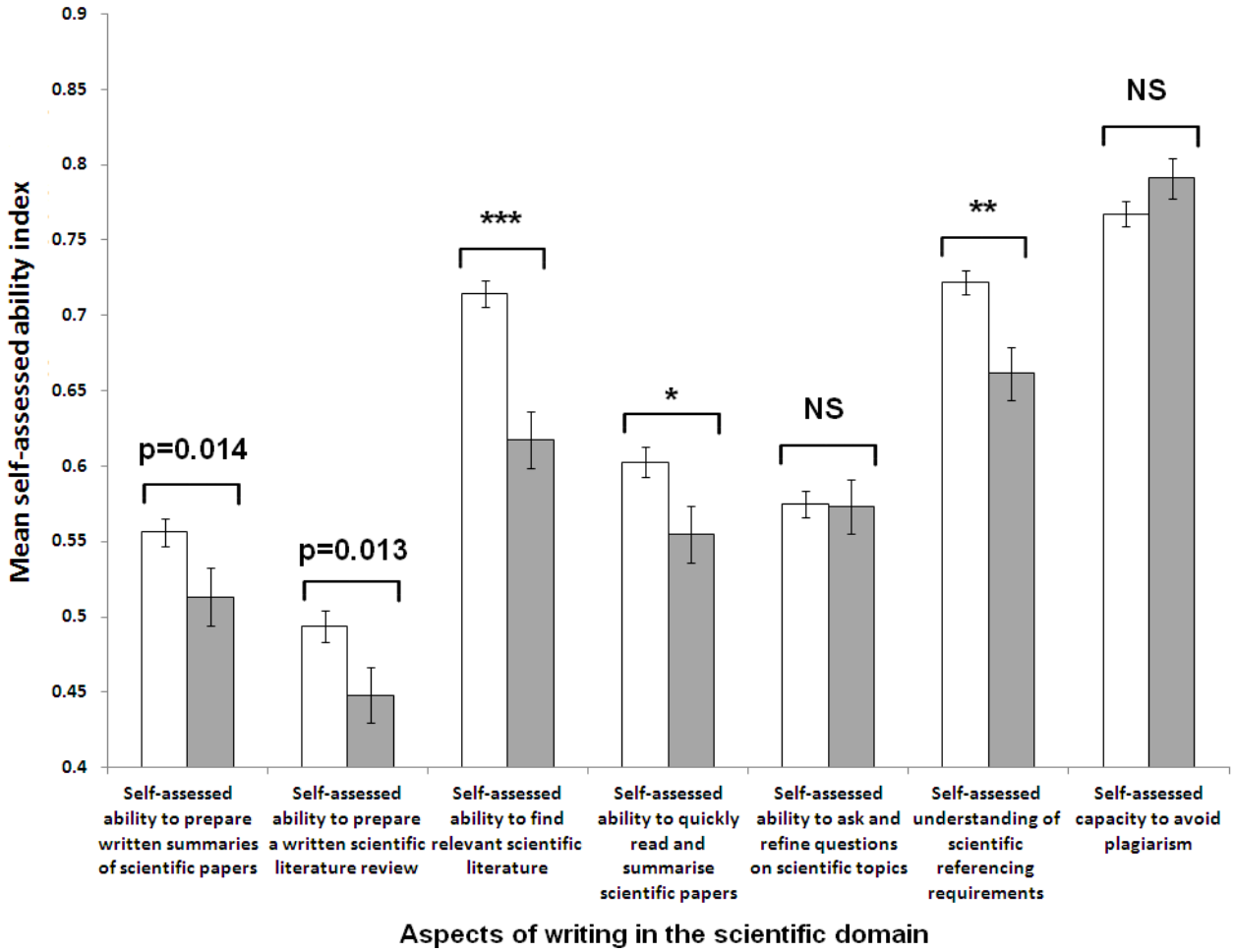

Figure 2. Student self-assessed ability (mean ± SEM) in relation to seven writing and writing-related skills, upon commencing SCI2010, grouped with respect to first year essay writing history. For the "essay" cohort (open columns), $n = 544$; for the "no essay" cohort (shaded columns), $n = 179$. NS indicates Not Significant, * denotes $p < 0.01$, ** denotes $p < 0.001$, and *** denotes $p < 0.0001$. Ability index ranged from 0 (no ability) through 0.5 (moderate ability) to 1.0 (very strong ability).

