Scientific Research

Meaning Check Questions as an Active Learning Tool in the University Biology Laboratory Assists International Students

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Greater participation by students is associated with better learning outcomes. Therefore active learning approaches in teaching have been encouraged for teachers to use in the classroom. In particular, student-centered learning is highly appreciated in a classroom where international students have to learn in English while it is not their first language. Master of Science students at Griffith University, Australia, all international students, were exposed to an environment where Meaning Check Questions (MQ) were practiced as an active learning approach. The MQs were incorporated into a biology laboratory course and required the students to answer short verbal questions relating to the course content, experimental procedures and scientific writing. The results show that these methods encouraged students to be more active in class and improved their confidence level and knowledge of the key concepts during the course, compared to students who did not experience the MQ learning approach. Students exposed to MQs during the course also showed a distinct improvement in their confidence towards scientific writing.

Keywords: Student Centered Learning; Meaning Check Questions (MQ); Scientific Writing Skills;
International Student; Biology Laboratory

Introduction

It is now well established that students learn more effectively when "student-centered learning" approaches are used in the University classroom (Biggs, 2003; Smith et al., 2005; Wood, 2003). In "student-centered" learning, "*Learning takes place through the active behaviour of the student and not through what the teacher does*" (Biggs, 2003). According to studies completed in the USA a large number of science and mathematics students withdrew from their programs largely due to lectures being perceived as boring and hard to relate to (Kardash & Wallace, 2001; Seymour & Hewitt, 1997; Strenta et al., 1994). A core message is therefore to ensure students are actively involved in their own learning by providing them tools or opportunities to interact in class (Chickering & Gamson, 1999; Smith et al., 2005; Walczyk & Ramsey, 2003). The challenge is to design the course structure to include activities that motivate and encourage students to actively engage with the curriculum (Knight & Wood, 2005).

A highly effective approach to encourage student involvement in the classroom is via Meaning Check Questions (MQs), also known as concept check questions (Workman, 2005). MQs are typically simple questions that require short answers. They are asked just prior to starting an activity and often right after instructions have been given. The typical amount of time given to these types of questions is between 2-5 minutes. MQs can focus on key parts of how and what to do for an activity or the crucial elements of a concept's meaning. MQs are viable in many teaching situations and have been widely used as a tool for teaching languages (TEFL, 2007).

MQs encourage students to think about the question they have been asked since they need to verbalise an answer. In contrast merely asking "Do you understand?" is all too often just answered with "yes", even though students in reality do not understand. Similarly, students in science laboratory classes quite often follow verbal or written instructions without necessarily knowing why. Thus we considered that adapting MQs to a laboratory class setting would help to check a student's conceptual understanding before doing an activity, resulting in more student interaction as well as less class time lost due to students not really knowing what to do. The goal is also for students to develop a deeper understanding of the important concepts through verbalising their answers. Vygotsky (1986) postulated that there is a strong relationship between thinking, talking and learning and more recently other teachers have promoted the idea of learning through the spoken word (Myhill, 2010).

Active learning applies to all students, regardless of cultural background or discipline of study. However, according to some researchers there is a common perception amongst many teachers that Asian students rely on rote learning (Chan, 1999) and therefore prefer a teacher-focused approach. This view has been challenged by studies showing Asian students, including science students, can adapt to a more student-centred style of learning and in fact, prefer it (Kember, 2000; Wong, 2004). Thus, learning styles are more likely to be contextual rather than cultural (Wong, 2004). It is therefore important for teachers to adopt strategies that promote active student learning and be aware that despite initial reluctance, students from all cultures will respond similarly.

Within science, a key issue is to teach scientific writing effectively. Significant scientific research findings need to be

clearly communicated through writing, which takes many forms including reports, journal articles and conference presentations. Improving students' writing skills in science degree programs is necessary because writing is an important form of professional communication and also improves critical thinking (Libarkin & Ording, 2012; Peat et al., 2002; Quitadamo & Kurtz, 2007). It is clear that a greater emphasis on developing effective communication is required among scientists and thus needs be part of their education (Ali et al., 2007; Libarkin & Ording, 2012; Quitadamo & Kurtz, 2007). However a survey at the University of Wisconsin-Madison found that 45% of biology students did not like writing despite 98% regarding writing as important for learning (Manske, 2010)**.** International students who do not have English as their preferred language are even more overwhelmed when faced with a technical writing task (Jordan & Kedrowicz, 2011). Tools and activities must therefore be utilised that inspire students to want to develop their writing expertise. We have shown previously (Lee et al., 2011) that the use of writing activities embedded into a laboratory class can assist students to gain confidence in their writing and we were therefore interested if oral MQs could complement this approach to encourage international students to write.

