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The effects of using a wiki on student engagement and learning of report writing skills in a university statistics course

David L. Neumann and Michelle Hood
Griffith University

A wiki was used as part of a blended learning approach to promote collaborative learning among students in a first year university statistics class. One group of students analysed a data set and communicated the results by jointly writing a practice report using a wiki. A second group analysed the same data but communicated the results in a practice report that they wrote individually. Both groups were taught the same material. The report was used for practice as a way to support student learning and was not submitted for assessment. Both approaches improved report writing knowledge and did not differ in the mark obtained on an individually written research report subsequently submitted for assessment. The wiki approach produced higher engagement with other students, cognitive engagement, and class attendance than the individual approach. Qualitative feedback suggested some drawbacks to using a wiki. Overall participation was also low with only 2 of the 22 wiki subgroups completing all components of the practice report. The present findings suggest that student engagement, but not performance on assessment, may be enhanced when a wiki is used to support learning in higher education.

Introduction

Technology is transforming the university classroom by influencing the ways in which teachers and students communicate, collaborate, and learn. A relatively recent technological tool that has been used in higher education is the *wiki*. Wiki means "quick" in the Hawaiian language and its originator, Ward Cunningham, described the wiki as an extremely simple online database (Leuf & Cunningham, 2001). Wikis are interlinked web pages based on the hypertext system of storing and modifying information. Each page can store information and is easily viewed, edited, and commented on by other people using a web browser. Functionally, a wiki is meant to engage individuals to regularly update wiki pages in a collaborative fashion, to add new information, and to create links between pages. Wikis are being increasingly used within the higher education context. For instance, wikis have been employed to assist knowledge management in an academic setting (Raman, Ryan & Olfman, 2005) and develop a collaborative online textbook (Ravid, Kalman & Rafaeli, 2008). However, most interest has focused on how wikis might foster learning in students (see the recent articles in this journal by Elgort, Smith & Toland, 2008; Robertson, 2008; and Ruth & Houghton, 2009 for examples).

In the constructivist approach to learning and teaching, the student is actively involved in creating knowledge, instead of absorbing it (Bruner, 1990). The integration of ideas into existing frameworks and reframing beliefs as a result of new learning experiences

are key components of this approach (Piaget, 1971). Ebner, Kickmeier-Rust and Holzinger (2008) have noted that the requirement to create knowledge by editing web pages makes the wiki consistent with the constructivist approach. Moreover, wikis promote learning when acquisition of that knowledge is dependent on social processes and collaborative efforts among students (Wheeler, Yoemans & Wheeler, 2008), as proposed by socio-cultural perspectives of learning (Vygotsky, 1998; Bonk & Kim, 1998). Collaborative learning has been associated with higher achievement, higher motivation, positive student-student relationships, and more positive attitudes towards the discipline of study (Giraud, 1997; Keeler & Steinhorst, 1995; Rohrbeck, Ginsburg-Block, Fantuzzo & Miller, 2003). It has also been suggested that the review and editing process that is central to wiki applications fosters metacognition and reflexivity in students (Kirschner, 2004).

Based on the links between the wiki approach and learning theory, it is not surprising that there are reports of the successful application of wikis in higher education (Guzdial, Rick & Kehoe, 2001; Pappenberger, Harvey, Beven, Hall & Meadowcroft, 2006). For example, wikis facilitate student-teacher and student-student interactions (Stahmer, 2006), promote casual and flexible discussion (Read, 2005), and allow students to collaborate to conduct research and communicate their findings (Bold, 2006). However, Ebner et al. (2008) note that most claimed successes of wikis are not based on improvements in learning outcomes, but were related to the frequency of use of the system. Moreover, many reports of wiki applications in higher education consist of qualitative descriptions of teacher and student experiences and, by consequence, lack quantitative evaluations. One example of an empirical study is provided by the evaluation of a wiki related format termed *CoWeb* (Rick & Guzdial, 2006). The *CoWeb* approach facilitated learning in English composition, but was less effective in some science, technology, and mathematics classes. Students in the latter classes seemed to have resisted the collaborative learning approach, prompting the authors to suggest that there must be compatibility between the classroom culture, discipline culture, and the technology used.

The particular learning and teaching context examined in this study was the teaching of report writing skills in a first year statistics course. Course evaluations by students and the assessment of learning outcomes indicated this as an area in need of improvement for both student learning and engagement. Ben-Zvi (2007) has recently argued that wikis and statistics are compatible because the use of statistics in the workplace is collaborative in nature. Statisticians work as part of a team and consult with various people during the research process. Moreover, recent teaching guidelines encourage group learning in the statistics classroom (Franklin & Garfield, 2006) and a collaborative approach can enhance learning in statistics (Giraud, 1997; Keeler & Steinhorst, 1995; Magel, 1998). In addition, Ben-Zvi (2007) argued that wikis are particularly well placed to enhance learning of report writing skills. Such applications are facilitated by a wiki because students can edit pages from independent locations, there is only one version of the document at any one time, incompatibilities between computer software are avoided, and the wiki keeps track of edits made and has the ability to post comments. It is advised that for such applications to succeed, the teacher should help form wiki subgroups and promote a classroom culture that has a feeling of community, is tolerant of mistakes, and values high quality writing (Ben-Zvi, 2007).