3.2. Comparing students' writing-related and task-related abilities at commencement of SCI2010

The students' self-assessed ability to prepare a written scientific LR ranked significantly lower than each of the other six competencies, for both the "essay" (all *t*-values between 2.3 and 10.4, with all corresponding *p*-values < 0.0001) and "no essay" (all *t*-values between 1.2 and 7.5, with all corresponding *p*-values < 0.008) cohorts (Figure 2). By contrast, their self-assessed ability to prepare written summaries of scientific papers (i.e. the AB) ranked lower than four of the other five competencies, for both the "essay" (all *t*-values between 1.7 and 8.5, with all corresponding *p*-values < 0.003) and "no essay" (all *t*-values between 1.1 and 5.9, with all corresponding *p*-values < 0.008) cohorts (Figure 2). For the "essay" cohort, there was no significant difference with the self-assessed ability to ask and refine questions on scientific topics: for the "no essay" cohort, it was the self-assessed ability to quickly read and summarise scientific papers.

3.3. Effects of SCI2010 writing on student self-assessed ability

Upon completing SCI2010, student self-assessed ability was significantly higher for all seven writing and writing-related skills, regardless of whether or not they had written the first year essays in biology (see Table 2). The effect size of the course on each of the competencies was very large (Table 2).

Table 2. Increase from the beginning to the end of the semester in mean self-assessed ability (index units) with respect to seven writing and writing-related skills for SCI2010 students (n = 723). For all *t*-tests, *** denotes $p < 0.0001$.

Variable	Mean self-assessed ability index increase	Effect Size
Ability to prepare written summaries of scientific papers	0.23***	1.08
To prepare a written scientific literature review	0.22***	1.00
To find relevant scientific literature	0.15***	0.72
To quickly read and summarise scientific papers	0.18***	0.83
To ask and refine questions on scientific topics	0.18***	0.88
To understand scientific referencing requirements	0.15***	0.83
To be able to avoid plagiarism	0.10***	0.57

Of all students, those who had completed first year biology essays had significantly higher self-assessed ability for four of the seven skills upon completion of SCI2010, compared to students who had not undertaken these tasks (see Figure 3). Skills for which there was no significant difference between the cohorts were (i) the ability to quickly read and summarise scientific papers, (ii) the understanding of scientific referencing requirements, and (iii) the capacity to avoid plagiarism (see Figure 3). The skills for which there was a significant difference between the "essay" and "no essay" cohorts upon commencing SCI2010, but which were no longer significantly different after completing this second year unit, were (i) the ability to quickly read and summarise scientific papers, and (ii) the ability to understand scientific referencing requirements (compare Figures 2 and 3).

3.4. Comparing students' writing-related and task-related abilities upon completion of SCI2010

Students' self-assessed ability to prepare a written scientific LR still ranked significantly lower than the other six competencies, for both the "essay" (all *t*-values between 1.8 and 7.3, with all corresponding *p*-values < 0.0002) and "no essay" (all *t*-values between 1.4 and 4.6, with all corresponding *p*-values < 0.0006) cohorts (Figure 3). However, their self-assessed ability to

prepare written summaries of scientific papers (i.e. the AB) had increased to the extent that it only ranked lower than three of the other five competencies for the "essay" (all *t*-values between 2.6 and 4.7, with all corresponding *p*-values < 0.0001) and "no essay" (all *t*-values between 1.6 and 3.1, with all corresponding *p*-values < 0.006) cohorts (Figure 3). For both cohorts, there was no significant difference with students' self-assessed abilities to (i) ask and refine questions on scientific topics and (ii) quickly read and summarise scientific papers.