In the study described herein oral MQs are implemented as a simple method to encourage non-native English speakers to adapt to a student-centered style of learning in a biology laboratory course, with the goals of developing a deeper understanding of the concepts underpinning their laboratory experiments and improving their confidence at performing scientific writing tasks.

Methodology

Participants

Student participants were in the course entitled "Biotechnology and Molecular Biology Laboratory", which is taken by students in the second semester of the first year of the Master of Science program at Griffith University, Australia. This program is only available to international students who complete undergraduate studies overseas and then come to Australia to undertake a two-year program. This research project received ethics approval from the Griffith University Human Research Ethics Committee and students signed consent forms to allow the use of their responses for research purposes.

Course Description

Five students were enrolled in 2008. They were all international students and English was their 2nd language. The aim of the course was to conduct a project (a series of experiments) in the laboratory and to submit a written report. It is a 7-week, 8 hours/week (in 2×4 hour sessions) semi-intensive course. Experiments are completed in the first 5 weeks. Students also commence work on their written report with feedback through writing exercise (Lee et al., 2011). In the final 2 weeks students were given 2-hour workshops aimed at improving their written report. Assessment also includes 2 written quizzes (weeks 3 and 5) on the concepts underpinning their experimental work and includes problem-solving questions. A control group of 8 students was also used for this study. These students experienced the same course taught in the following year without MQs.

Use of MQs to Learn Scientific Concepts

Before, during and after each laboratory session students were asked oral MQs. This was to encourage students to prepare for the class and to check how much they had learnt. Another benefit is that the teacher receives frequent real-time feedback of what students know. A teacher would explain a technical procedure and then ask short questions to the students to probe their understanding. The number and type of MQs varied, with questions based on information from the laboratory manual. Example MQs are: "Why are we using NaOH in this step of the plasmid preparation procedure? What is the next step?" How does the T7 expression system work to induce protein expression? Unless students understand what they are doing and why they are doing such an experiment, they can't answer those MQs. The intention is to encourage students to think and to verbalise their answers. Then as needed, the teacher guides them towards the right answer. The MQ approach contrasts to asking students one-on-one questions once the class has commenced, as is normal practice in laboratory courses. Students know they must answer the MQs before commencing laboratory work and therefore they come to class prepared. Implementing MQs only requires a few minutes yet it is a simple and effective approach to involve students in the subject material. The time spent on MQs is soon saved as students are more efficient in the laboratory.

At the end of a session MQ questions were asked such as, "Why were we doing this experiment? Why did you use this chemical and not that one?" The purpose is to ensure that students have cemented their understanding of the laboratory procedures and why they were performing them.

Writing Activities and the Use of MQs

During the laboratory sessions the students also completed some writing activities similar to those reported for an undergraduate biology laboratory class (Lee et al., 2011). These writing activities included simple written tasks that required analysis of their own experimental data on which they received formative feedback from teaching staff to assist them with their final report. Tasks varied in each session but included writing figure legends, describing results and deciding which information should go into the discussion section. The Masters students also had two 2-hour workshops devoted to developing and receiving feedback on their written report drafts. The type of verbal MQs used to guide students in their scientific writing development included "What type of information do you need in this particular figure legend" and "With respect to your restriction digests what analysis will you provide in your discussion".

Evaluation of Teaching Strategies

Evaluation of the effectiveness of the MQs was conducted using five different evaluation methods:

1) *Regular written surveys*

Anonymous surveys were conducted at weeks 3, 4 and 5. Students were asked open-ended questions such as to recall the MQs asked that day, whether MQs had helped with subject material comprehension and if MQs had helped them to perform experiments correctly. They were also asked to specifically describe how the MQs helped.