In the present application, the wiki was employed within a blended learning approach (Heinze & Procter, 2004) by using it to complement the face to face teaching of

students. In order to evaluate the potential merits of using the wiki, a comparative approach was used, by having students in some classes write a practice research report collaboratively using a wiki, whereas students in other classes wrote the practice report individually using word processing software. Due to the potentially wide benefits of collaborative learning through a wiki (higher achievement, higher motivation, positive student-student relationships, and more positive attitudes towards the discipline; Giraud, 1997; Keeler & Steinhorst, 1995; Rohrbeck et al., 2003), the present study measured learning outcomes, knowledge of report writing, attitudes towards statistics, statistics anxiety, and engagement with other students and the discipline. It was hypothesised that both the wiki and individual instruction in report writing would have positive effects on student learning outcomes and attitudinal measures from pre-test to post-test. However, the wiki approach was hypothesised to result in a greater engagement with other students and the course material and higher marks on a research report subsequently submitted for assessment than the approach in which the practice report was written individually.

Method

The implementation and evaluation of the project was granted approval from the institutional ethics review board. Participation in completing the questionnaires and evaluations by the students was voluntary.

Description of the course

The wiki was implemented in a first year research methods and statistics course (1003PSY) at Griffith University. Griffith University is a large, multi-campus university, although the wiki was implemented and evaluated only on one campus in which the course was taught. The course is a required component in the psychology programs at the university and had enrolments of 180 students across the semester. Demographic information obtained from a survey previously conducted by the school indicates that the students are mostly aged from 17 to 19 years (60%). A further 20% are aged between 20 to 24 years, and 20% are aged 25 years and older. Most students are female (84%). Most are also single with no children (68%), while the rest are in a relationship with no children (12%), or in a relationship or single with children (20%). The vast majority are domestic students (96%). The course itself aims to provide students with a basic introduction to the theory and application of statistics in psychological research and practice. Topics include basic research methods, descriptive statistics (e.g. histogram, boxplot, mean, median), bivariate correlation, probability, sampling distributions, confidence intervals of the mean, and hypothesis testing. The course is taught through a weekly 2-hour lecture and a 2-hour tutorial across 13 weeks of the semester. Students are taught data analysis using the SPSS statistical software package.

Teaching approach

The course contained 10 tutorial classes varying in size from 15 to 25 students, conducted by three tutors. Cluster sampling was used to randomly assign five tutorial classes to incorporate the wiki approach (*Wiki group*) and five tutorial classes to use the individual writing approach (*Individual group*). Of the three tutors, one tutor had two wiki and two individual practice report classes, the second tutor had two wiki and one individual practice report classes, and the third tutor had one wiki and two individual

practice report classes. The tutors were not informed that a formal assessment of the two teaching approaches would be carried out. They were told by the course convenor (first author) that he was "interested in which approach worked best in the course".

The teaching methods were guided by Biggs and Tang's (2007) philosophy of the purposeful alignment between teaching and assessment. Consistent with this approach, all students were taught the skills required to analyse a data set and write a practice report, and were subsequently required to submit a research report assignment for grading. The teaching methods used across the wiki and individual writing classes were identical in terms of teaching materials and class objectives, differing only in how students completed the practice report. Six tutorial classes were devoted to teaching students the necessary skills for data analysis and report writing. The main learning objectives were as follows. Students were initially taught the format of a laboratory report, how to use the *PsychINFO* database to conduct a literature search, and the writing of the title page and *Introduction* section (class 1). The calculation and write up of the results in the practice report for graphical (class 2) and numerical (class 3) descriptive statistics were taught next. The following class taught students the calculation and write up of scatterplots and correlation (class 4). Next, students were taught how to write the *Abstract*, *Method*, and *Discussion* sections of the practice report (class 5). In the final class (class 6), students were asked to bring in a printed copy of their practice report for formative, peer assessment. In the week following this class, the students were required to submit their own, individually written research report for summative assessment. This assessed report was completed on a different research topic and used an individualised data set. However, it required the same skills as were taught in the tutorial classes (i.e. to calculate and report descriptive statistics, scatterplots, and correlations).

Each tutorial class included time in which students completed a writing task relevant to the material covered in the tutorial (e.g. class 4 required students to produce scatterplots, a table of correlation coefficients, and describe this information in the *Results* section of the practice report). If students did not complete the writing task during the class, they were asked to complete it outside of class time. In both the Wiki group and Individual group, the practice reports were completed across six weeks during class time and students were also encouraged to continue working on the practice reports outside of class time as required.