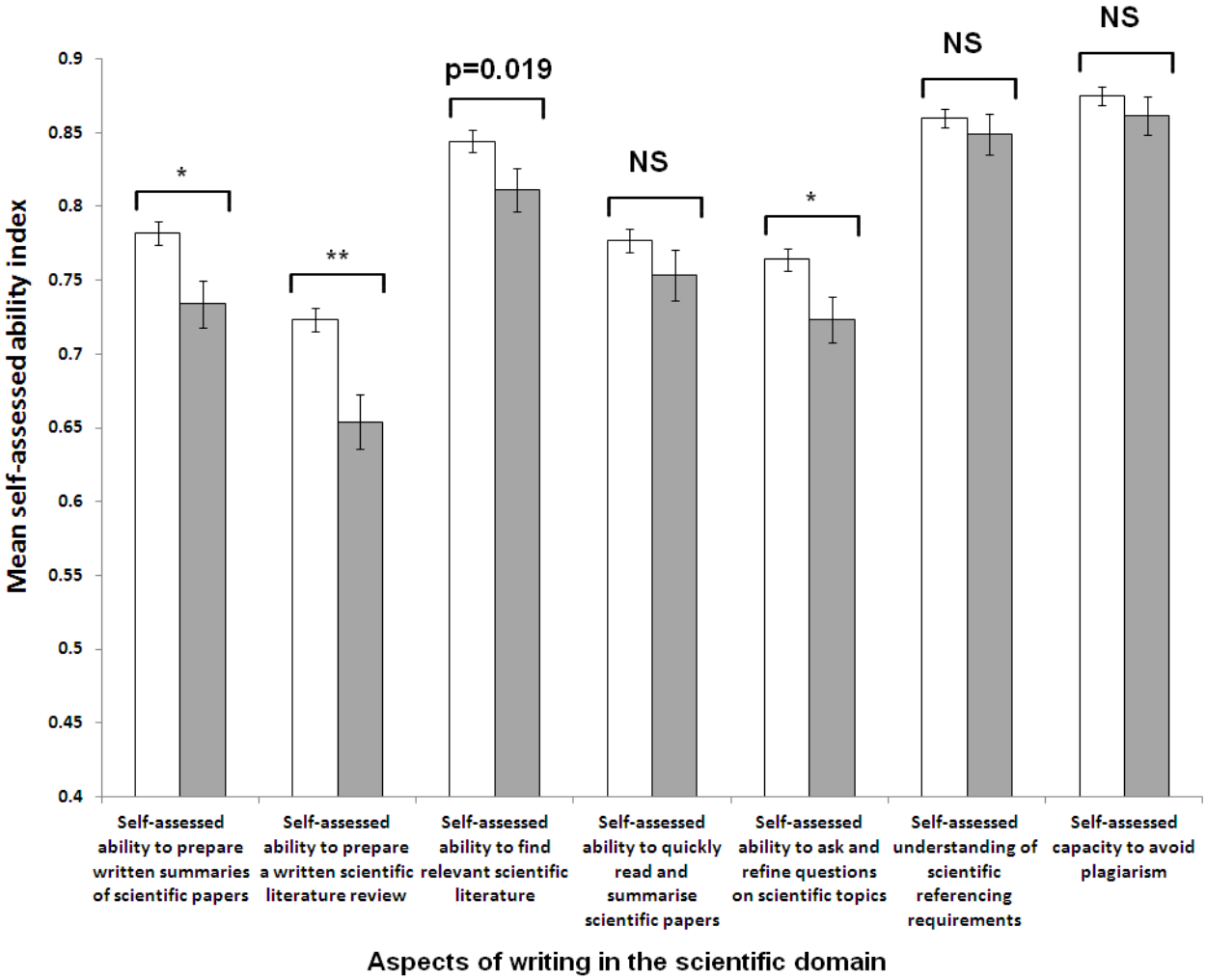

Figure 3. Student self-assessed ability (mean ± SEM) in relation to seven writing and writing-related skills, upon completing SCI2010, grouped with respect to first year essay writing history. All other indications are as for Figure 2.

3.5. Effects of first year biology essay writing on marks for second year writing assignments

Students who completed first year essays did not gain significantly higher marks for the AB than students who did not undertake them (73.0 ± 0.7% and 71.2 ± 1.4% respectively). There was also no significant difference in LR marks between the two cohorts (69.9 ± 0.7% and 69.9 ± 1.3% respectively).