2) *Interviews of students*

A teacher (external to the course) conducted interviews with the Masters students in the final session of experiments (week 5) without the presence of the teacher who utilised the MQs. Students were asked specific open-ended questions regarding their opinions on the effectiveness of using MQs during the laboratory sessions and if improvements could be made.

3) *Official university evaluation*

An anonymous voluntary survey was conducted, at the end of the course, according to University policy asking students to rate the effectiveness of the teaching strategies implemented in the course. Respondents were asked to mark one number on a Likert scale rating from 1 to 7, where 1 is regarded as poor and 7 as excellent. Open questions further encouraged feedback on course strengths, weaknesses and the teaching activities.

4) *Analysis of quiz results*

The student results from both quizzes were compared to quiz marks obtained by the control group of students who did not experience MQs. The data were analysed using the GraphPad Prism software package and applying the student's t-test. The grade point averages (GPA) of the students in each group were also compared and analysed using a t-test. The GPAs are calculated on the courses undertaken by the students in their first semester of the program. These courses are theory based and specialised to their discipline of study. Thus they are an indicator of a student's academic capability prior to commencing the laboratory course.

5) *Students' attitudes towards scientific writing*

Surveys were also conducted at the start and end of the course regarding student attitudes towards scientific writing. The same surveys were given to the control group (in the following year) who did not experience MQs. Participation was anonymous and voluntary. The closed items were designed to determine the student perceptions of their own scientific writing ability and their confidence at performing certain writing tasks, such as writing a figure legend and deciding what information should go into discussion versus results sections of a report. Students were asked to circle one number on a Likert scale rating from 1 to 5. The data were analysed using the SPSS software package and applying the Mann-Whitney two-group test, which tests whether there is a difference between two population medians. Open-ended questions sampled student opinions on the course teaching strategies used.

Results

MQ Approach and Student Acceptance

To determine if students adapted to the use of MQs in class, surveys were undertaken on a regular basis (**Table 1**). The results show that students retained the information probed by MQs earlier in the course. Students also reported that the MQ approach helped them to understand more about the project.

Initially, when students were asked MQ questions, further explanation was given for wrong answers only. Survey results indicated that students wanted a brief summary or further explanation even after MQs were answered correctly to ensure they understood the concepts accurately and in sufficient depth. This feedback was taken into consideration and from week 3 a summary of all questions and the day's laboratory activities were included as part of the session. In week 4, all students were satisfied with the improved approach (**Table 1**) with no

further recommendation or dissatisfaction. The students' request to provide more explanation shows that they were comfortable in providing an honest evaluation if they thought something needed improvement. The students also stated that the MQ approach helped them to better understand the laboratory experiments with quotes such as "*My understanding has improved and I know what I am doing*". In addition the quote "*It is interactive and informative*" shows that getting involved in their own learning is perceived as a benefit.

A teacher familiar with the content, but external to the course interviewed the students after the experimental phase had concluded. Opinions were solicited regarding the use of MQs during the laboratory sessions (**Table 2**). Quotes such as "*Improved understanding of the lab*" and "*Consolidated knowledge about lab work*" revealed students regarded the MQs as beneficial. There were no recommendations for further improvement.

The final official University evaluation consisted of an anonymous survey with both open and closed questions that sought students' opinions of the effectiveness of teaching strategies (**Table 3**). They indicate overwhelming support for this teaching style, with all questions scoring an average greater than 6 out of 7, placing the course in the top 5% out of the 350 courses taught within the faculty in this semester. The following are representative comments made by students: "*MQs really helped me...!!*", "*MQs as well as the feedback given were very good*" and "*The MQs are done well and should be continued*".

Use of MQs Enhance Student Learning

In their surveys and interviews the students also stated that the MQs helped them prepare for the laboratory quizzes (which test understanding of the laboratory course techniques and data analysis). The marks from both quizzes were shown to be statistically significantly higher, when compared to a control group of 8 students who completed the same course in the subsequent year when MQs were not utilised (**Figure 1**). All other learning techniques were identical between the two groups. An analysis of the grade point average (GPA) was not significantly different between the two groups of students (5.1 (with MQs) compared to 5.0 (without MQs)), indicating that their academic ability was comparable (as detailed in the methods).