For the students in the Wiki group, the practice report components and ultimately the entire practice report, was written using a wiki. In Class 1 in those wiki classes, the tutors helped to form the students into self selected subgroups of four to six students. Each subgroup decided on a name and access to their wiki document was set up. The wiki was a component of the *Blackboard* learning management system and this allowed access to a wiki to be restricted to only those students in that subgroup and the teaching team of the course. The tutor set up each subgroup's wiki during Class 1 and also gave a 15 minute introduction to the wiki. The students were shown how to access the wiki, how to edit the document and add comments, and how to access the help system. Students were able to access the document during and outside of class time via the Internet and were able to access their tutor during his/her consultation sessions for additional support in using the wiki.

The emphasis on the use of the wiki during the classes was that it provided a common interface for students to create a practice report. It provided a collaborative

environment that allowed each student to contribute to the practice report and to ask questions about or discuss changes to the report. Due to its use within the blended learning environment, students were able to engage collaboratively either in person during class time or virtually online outside of class time. Moreover, the wiki provided a means to highlight the progressive nature of report writing. Sections were added to the practice report in a progressive manner because each class focused on a specific aspect of the report. The wiki system also allowed students to revise earlier sections of the practice report and to keep a record of the edits that had been made. The edits provided a point of discussion among students and allowed them to learn from one another. In each class, the tutor checked on the progress made by each of the wiki subgroups on compiling the practice report and answered technical questions as they arose.

For the students in the Individual group, the report was written individually using a word processing program (Microsoft *Word*). In a 15 minute session during Class 1, the tutor showed students how to start the program on the computers in the tutorial classroom, the basic functions of the program, and how to access the help system. Students had access to the word processing program during and outside of the tutorial classes in computer laboratories located on campus.

Materials and measures

Tutorial attendance across the six tutorials and marks obtained in the assessed research report were collected from course records. In addition, students were administered questionnaires to measure demographic characteristics, self efficacy for statistics, statistics anxiety, report writing knowledge, student engagement experiences, and to obtain qualitative feedback on the tutorials.

- A questionnaire was developed to obtain information on student gender, age, English as first language, enrolment status, program of study, and prior mathematics study (completion of final year of school or equivalent and achievement level). Achievement was rated on a 5-point scale that varied from 1 = *very poorly* (e.g. VLA) to 3 = *average* (e.g. SA*)* to 5 = *very well* (e.g. VHA).

- The second instrument assessed perceived self efficacy for statistics. The 10 items were those used by Bandalos, Finney and Geske (2003) and consisted of eight items adapted from the self efficacy subscale from the *Motivational Strategies for Learning Questionnaire* (Pintrich & De Groot, 1990) plus two items previously used by Bandalos, Yates and Thorndike-Christ (1995). The wording of some items was modified to make them specific to the statistics class being taught. Items were answered on a 7-point scale that varied from 1 = *strong disagree* to 7 = *strong agree.* Bandalos et al. (2003) reported an internal consistency coefficient of .95 for the 10 item scale. The values for the Cronbach alpha coefficient in the present study were .93 at pre-test and .89 at post-test.

- The *Statistical Anxiety Rating Scale* (STARS) developed by Cruise, Cash and Bolton (1985) is the most widely used measure to assess statistics anxiety (Onwuegbuzie & Wilson, 2003). The STARS is divided into two components. For items 1 to 23, students indicate how much anxiety they would experience in different situations on a 5-point scale that varies from 1 = *no anxiety* to 5 = *considerable anxiety*. The items measure test and class anxiety, interpretation anxiety, and fear of asking for help.

For Items 24 to 51, students indicate their level of agreement to various statements on a 5-point scale that varies from 1 = *strongly disagree* to 5 = *strongly agree*. The items measure worth of statistics, fear of statistics teachers, and computational self-concept. Some items in the STARS were modified to more appropriately reflect the cultural context (e.g. the word "professor" was replaced with "lecturer"). The STARS internal consistency across the entire 51 items has been reported to have an alpha value of .96 (Baloglu, 2002). Cronbach's alpha across all the subscales has varied between .83 and .94 (Hanna, Shevlin & Dempster, 2008). In the present study the entire 51 items yielded an alpha of .94 at pre-test and .92 at post-test and the subscales alpha values ranged from .72 to .93, although the test anxiety subscale at post-test had value of .46.

- A 10-item test was developed to assess report writing knowledge. The items assessed factual knowledge about the *American Psychological Association Publication Manual* (American Psychological Association, 2001) formatting requirements (e.g. *the figure caption should be placed above the figure*) and report writing conventions (e.g. *in a table or figure, the statistical significance of < .01 is indicated by the symbol "**"*). Items were answered as *True, False,* or *Don't know*. The latter option was used to discourage guessing among students.