There was no correlation between the confidence (at commencement of SCI2010) of "essay" cohort students and their marks for the AB (r = 0.02). However, this correlation was strong, positive and significant for the "no essay" cohort (r = 0.43, F = 6.67, p = 0.01). For the LR, although the positive correlation between "essay" cohort students' confidence (at the end of semester) and marks for this assignment was low (r = 0.1), a regression of these variables was significant (F = 6.48, p = 0.01). In comparison, for the "no essay" cohort, there was no

correlation between their level of confidence and LR marks, and the regression was not statistically significant ($F = 3.64$, $p = 0.06$).

4. Discussion

The writing skills program reported in this study is limited, in that it only promotes and assesses writing and associated skills up to completion of second year of a degree. For more conclusive results, it would be worthwhile to monitor students' self-assessed abilities and writing assignment marks from commencement to completion of their degree studies. Another possible study limitation is the number of surveyed students, which was less than 30% of the total student body during 2010-2012; however, the student numbers reflect a relatively large overall cohort, which should enable translation of these results into the general student population.

Of the seven competencies, those that related to the preparation of the LR and AB are perhaps most strongly aligned with students' self-efficacy of their actual writing *skills*, with the other five competencies being more writing *task* related. Students' actual writing skills are likely to variously reflect their proficiency in grammar, punctuation, word use and composition, which to varying degrees are considered deficient across a range of disciplines, including engineering (Kramberg-Walker, 1993), business (Mascle, 2013), and medicine (Marusic & Marusic, 2003). Thus, it is perhaps unsurprising that at the commencement of SCI2010, students ranked their self-efficacy of the two writing skills-related competencies lowest of the seven, regardless of their previous writing history. Further, student judgements of their writing self-efficacy have considerable potential to impact the actual quality of such writing, through the integrative effects of effort, interest, attention to detail, and perseverance and resilience under stressful conditions (Pajares, 2003). This demands that further research be done on the links between students' self-efficacy of their writing skills and their actual ability with respect to such.

These results show that while students who had completed first year essays were generally more confident about their writing-related skills than students who had not, this did not translate into higher grades for the AB. That the confidence of students without first year writing experience did correlate with their AB marks is intriguing, and may reflect conservatism based on lack of prior experience. Conversely, the lack of a correlation between the confidence of the "essay" cohort and their AB marks may be due to a number of interacting explanations. Firstly, the nature of the actual writing tasks may have been sufficiently different between year levels as to make the skills acquired during first year less adequate for, or relevant to, performance in the AB. Secondly, students who had completed first year writing tasks may have considered the AB to be just "more of the same", with little further to learn, giving them a heightened sense of writing ability and reducing their awareness of the requirement for a step-change in expected levels of writing proficiency. A third explanation is that students find it difficult to accurately self-evaluate their proficiency. For example, Dunning et al. (2003) found that students consistently overestimated their preparedness for an assessment task, and were consequently less likely to put in the extra effort required to gain superior academic results. This highlights the importance of clearly articulating writing standards expected for grades at each year level and across the course of a semester (Yucel et al., 2009). In regard to this, initiatives such as targeted, iterated ALL workshops (as per Constable, Schneider, & Scheckelhoff, 2012) and tutorials may enhance the scaffolding of student writing and writing-related skills, and better align their perceptions with their actual skills.

For the LR, the correlation between "essay" cohort student confidence and marks for this assignment is consistent with that reported extensively in the literature (e.g. Pajares & Johnson 1993; Collins & Bissell, 2010; Brownell, Price, & Steinman 2013). Thus, repeated opportunities for students to write in a scientific domain, such as was undertaken in the tasks reported herein, *should* generate improvement over time (Libarkin & Ording, 2012; Schofield, 2003). Writing tasks confer optimal results when formative feedback is provided (Gibbs & Simpson, 2004) even if its value can be somewhat variable (Carless, 2006). Formative feedback, as a dialogue between a tutor and student, or among student peers, strongly aligns with social constructivist theories of learning, as it provides indicators and suggestions related to both writing quality and body content. Consequently, the acquisition of information and development of deeper

understanding and skills are enhanced via active construction of *shared* knowledge and experiences (Rust, O'Donovan, & Price, 2005).