The Quiz results show that the students' understanding and knowledge did match their belief that the MQs had assisted them to better understand the experiments they were performing. The quizzes contained some questions that assessed their ability to utilise their knowledge and understanding of the core concepts to solve problems, rather than to merely recall information. Thus, questions were in a different format to MQs, which typically were shorter simple questions. The quiz results suggest that MQs were encouraging a deeper learning approach and that students could apply their knowledge to a wider scope of situations.

MQs Enhance Student Attitudes and Confidence towards Writing Tasks

One goal of the course was to instruct students in scientific writing. As such we wanted to determine if the students found the teaching strategies helpful. The anonymous surveys at the commencement and end of the course asked students how they rated their confidence and ability to write. The results are shown in **Figure 2**.

Table 1.
Biotechnology laboratory student surveys (MQ approach).

Survey Questions	Yes (%)		Student Responses
Did you understand what "Meaning Check Questions" are when the teacher explained them to you?	Wk 3	80%	
What MQs have you been asked today?	Wk 4		✓ How the insulin assay and expression system works, why we run a protein gel. ✓ Regarding the protein expression. ✓ About the last stage of the experiment especially analytical procedures. ✓ Protein expression. ✓ Regarding protein expression system and activity assay etc.
	Wk 5		✓ Introduction of fragments into pETThio vector and summary of whole project. ✓ About the entire project. ✓ Which enzymes would you use for experiment; expression vector. ✓ The work done in the lab today and yesterday. ✓ MQs were about the entire process that was carried out during the past 4 weeks.
Do you think MQ has helped you in the course today?	Wk 3	80%	✓ Yes. It is a good way to check your knowledge about the subject. Along with the MQs, the demonstrator should also explain the entire activity.
	Wk 4	100%	Yes, it helped me a lot.
	Wk 5	100%	Yes, it explained the gaps in part of the experiment.
If yes, how did you benefit from this MQ approach?	Wk 3		✓ It helps us realize our weakness and improve on them as well as preparing questions as it encourages us to read ahead of time. ✓ Helped me to understand the activity better. I think the explanation given by her is sufficient enough for me to present myself in the MQ. ✓ My understanding has improved along with the technique. I get to know what exactly I am doing and why I am doing that.
	Wk 4		✓ It consolidates what I already know and emphasizes important things. ✓ I think it helps me for quiz (test). ✓ It helps to know how certain questions should be answered. ✓ Improved my understanding. ✓ It has improved my understanding and has made me think about this project.
	Wk 5		✓ My understanding has improved and I know what I am doing. ✓ It is interactive and informative. ✓ It made answers clearer. ✓ This MQ is a link for the missing clues of the lab. ✓ Helped to improve my understanding.
If any, please mention what we can do better to assist you to learn.	Wk 3		✓ The demonstrator should also explain a bit more.
	Wk 4		✓ All good. ✓ Everything is perfect.
	Wk 5		✓ All good.
Previously, students asked for a summary of MQs. Did the teacher summarise the answers to all MQs?	Wk 4 Wk 5	100% 100%	✓ Yes, she was giving explanation as well as the summary. ✓ Yes, she was giving explanation as well as the summary.

Students showed a statistically significant improvement in their rating of their scientific writing ability (Panel A) and in their confidence at being able to decide if information should be included in the results or discussion section (Panel C). While the results also show an improved trend in their confidence at writing figure legends (Panel B) there was no statistical significance. This is likely due to a couple of reasons. First, writing a figure legend follows relatively simple rules and second, they were Masters students with some prior experience. In contrast, writing a coherent results and discussion section requires higher order analytical and critical thinking, which can only be obtained by practice and appropriate training.

Of particular interest is that this course was also conducted in the same format in 2009, without the MQ approach. Identical survey questions were asked before and after the course and there was no statistically significant improvement in the student rating of either their scientific writing ability, figure legend writing or ability to decide which information went into results vs. discussion sessions (data not shown). The students in 2009 also stated in the open ended questions that they had problems learning the scientific language needed for writing reports, whereas the students in 2008 had very positive things to say about how the teaching strategies (including MQs) helped to improve their scientific knowledge and writing skills. In the 2008 survey 100% of students responded that they better understood the purposes of the experiments after MQs and writing activities. In contrast only 50% of students in 2009 responded that they understood better the experiments after the writing

Table 2.
Interviews of students taken at end of course by another teacher.