- A set of 14 items was based on *The National Survey of Student Engagement* (2007) to evaluate student participation and engagement. Four items asked about working with other students (e.g. *worked with other students during class time*) on a scale from 1 = *never* to 4 = *very often*. Five items asked about how the tutorial classes emphasised various mental activities (e.g. *applying theories and/or concepts to practical problems or in new situations*) and were answered on a scale that varied from 1 = *very little* to 4 = *very much*. Five final items asked students to rate the extent to which the tutorial classes contributed to the development of skills (e.g. *working effectively with other students*) using the same scale of 1 = *very little* to 4 = *very much.* The questionnaire thus resulted in subscales to measure engaging with other students, cognitive engagement, and skill development. Cronbach's alpha for all items was .78, which was satisfactory, and for the subscales of engagement with other students, cognitive engagement, and skill development were .58, .78, and .72, respectively.

- Four items obtained qualitative feedback from the students on the teaching strategy used in the tutorial. The questionnaire asked students to give written comments on both positive and negative experiences with the approach used in their classes (wiki or individual practice report). In addition, students were asked whether they would recommend the same teaching approach be used again.

The questionnaires were administered at two times. The first administration (pre-test) occurred during the first lecture in the course, prior to any tutorial classes. At this time, students were administered the demographic questionnaire, self efficacy questionnaire, STARS, and report writing questionnaire. The second administration (post-test) occurred during a lecture or tutorial class in the week following that in which the research report assignment was submitted for assessment. The self efficacy questionnaire, STARS, report writing questionnaire, student experiences questionnaire, and tutorial feedback questionnaire were administered at this time.

Results

Demographic sample characteristics

Due to the voluntary nature of the participation, not all students in the course completed the questionnaires. Table 1 shows the demographic characteristics for the students who completed the questionnaires at both pre-test and post-test administration periods. As can be seen, 52 students (29% of the total class) were in the final sample. To check if the groups differed on variables that might confound comparisons between groups on outcome measures, a series of chi-square (for qualitative variables) and independent groups *t*-test (for quantitative variables) analyses were conducted on the demographic variables. The groups did not differ on any measures, all $p > .05$.

Table 1: Demographic characteristics for students who completed the questionnaires at both pre-test and post-test administration.
Counts are shown for qualitative variables and means are shown for the quantitative variables (standard deviations in parentheses).

Variable		Group		Total
		Wiki	Individual	
Sample size (*n*)		27	25	52
Male:Female ratio		2:25	4:21	6:46
Age (years)		23.81 (8.74)	21.92 (7.19)	22.63 (8.07)
English as first language	Yes	21	19	40
	No	6	5	11
Enrolment load (a)	Full time	24	24	48
	Part time	2	0	2
Enrolment status (b)	Domestic	22	21	43
	International	5	3	8
Completed mathematics in Year 12(c)	Yes	19	18	37
	No	8	6	14
Rating for achievement in Year 12 mathematics (d)		3.83 (0.71)	3.74 (0.87)	3.78 (0.79)
Repeating course (e)	Yes	1	1	2
	No	26	23	49

a. Only 26 students in the Wiki group and 24 students in the Individual group reported enrolment load.
b. Only 24 students in the Individual group reported their enrolment status.
c. Only 24 students in the Individual group reported on the completion of Year 12 mathematics.
d. Only 24 students in the Individual group rated their achievement.
e. Only 24 students in the Individual group reported on repeating the course.

Quantitative comparisons between the wiki and individual groups

The students completed the self efficacy for statistics questionnaire, STARS, and research report test at both pre-test and post-test. The mean ratings and scores obtained for these measures are shown in Table 2. A 2 x 2 (Group x Time) ANOVA for the self efficacy questionnaire responses yielded no significant main effects or interactions, all F values < 2.24, $p > .05$. Examination of the mean ratings for the subscales of the STARS with separate 2 x 2 (Group x Time) ANOVAs yielded main effects of time for interpretation anxiety, F (1, 50) = 6.12, $p < .05$; fear of asking for help, F (1, 50) = 5.78, $p < .05$; and computational self concept, F (1, 50) = 13.67, $p < .01$. These

effects suggested that interpretation anxiety and fear of asking for help decreased and computational self concept improved from pre-test to post-test.

Table 2: Mean ratings for the self efficacy questionnaire, the subscales of the statistics anxiety rating scale, and performance on the research report test for the pre-test and post-test assessments in the Wiki and Individual groups (standard deviations are in parentheses).

Measure		Group			
		Wiki		Individual	
		Pre-test	Post-test	Pre-test	Post-test
Self efficacy		4.28 (1.06)	4.09 (1.28)	4.16 (1.05)	3.80 (1.15)
Statistics anxiety rating scale	Test and class anxiety	3.06 (0.85)	3.30 (1.57)	3.31 (0.73)	3.23 (0.71)
	Interpretation anxiety	2.74 (0.83)	2.45 (0.65)	2.91 (0.56)	2.73 (1.11)
	Fear of asking for help	2.40 (0.92)	2.06 (0.75)	2.75 (0.99)	2.46 (1.06)
	Worth of statistics	2.09 (0.55)	2.32 (0.77)	2.39 (0.68)	2.36 (0.81)
	Fear of statistics teachers	1.98 (0.70)	1.73 (0.56)	2.10 (0.73)	1.96 (0.70)
	Computational self concept	2.64 (1.00)	2.32 (0.86)	3.05 (0.92)	2.59 (0.91)
Report writing test	Correct answers (%)	41.11 (20.82)	74.44 (25.17)	41.67 (18.80)	61.25 (30.40)
	Don't know responses (%)	30.37 (22.27)	2.96 (6.09)	25.00 (20.00)	7.08 (12.33)