The increase in student confidence in their writing skills over the duration of SCI2010, regardless of their first year essay writing background, is laudable and indicates the value of iterative writing cycles in inculcating such confidence (Vardi, 2012). This inference is validated by the effect size of the course on each of the writing competencies, which greatly exceeds the mean effect size reported for comparable educational interventions (Hill, Bloom, Black & Lipsey, 2007). Further, that the "no essay" cohort were as confident about their referencing ability as the "essay" cohort after completing SCI2010 indicates the potential worth of formative feedback together with a range of resources, such as exemplars and guidelines, in generating such confidence. However, this begs two questions: was it justified, in terms of their marks, and if not, why not? These questions require further investigation, and are potentially fruitful areas of future research.

Student writing and other communication skills are highly regarded graduate attributes, regardless of discipline. Therefore, writing proficiency is one of a number of graduate abilities under the spotlight of quality auditing by government regulators of higher education. In 2008, the Learning and Teaching Academic Standards (LTAS) project was established by the Australian Office for Learning and Teaching to generate Threshold Learning Outcomes (TLOs) for science graduates at Australian higher education institutions (Jones & Yates, 2010). This was one of a number of responses to the establishment of the Tertiary Education Quality Standards Authority (TEQSA), the body responsible for auditing Australian tertiary institutions against five sets of academic standards, including relevant learning and teaching criteria (Holmes, Jones, & Yates, 2012). The TLOs have potential to be used as benchmark standards for both the TEQSA and higher education institutes themselves (Hannan et al., 2012; Jones, Yates, & Kelder, 2012), and importantly, align with the Australian Qualifications Framework (AQF), which facilitates pathways to, and through, formal university qualifications (http://www.aqf.edu.au/). This is in line with the paradigm that ALL outcomes should focus on what the student has learned and how such knowledge can be applied, rather than a focus on the teacher and what has been taught (Allan, 2006; Calder & Daly, 2009). The TLOs also strongly align with moves elsewhere in the world toward degree frameworks and *qualification profiles*, which clearly articulate what students are expected to know and be able to do upon completion of their degree (Biggs & Tang, 2011; Dill & Beerkens, 2012). The *able to do* component has particular relevance to this study, which has demonstrated the apparent gap between perceived skills standards and actual ability, and / or between assumptions about skills transfer and the reality that different tasks require specific skills that overlap in many ways, but differ in others.

5. Conclusions

This study demonstrates that providing undergraduate students with the opportunity to practise their writing skills over the first two years of a science degree increases their self-perceived ability to prepare, research and write in the scientific domain. However, since such perceptions were not associated with better marks compared to those of non-iterated students, writing confidence may not always correlate with writing competence. Students should recognise that expected standards of writing will be higher both within a year of study and over the course of their degree, and that different tasks require different (if overlapping) skills. To help achieve this, students must be provided with guidelines, rubrics and feedback that clearly articulate such skills and standards.

To build further on these findings, future research should investigate students' perceptions of their actual writing skills, both before and following iterated writing programs, in order to supplement what we have reported about their self-efficacy with respect to writing-related tasks. Further, we suggest that there be greater sharing of innovation and best practice among academics, ALL staff and sessional tutors with respect to iteration of student writing and writing-related skills. Additionally, students should be provided with integrated opportunities for writing skills development which should include elements such as punctuation and grammar, as has been previously suggested by Chanock, D'Cruz, and Bisset (2009). The ultimate aim of

these initiatives should be to embed a culture among students of continued practice and refinement of writing and writing-related skills. If this can be accomplished, then greater alignment between assignment marks and student perceptions of such skills may be achieved. These outcomes will have important implications for graduate attributes, employability and TLOs in accordance with greater university accountability associated with TEQSA and the AQF.

Acknowledgments

We would like to thank Yardenah Brickman and Chris Wilson for provision of first year essay assignment data, and Dinah Cragg for the second year self-assessment survey data. We would also like to thank Melissa McKnight for technical assistance, Allie Ford for supervising the workshop program in SCI2010 during 2011, and all the participants who took part in our survey during 2010-2012.

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