Survey Questions	Student Responses	
	Yes (%)	Open-Ended Responses
1. Did the teacher ask MQs in every lab class?	100%	
2. Do you think MQ has helped you in this class?	100%	
3. If yes, in what way did you benefit from MQs approach?		✓ Helpful for the quiz and understanding the lab better. ✓ Helps with answer structures. ✓ Understand lab activities. ✓ Improved understanding of the lab. ✓ Made work clearer.
4. Did the teacher summarize the answer of MQs that are asked in the class?	100%	
5. If yes, how did you benefit from this "MQ" approach?		✓ Helpful for the quiz and gave a clear picture about the lab approach. ✓ Knowing the correct answer and how to write them. ✓ Learned how to better phrase scientific writing. ✓ Understand overall picture of lab. ✓ Consolidated knowledge about lab work.
6. If anything, what we can do better to assist you in better learning.	No further suggestions	

Table 3.
Final university survey taken at end of course.

Survey Questions	Average Response[a]
Explaining Aims and Objectives 1: How effective was this lecturer/tutor in helping you to understand what you were expected to learn?	6.6
Teaching Skill 2: How effective was this lecturer/tutor in using teaching methods that helped you to learn?	6.4
Teacher's Capacity to Motivate 3: How effective was this lecturer/tutor in motivating and inspiring you to learn?	6.6
Concern for Students and their Learning 4: How effective was this lecturer/tutor in showing concern for you and your learning?	6.4
Commitment to the use of Feedback 5: How effective was this lecturer/tutor in ensuring that you received feedback which helped you to learn (written or oral on your work)?	6.6
Assessment Requirements 6: How effective was this lecturer/tutor in helping you to understand the standards of work required in the assessment items?	6.8
Focus on Learning 7: How effective was this lecturer/tutor in helping you to extend your knowledge understanding and skills (i.e. beyond memorisation)?	6.4
Teaching Coherence 8: How effective was this lecturer/tutor in teaching in an organised, coherent and well ordered way?	6.6
Commitment to Improvement 9: How effective was this lecturer/tutor in seeking and using feedback to improve his/her teaching?	6.6
10: Overall, how effective was this lecturer/tutor in helping you to learn?	6.8
11: How effective were the meaning check questions in helping you to understand the laboratory course?	6.8

Note: [a]The score is rated on a 7 point Likert scale where 1 = Poor, 4 = Average, and 7 = Excellent.

activities alone. This belief by the MQ group of their enhanced understanding was borne out by achieving higher quiz marks (**Figure 1**).

Students were asked to prepare a draft of their written report, which was assessed by an independent examiner not involved in teaching the course. The trend was for students who experienced MQs to achieve a higher average mark (7.2/10) compared to the control group of students (5.9/10). However upon individual feedback to each student both groups of students ultimately ended up with very similar overall marks for their assignment, but the control group required more assistance to reach this level.

The overall results suggest that MQs are a simple, yet effective approach in assisting students to learn concepts and to enhance their confidence at performing scientific writing tasks.