Performance on the report writing test was examined by calculating the percentage of correct answers and the percentage of *don't know* answers. A series of 2 x 2 (Group x Time) ANOVAs conducted separately for each measure did not yield any significant main effects or interactions involving the Group factor, all Fs < 1.31, $p > .05$. However, the percentage of correct responses increased and the number of *don't know* responses decreased from pre-test to post-test, both Fs > 41.39, $p < .001$, to suggest that students did improve in their knowledge of report writing.

The students completed the student engagement experiences questionnaire, obtained a mark for the assessed research report, and had a final value for tutorial attendance only for post-test. The mean values for each of these variables are shown in Table 3 for each group. As can be seen for the engagement ratings, the groups showed similar values for the skill development subscale, but were different on the other subscales. Statistical analyses suggested that that the Wiki group rated their engagement with other students, t (50) = 2.16, $p < .05$, and cognitive engagement, t (50) = 2.08, $p < .05$, as higher than the Individual group, whereas there were no differences between groups for ratings of skill development, t (50) = 0.30, $p > .05$. Table 3 also suggests that the Wiki group obtained a slightly higher mark and attended more tutorials than did the Individual group. The difference in the assessed research report mark was not significant, t = .45, $p > .05$, although the group difference in tutorial attendance was marginally significant, t (50) = 1.88, p = .06.

Table 3: Mean values for the subscales of the student experiences questionnaire, research report mark, and tutorial attendance for the Wiki and Individual groups (standard deviations are in parentheses).

Measure		Group	
		Wiki	Individual
Student experiences questionnaire	Engagement with other students	2.53 (0.63)	2.15 (0.68)
	Cognitive engagement	2.69 (0.42)	2.41 (0.55)
	Skill development	2.34 (0.45)	2.38 (0.61)
Research report mark (%)		73.30 (12.54)	70.95 (15.06)
Attendance (%)		81.48 (14.73)	72.57 (17.46)

The tutorial evaluation questionnaire included a question asking students whether they would recommend the use of the same teaching approach in the future. The percentages of students who responded *yes*, *no*, and *unsure* in the Wiki group were 70%, 8%, and 22%, respectively. A similar pattern emerged in the Individual group with 72%, 0%, and 28%, of students responding with *yes*, *no*, and *unsure*, respectively. The relationship between the responses and group membership was not significant, chi-square = 2.03, $p > .05$.

Qualitative comparisons between wiki and individual groups

The written responses to the questions on the tutorial evaluation questionnaire were examined by a qualitative coding approach that followed the methods of Neuman (2006). The statements were initially examined to group similar comments into themes. The relationship between the themes and the fit between each statement and the theme were then evaluated. Finally, each theme was given a label, the percentage of students who contributed comments to the theme was calculated, and representative statements for each were selected. As some students provided multiple statements and each individual statement was allocated to a relevant theme, the final percentages reflect the number of students that contributed comments for each theme.

Three positive themes emerged in the Wiki group. The first theme labeled *Learning benefits* (37% of students provided statements) reflected that the wiki assisted the students to learn about report writing and the assessment requirements. Students commented that using the wiki "helped me improve my own assessment", helped in "practising for the real report", and "learnt some more about computers". The second theme was labeled *Technology advantages* (33% of students). This theme captured the benefits and ease of use of the wiki technology. The wiki was "easy to access", was "easy to save and edit", made it possible to "work as a group from home", and "have easy access at home and uni". Finally, *Group work benefits* (30% of students) suggested that the wiki facilitated learning within a group through comments such as "it enabled me to get opinions from students", I received "help from other group members", and "we could discuss others thoughts and ideas".

The positive experiences from the Individual group also yielded three themes. The first was labeled *Learning benefits* (48% of students) and reflected that the tutorial work helped students to learn how to structure and write a research report. The student's noted that it helped in "understanding how a stats report should be structured", how to write the "report, graphs and tables", and that it made "it easier to follow the APA format". The theme *Technology advantages* (23% of students) largely reflected that the word processing program was familiar and easy to use for the students. For example, students commented that "I knew my way around it" and "it was easy to use". The third and final theme was labeled *Interaction* (25% of students) and it suggested that there was interaction with others during the tutorials. The interaction included both with the tutor (e.g. "to get help and advice from the tutor", and "the tutor can show exactly what it should look like") and the class as a whole (e.g. "going through it as a tutorial group was very helpful").