Discussion

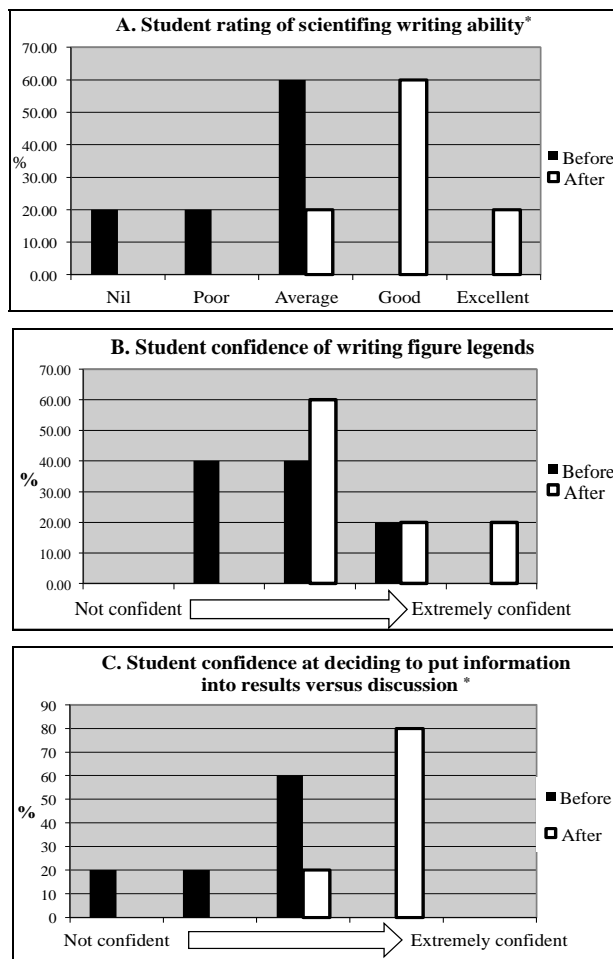While student-centered learning is now regarded as good
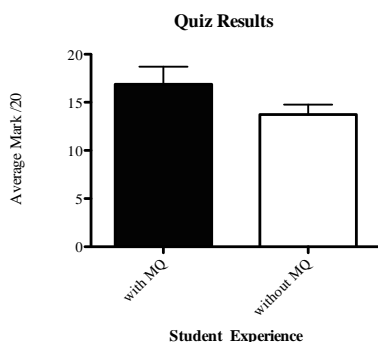
Quiz Results

Figure 1.

Quiz results from students experiencing MQ approach compared to those who did not. Results from quiz 1 and quiz 2 were pooled. Mean ± SEM. N = 10 (with MQ) and N = 16 (without MQ). Statistical significance was determined using a student's t test ($P < 0.05$).

Figure 2.

Student opinions of their scientific writing ability (Panel A) and their confidence at performing scientific writing tasks (Panels B and C). The Likert rating scales were: Panel A: 1 = Nil, 2 = Poor, 3 = Average, 4 = Good, 5 = Excellent; and Panels B and C: student confidence levels of Not confident (=1) through to Extremely confident (=5). Students were surveyed pre and post course. *Significant differences between pre and post course surveys were determined using the Mann-Whitney test (2 group); $P < 0.05$ for Panels A and C.

practice, selecting the appropriate active learning approach may be influenced by many factors including the teaching context, class size, and the previous experience of participants. Teachers may also be reluctant to adopt particular active learning strategies for their course without prior validation they are likely to be worth the effort (Knight & Wood, 2005). MQs are a tool used in teaching English and this study demonstrates that successful approaches in one discipline can be transferred to another, in this case to teach scientific concepts in a laboratory setting. The MQs assisted students to consolidate and extend their knowledge and to apply it to problem solving questions and to scientific writing. This approach is particularly suited to laboratory classes because the student: demonstrator ratios are in a range that enables active participation of each student, however MQs may also be adapted for other courses.

MQs were used to specifically check if students understood the content relevant to each particular session or activity. However it had even greater benefits than originally intended. Students began automatically reviewing and previewing the course materials before coming to the laboratory sessions. The class time could then be spent focusing more on "how much" or "what" students know. MQs also helped to verify what they had learned in the previous session without the need for a formal test. Since students studied before coming to laboratory sessions, MQs also functioned as an interactive review. As a result, students became more positive and competent towards all aspects of the course, as seen in **Figures 1** and **2**. Students could therefore be challenged with deeper, harder questions to enhance their scientific knowledge and skill base. One MQ was particularly powerful: "*Tell me one important thing you learned from the previous class*". This greatly helped the teacher to determine what students learned and any important points not mentioned could then be re-emphasized. Thus, MQs acted as a checkpoint for the teacher to determine what students were learning and which concepts needed further explanation.