The evaluation of the negative experiences resulted in three themes for the Wiki group. A theme labeled *Group work* (37% of students) suggested that some students had negative experiences in working with others. These included poor contributions from other students (e.g. "only 2 of the 4 of the group contributed"), that "others can change work that you may have wanted to keep", and that it was "hard to speak up and get

your opinions/ideas across". The theme labeled *Technology difficulties* (22% of students) reflected some problems in using the wiki in both general terms (e.g., "using wiki was a bit challenging") and for specific tasks (e.g., "trying to format or put figures in", and "punctuation errors were not found by the program"). The final theme was labeled *Time issues* (41% of students). The comments suggested that some students would have rather completed the real assignment in the time that was used. This perception is particularly well captured by the comments "time consuming when it did not count for anything" and "wanted to focus more time on the real assignment... rather than do the practice method".

Four themes emerged from comments on the negative experiences with the Individual group. The theme of *Learning problems* (25% of students) reflected difficulties in the learning experiences of students, such as "confusing overall", "not specifically detailed", and "was difficult to begin". Problems with using the word processing software were also evident with the theme of *Technology difficulties* (29% of students). The students highlighted problems in using the word processing software, such as "get the APA format right", "it was difficult to put the tables into APA" and "graphs/tables/data hard to display". The third theme was labeled *Time issues* (42% of students). As noted above for the Wiki group, the comments related to students perceiving that they would have preferred to work on the assessed report instead of a practice report. Although only two students wrote comments related to the final theme, it is noted here for its relevance. One student commented that they "would have liked to be in a group instead". Conversely, the other student stated that "if I was able to choose between group or individual, I would remain with individual work". These divergent responses suggest individual variability in preferences for collaborative versus individual work.

Evaluation of wiki participation

There were 22 subgroups formed across all the classes that employed the wiki approach. Students were encouraged to name their group and many groups formed inventive names that were often statistics related. Notable names included *Superstats*, *The Statistical Anomalies*, *Stems & Leaves*, and *Bin Buddies*. To quantify the extent of participation in the wikis, the wiki documents were examined and scored according to the number of sections of the practice report that had been completed. One point was awarded for each of the following sections, with a maximum of seven points possible: Title page, Abstract, Introduction, Method, Results, Discussion, and References. As can be seen from the distribution in Figure 1, the full range of participation was shown with scores ranging from 0 to 7. The mean number of sections completed was 3.05 (*SD* = 2.28) indicating that on average, just under half the required sections was completed. No data was collected on the number of sections completed by students who wrote the report individually and as such this information cannot be presented here.

Discussion

The present study evaluated the use of a wiki to promote student engagement and learning of research report writing skills in a statistics course. The results suggested that the design of the curriculum contributed to a reduction in statistics anxiety in some areas (interpretation anxiety, fear of asking for help), improved computational self concept, and increased knowledge of report writing requirements. These changes were observed from pre-test (beginning of semester) to post-test (after formal

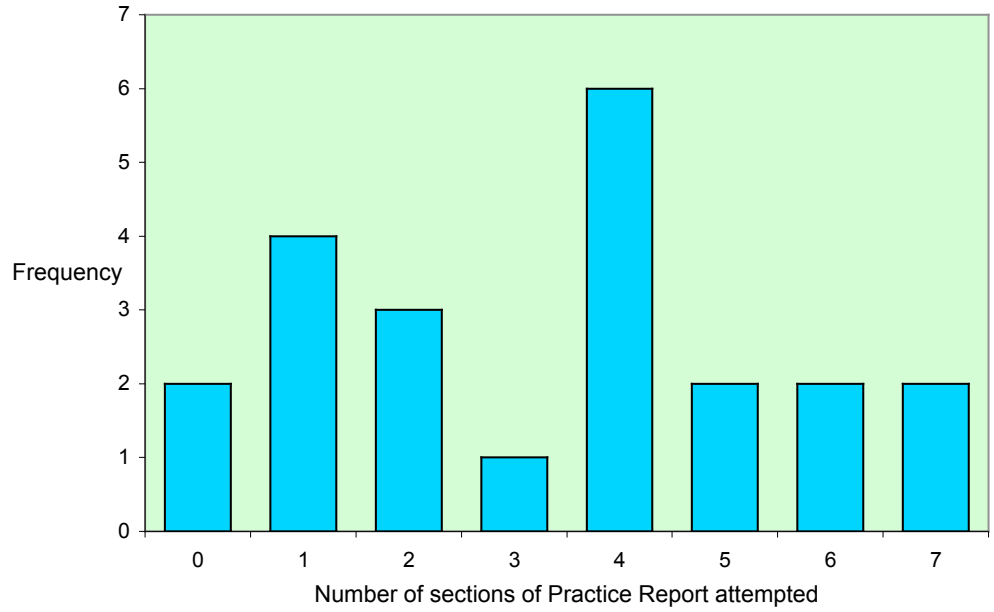

Figure 1: Number of sections of the practice report started or completed by each Wiki subgroup

assessment completed) and were found regardless of whether a wiki or individual word processing software was used in the blended learning approach. The differences between writing a practice report using a wiki and writing the practice report individually were found in measures of student engagement (engagement with other students and cognitive engagement) and in attendance at the tutorials. The qualitative evaluations suggested that there are some disadvantages to using a wiki in a classroom setting, although many of these were shared with the individual use of word processing software.

The wiki has been promoted as a collaborative medium by which individuals are not merely passive recipients of information, but can become actively involved in reviewing, editing, and adding to the documents (Leuf & Cunningham, 2001). The present findings give some support these impressions when a wiki is implemented within an educational context. Students who used the wiki to write the practice report gave higher ratings on engagement with other students and cognitive engagement than the students who wrote the practice report individually. From a sociocultural perspective on learning (Vygotsky, 1998; Bonk & Kim, 1998), a wiki provides a communication medium through which students can work together to construct knowledge and share ideas. Results from the present study suggest that wikis support collaboration among students. Moreover, through this collaboration, the students became more cognitively engaged in the subject matter, a finding consistent with the notion that working with others can enhance involvement in the intellectual components of the learning process (Harasim, 1990).

Attendance tended to be higher in the classes that used the wiki approach than in the classes in which students wrote the report individually. One interpretation of this

difference is that using the wiki promoted collaborative learning among students and enhanced their motivation to attend classes to continue this collaboration. An alternative interpretation is that the students in the Wiki group became aware that they were writing the practice report in a new or special way. This might have occurred via a diffusion effect because the students from the different tutorial classes attended the same lecture. At the lecture, the students from the different tutorial classes may have discussed and compared the learning approach used during the tutorials. If the students in the wiki subgroups became aware that they were writing the practice report in a special way, this may have increased their motivation to attend class. This is related to the Hawthorne effect, where merely observing individuals can influence the behaviour being observed (Roethlisberger & Dickinson, 1939). The present study was conducted in a way that attempted to minimise any such bias on behalf of the student or tutor. For instance, the tutors were not told that a formal assessment of the wiki teaching approach would be carried out and they did not know that pretest measures (e.g. report writing knowledge) were taken from students. Likewise, students were not told that some classes were writing the practice report individually and other classes were using a wiki.

Learning is enhanced when students can become actively engaged in what they are doing, discuss ideas with others, and obtain formative feedback on a regular basis (Biggs & Tang, 2007). Based on the findings of greater engagement in students who used the wiki during the tutorial classes, it might be expected that these students should also show better learning outcomes on assessed work. However, the mark obtained on a research report that was subsequently submitted for summative assessment did not differ between the Wiki and Individual groups. The research report submitted for assessment was based on a different data set than the practice report, but had similar requirements in terms of data analysis and content. The lack of significant differences between the groups is thus not likely to reflect discordance between the teaching and assessment approaches. Rather, the results may reflect that the students in each group had access to other resources to help them complete the assessed report. Students in each group attended the same lectures, followed the same lesson plans in the tutorial classes, and had access to an online discussion board. Each of these factors may have weakened the strength of the experimental manipulation in terms of the effects of the writing approach on learning outcomes.

The effects of using a wiki on student learning outcomes (i.e. grades) may be stronger when a wiki is implemented in alternative teaching contexts. The present application was based on a blended learning approach (Heinze & Procter, 2004) in which the wiki was integrated with face to face teaching. A stronger effect on learning outcomes may be found when the wiki is used to supplement courses that have an entirely online mode of delivery (see Choy & Ng, 2007 for one such example). However, this suggestion is tentative and requires empirical validation. Another point is that the present teaching context was centred on the discipline of statistics. Although statistics has been argued to be a collaborative discipline (Ben-Zvi, 2007), prior research has indicated that the wiki may be more effective in disciplines that value open ended discussion and reflection through writing, such as courses on English composition (Rick & Guzdial, 2006). Nevertheless, the present results suggest that a wiki may promote engagement and discussion among students even in the statistics classroom.

Another important issue to consider when evaluating the effects of an instructional method on student learning outcomes is the extent to which the students participated

in the method. The full range of participation was observed in the present study. Two wiki subgroups did not attempt any components of the practice report, whereas two subgroups compiled complete and well-written practice reports. The remaining 18 subgroups produced limited to partially complete reports. The effects of using a wiki on student learning and engagement may have been limited in this study due to the relatively low participation across the wiki subgroups. Further research would be required to determine whether the learning benefits are enhanced when there are higher levels of participation. A further implication of the low levels of participation by some students is that it raises the question of whether those students with limited engagement can provide informed reports on their experiences in using the wiki. While these students may be able to report on some aspects in using the wiki, their limited experience would be expected to restrict their depth of insight into the benefits of the wiki approach. However, it might also be the case that these students may give particularly important insights into the problems associated with the wiki. Technical issues and difficulties when working in a group emerged as negative themes in the Wiki group and it could be the case that these issues caused the low levels of participation in some students. Reports on negative experiences can be valuable because they provide information on what needs to be addressed when revising and improving a curriculum.