Verbalising answers assists with the learning process and through talking ideas are formulated, refined and subsequently firmly established (Myhill, 2010; Vygotsky, 1986). In particular verbalizing something before doing an activity results in improved performance, especially in the initial stages of learning (McKeachie et al., 1986). The students in our class believed that the use of verbal MQs improved their understanding of the

laboratory experimental work and as a consequence became more confident with the course material. Confidence is an important attribute to develop among students. Increased confidence at performing a task usually results in higher productivity and better outcomes (Compte & Postlewaite, 2004). A study using data from 41 USA colleges and Universities showed that students with more confidence and greater self belief achieved higher GPAs and were more likely to graduate than students with the same academic ability, but with less self-belief. Thus even over-rated self-belief was of benefit. (Mattern et al., 2009). While our study size was small, the students recorded statistically significant quiz results compared to students who had not experienced MQ and who self-reported a lower confidence level. Thus it would appear that confidence among the MQ students did correlate with a better understanding.

An interesting finding was that using verbal MQs assisted the students to become more confident towards scientific writing. Training in scientific writing was provided in the laboratory

class and required the students to complete writing activities, where they received feedback. Verbal MQs also probed aspects of scientific writing. The use of both verbal and written approaches to guide writing development equates to a multimodal approach to develop academic literacy, as advocated by Archer (2006). A multimodal approach using verbal, written and visual approaches to train engineering students was preferred to solely focussing on a written mode, since learning can be shaped by many stimuli (Archer, 2006). In our class, where one goal was to develop scientific writing skills, verbalising their thoughts may have assisted the students to better organise how they would write their report. Alternatively it may have enhanced their overall confidence, leading to a belief that they were now more competent at scientific writing.

Since all students were Asian, these teaching methods had a deeper significance. In a classroom setting Asian students are usually regarded as quiet and do not often voluntarily speak in class in comparison with native English speakers (Farell, 2009). That means that it can be even harder to determine if they understand the material being discussed in class. However, the results from this study show that these active teaching approaches are very promising. In the beginning students expressed the usual "sigh" when they found out they had to participate so often. However, once they built up their confidence, they were quite comfortable expressing their opinions and even stated that they preferred this approach. In addition students stated that MQs helped them prepare for the formal quizzes and thus could see some personal benefit. These results support other research on how Asian students prefer active learning approaches once used to this style of teaching (Kember, 2000; Wong, 2004).

The results obtained in this study are significant as there is a growing number of overseas students who are studying in English speaking universities. Of the 34,000 students attending Griffith University in 2008 about 7000, or approximately 20%, were from overseas countries (GriffithUniversity, 2008). From experience in teaching both in Australia and Korea for over 10 years, it is empirically evident that students using English as a second language become particularly intimidated when they need to speak in a lecture, workshop and even in a small group setting with native speakers. By appreciating these difficulties and adopting strategies that encourage more active participation, students can adapt and succeed in a foreign environment.

Conclusion

This small study shows that MQs are a viable active learning approach for the biological science laboratory, and these initial results show that MQs warrant further investigation as a learning tool. Students whose mother tongue isn't English experience difficulty in communicating while learning due to obstacles such as English proficiency level, culture and customs. The results show that despite these obstacles a noticeable improvement in their competence, confidence and level of learning is possible once they became actively engaged in their learning. Furthermore the utilisation of simple active teaching methods, such as MQs, is potentially a powerful tool for student-centred learning in the biology discipline and could be easily applied to a larger range of courses.

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REFERENCES

Ali, F., Jadavji, N. M., Ong, W. C., Pandey, K. R., Patananan, A. N., Prabhala, H. K., & Yang, C. H. (2007). Supporting undergraduate research. *Science, 317,* 42. doi:10.1126/science.317.5834.42a

Archer, A. (2006). A multimodal approach to academic "literacies": Problematizing the visual/verbal divide. *Language and Education, 20,* 449-462. doi:10.2167/le677.0

Biggs, J. (2003). *Teaching for quality learning at university* (2nd ed.). Buckingham: Society for Research into Higher Education and Open University Press.

Chan, S. (1999). The Chinese learner—A question of style. *Education and Training, 41,* 294-305. doi:10.1108/00400919910285345

Chickering, A. W., & Gamson, Z. F. (1999). Development and adaptations of the seven principles for good practice in undergraduate education. *New Directions for Teaching and Learning, 80,* 75-81. doi:10.1002/tl.8006

Compte, O., & Postlewaite, A. (2004). Confidence-enhanced performance. *The American Economic Review, 94,* 1536-1557. doi:10.1257/0002828043052204

Farell, T. S. C. (2009). *Talking, listening, and teaching: A guide to classroom communication.* Thousand Oaks, CA: Corwin Press.

Griffith University (2008). Griffith University international. URL (last checked 30 October 2008). http://studylink.com/australia/display/provider/provider-info.html?pid=pid-mm-01-00233e

Jordan, J., & Kedrowicz, A. (2011). Attitudes about graduate L2 writing in engineering: Possibilities for more integrated instruction. *Across the Disciplines, 8.* URL (last checked 22 October 2012). http://wac.colostate.edu/atd/ell/jordan-kedrowicz.cfm

Kardash, C. M., & Wallace, M. L. (2001). The perceptions of science classes survey: What undergraduate science reform efforts really need to address. *Journal of Educational Psychology, 93,* 199-210. doi:10.1037/0022-0663.93.1.199

Kember, D. (2000). Misconceptions about the learning approaches, motivation and study practices of Asian students. *Higher Education, 40,* 99-121. doi:10.1023/A:1004036826490

Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell Biology Education, 4,* 298-310. doi:10.1187/05-06-0082

Lee, S. E., Woods, K. J., & Tonissen, K. F. (2011). Writing activities embedded in bioscience laboratory courses to change students' attitudes and enhance their scientific writing. *EURASIA Journal of Mathematics, Science & Technology Education, 7,* 193-202.

Libarkin, J., & Ording, G. (2012). The utility of writing assignments in undergraduate bioscience. *CBE—Life Sciences Education, 11,* 39-46. doi:10.1187/cbe.11-07-0058

Manske, B. (2010). That's not biology...Or is it? Changing student's perceptions of writing in the sciences. URL (last checked 22 August 2012). http://mendota.english.wisc.edu/~WAC/page.jsp?id=174&c_type=article&c_id=4

Mattern, K. D., Burrus, J., & Shaw, E. (2009). When both the skilled and unskilled are unaware: Consequences for academic performance. *Self and Identity, 9,* 129-141. doi:10.1080/15298860802618963

McKeachie, W. J., Pintrich, P. R., Smith, D. A., & Lin, Y. G. (1986). *Teaching and learning in the college classroom: A review of the research literature.* Ann Arbor, MI: The University of Michigan.

Myhill, D. (2010). Its good to talk—Participatory talk for learning classrooms. *Educational Research in Classrooms, 1,* 1-12.

Peat, J., Elliott, E., Baur, L., & Keena, V. (2002). *Scientific writing—Easy when you know how.* London: BMJ Publishing Group, Ltd.

Quitadamo, J., & Kurtz, M. (2007). Learning to Improve: Using writing to increase critical thinking performance in general education biology. *CBE—Life Sciences Education, 6,* 140-154.

doi:10.1187/cbe.06-11-0203

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Smith, A. C., Stewart, R., Shields, P., Hayes-Klosteridis, J., Robinson, P., & Yuan, R. (2005). Introductory biology courses: A framework to support active learning in large enrollment introductory science courses. *Cell Biology Education, 4,* 143-156. doi:10.1187/cbe.04-08-0048

Strenta, A. C. I., Elliott, R., Adair, R., Matier, M., & Scott, J. (1994). Choosing and leaving science in highly selective institutions. *Research in Higher Education, 35,* 513-547. doi:10.1007/BF02497086

TEFL. (2007). Is this a concept check question? URL (last checked 22 August 2012).
http://www.tefllogue.com/training/is-this-a-concept-check-question.html

Vygotsky, L. S. (1986). *Thought and language* (A. Kozulin, Trans.). Cambridge, MA: MIT Press.

Walczyk, J. J., & Ramsey, L. L. (2003). Use of learner-centered instruction in college science and mathematics classrooms. *Journal of research in science teaching, 40,* 566-584. doi:10.1002/tea.10098

Wong, J. K. (2004). Are the learning styles of Asian international students culturally or contextually based? *International Education Journal, 4,* 154-166.

Wood, W. B. (2003). Inquiry-based undergraduate teaching in the life sciences at large research universities: A perspective on the Boyer Commission Report. *CBE—Life Sciences Education, 2,* 112-116. doi:10.1187/cbe.03-02-0004

Workman, G. (2005). *Concept questions and time lines*. Cambridge: Chadburn Publishing.