The relatively low level of completion of the practice report by students in the Wiki group may reflect that although students were encouraged, they were neither enforced nor rewarded for participation (e.g. through assessment). Ebner et al. (2008) showed that of 287 university students, *none* created new articles or edited existing ones across an entire semester, when no rewards or incentives were offered for participation. Ebner et al. report that the main reasons why students did not participate included not having time (27%), no perceived benefit (12%), not trying (18%), and problems editing articles (24%) among others. Some of these themes also emerged in the qualitative feedback in the present study (e.g. time issues). As the present results and those of Ebner et al. indicate, using an interactive and collaborative technology will not necessarily translate into active engagement by students.

Participation in using the wiki might be enhanced if it was integrated with course assessment. Trentin (2009) has recently described a method that allows the evaluation of the contributions made by individual students to a wiki document. Importantly, this approach has the advantage of providing individual accountability and feedback to students within a collaborative learning environment. It might be argued that using assessment purely for the purpose of promoting participation in the wiki goes against the basic philosophy of why wikis were first developed. However, it does reflect there can be different motivations underlying the use of technology when that technology is employed in different contexts. Alternative approaches to using assessment could also be explored. For example, the teacher could emphasise more to students the affective and intellectual benefits of active participation.

The qualitative responses suggested that students had both positive and negative experiences when using the wikis. Students reported that the wiki helped their learning, the technology was easily used, and it facilitated interaction among individuals in the group. The first two themes, learning benefits and technology benefits, were also expressed by students who completed the practice report individually, although the technology benefits were related more to familiarity with the word processing software. Overall, these themes suggest that a wiki can be

implemented effectively in a blended learning approach to support student learning. Negative experiences were also reported by the students. Not all students found the wiki technology easy to use and some students expressed dissatisfaction with the amount of effort and participation from other members of the group. Some of these negative experiences with the technology could be addressed by providing students with more extensive training on using the wiki. Participation from other group members could be enhanced by forming the wiki subgroups later in the semester, at a time at which more students will have formed social relationships with others. In addition, larger groups might be used so that the lack of participation from one or two students has less impact.

The approach used in the present study was primarily experimental in which cluster sampling was used to randomly assign tutorials classes in a course to write the practice report using the wiki or individually. Pretest and posttest measures of student engagement, learning, and attitudes were taken for most measures. While this approach affords good control over several threats to validity when compared to other approaches (e.g. a quasi-experimental approach or approaches that lack a control group), some limitations did emerge. For instance, because the students in the different tutorials classes were part of the same university course and attended the same lecture, it is possible that there could have been diffusion of treatment effects. Students in the Wiki group may have interacted with students in the Individual group to share ideas, experiences, or resources. In addition to the Hawthorne effect noted earlier, the sharing of experiences among students could have had the effect of reducing the differences between the Wiki and Individual groups on the dependent measures like report writing knowledge and the grade obtained on the assessed report.

In addition, it would have been beneficial to have taken measures from students at regular intervals after the classes began, rather that having a single posttest measure at the end. In doing this, it would have been possible to determine whether the Wiki and Individual writing approaches differed in how quickly things were learnt (e.g. report writing knowledge) or whether levels of engagement differed across time. In addition, a more formal evaluation may have been able to identify the low participation by students in some wiki subgroups and to develop effective means to increase participation in these students. Finally, no data was collected on how many sections of the practice report were completed by students in the Individual group. It would be useful for future research if this information was collected to allow a comparison on the extent of participation between students who wrote the report using a wiki and those that wrote the report individually.

Conclusion

In conclusion, the present study suggests that there can be benefits to student engagement when a wiki is employed as part of a blended learning approach. However, there was no evidence that the wiki improved learning outcomes over and above similar work conducted on an individual basis. The outcomes of the present study seem to fall in between prior reports of wholehearted success (e.g. Guzdial et al., 2001) and disappointing failure (Ebner et al., 2008) when wikis are used to support student learning. The lack of an explicit incentive in terms of course assessment or other means of enforcing participation may relate to differences in the outcomes in prior research (Ebner et al., 2008). The present study also suggested that there is substantial variability among students in participation and preferences for

participation in the wiki (e.g. one student preferred to work in a group, whereas another student preferred to work individually). Notably, in a study that examined responses on a student survey, Elgort et al. (2008) concluded that the use of wikis may not necessarily counteract student preferences for individual work rather than group work. Further research is required to determine whether and how individual preferences, the teaching context, and the discipline area influence the effectiveness of wikis in educational applications. The present findings suggest that student engagement, but not performance on assessment, may be enhanced when a wiki is used to support learning of research report writing skills in a university statistics course.

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Dr David Neumann, School of Psychology - Gold Coast, Gold Coast Campus, Griffith University, QLD 4222, Australia Email: D.Neumann@griffith.edu.au
Web: http://www.griffith.edu.au/health/school-psychology/staff/dr-david-neumann

Dr Michelle Hood, School of Psychology - Gold Coast, Gold Coast Campus, Griffith University, QLD 4222, Australia. Email : michelle.hood@griffith.edu.au
Web: http://www.griffith.edu.au/health/school-psychology/staff/dr-michelle-hood