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Enhancing self-directed learning through a content quiz group learning assignment
Natalie Warburton & Simone Volet


Enhancing self-directed learning through a content quiz group learning assignment

ABSTRACT This article presents the findings of an empirical study that examined the learning value of a novel group assessment activity aimed at promoting first year students’ development of basic self-directed learning skills required for university study. A content quiz group learning assignment was designed to enhance students’ capacity to ask appropriate questions to guide inquiry, identify appropriate resources and tools, and draw links between different learning resources, all skills embedded within their learning in a science unit. Questionnaire data and written reflections revealed the extent to which students used core, accessory and optional resources to complete this assignment, which specific resources were perceived as most useful for what aspects of their content learning, and how strategy use was related to achievement. Metacognitive experiences expressed in the open questions and assessed reflections revealed students’ emerging awareness of how their approach to study impacted on the quality of their learning.

KEYWORDS: self-directed learning, learning skills, first year students, reflective learning, self-test, assessment, learning resources

Many students find the transition to tertiary study difficult due to the need to move from a more teacher-guided approach in the school environment to university instruction designed for autonomous learners (Brinkworth et al., 2009). Even the most academically successful students find this transition challenging (Raidal and Volet, 2009). A capacity for active, self-directed and self-regulated learning (Boekaerts and Corno, 2005; Schunk and Zimmerman, 2008) is widely recognised as a key determinant of academic success at university. Yet, case studies reporting attempts to foster the development of such skills embedded within first year content units are limited in the literature on transition to tertiary study and learning at university more generally. In this article, we report the findings of an empirical study that examined the learning value of a novel group assessment for a first year science unit, which made explicit to students some of the basic active, self-directed learning skills required for university study.

Brief review of the literature on effective learning at university

University students as adult learners are expected to play an active role in the decision making of what material they learn and how they approach their learning, particularly with regard to learning that takes place outside formal classes. Two inter-related, and sometimes overlapping, bodies of literature related to effective learning at university are self-directed learning and self-regulated learning. The importance of self-directed learning has its origin in the adult learning literature. Self-directed learning, with its emphasis on learners’ responsibility, is regarded as essential not only for successful undergraduate education (Candy, 1991; Ramsden, 2003) but also for the development of skills for lifelong learning (Dyanan et al., 2008). The importance of developing skills for self-directed learning has been acknowledged in fields as diverse as engineering (Bary and Rees, 2006), business (Dyanan et al., 2008), nursing (O’Shea, 2003), and veterinary sciences (Blumberg, 2005).

The organisation of structured self-directed learning activities during undergraduate study may provide opportunities to guide students’ development of effective self-regulated learning strategies but is typically not considered sufficient. The extensive body of literature on self-regulated learning (e.g. Boekaerts et al., 2000; Schunk and Zimmerman, 2008; Vermunt and Vermetten, 2004), located in the field of educational psychology, complements research on self-
directed learning by focusing on the nature and effectiveness of the strategies used by learners, and how students can become masters of their own learning processes. Consistent across the self-directed and self-regulated learning perspectives is the claim that effective learners are those who take responsibility for their own learning, and use adaptive metacognitive strategies to monitor their learning process. Metacognitive strategies and a reflective approach to learning are recognised as key features of self-regulated learners (Granville and Dison, 2005; Masui and De Corte, 2005; Gourlay, 2009; Van den Hurk, 2006). Self-regulated learners appear to have greater success than individuals who do not exhibit self-regulated learning behaviours (Barnard-Brak et al., 2010; Jansen and Suhre, 2010) and report deeper learning strategies (Vermetten et al., 2001). The relationship between self-regulated learning strategies and academic achievement is well documented (Boekaerts and Corno, 2005; Schunk and Zimmerman, 2008).

In regard to learning content knowledge, self-directed learners have been described as students who ask appropriate questions to guide their enquiry, interrogate the assumptions behind the ideas presented to them, identify appropriate resources and tools, and use or modify these strategically to achieve their learning goals. These metacognitive strategies reflect some of the higher order reasoning skills highlighted in Bloom's taxonomy, namely, application, analysis, synthesis and evaluation (Dynan et al., 2008). For Jansen and Suhre (2010), becoming an independent self-directed learner also includes a growing ability to distinguish between major concepts and supporting ideas, use strategies for elaboration and organisation of major concepts, and evaluate the time needed to absorb large amounts of subject matter.

Around the world, the first year of university study is considered a critical period of transition for most students (Brinkworth et al., 2009; Krause and Coates, 2008), and therefore it is a valuable time for promoting change in their personal epistemological beliefs about knowledge and learning (Haigh and Kilmartin, 1999; Brownlee et al., 2009). Research studies and anecdotal accounts also suggest that many students require further development of their self-directed and self-regulated learning skills to be successful at university (Credé and Kuncel, 2008; Dynan et al., 2008; Hattie et al., 1996; Jansen and Suhre, 2010). This is important in light of evidence of great diversity in pre-university study skills preparation (Jansen and Suhre, 2010) and a continuum of self-directed learning readiness in most cohorts (Fisher et al., 2001).

The importance of designing structured “powerful” learning environments (De Corte, 2003), which promote effective self-regulated learning, is strongly advocated in the educational psychology literature. De Corte argued that carefully designed learning environments, which foster students’ engagement in active and constructive learning processes and provide socio-cultural supports via interaction and collaboration, not only promote better learning outcomes but also benefit future learning. Similarly, Kirschner et al. (2006) claimed that “a strong emphasis on guidance of the students’ learning process” (p.75) is more effective than minimally guided instruction. Dynan et al. (2008) found empirical evidence that self-directed learning development is enhanced in more structured learning environments. They concluded that such environments should therefore be provided in the early years of university study since they would benefit the majority of students. Guiding transition towards more autonomous forms of learning may, however, best take place in collaborative learning settings, as suggested by Raidal and Volet (2009) based on their research with preclinical students, and widely supported by research on the value of peer learning at university (Springer et al., 1999).

One potentially useful way to address some of the difficulties associated with the transition to university learning is to make explicit the skills for self-directed learning and to facilitate their development through targeted teaching and learning activities. Since, according to Schunk (2001), self-regulated learning behaviours are “highly context dependent” (p.125) and students are strategic in their approach to learning in different contexts, promoting the development of self-regulated learning skills should be customised to students’ content learning to have the greatest impact.

Research on the development of self-regulated learning skills embedded in the teaching of content learning in first year at university is still scarce, especially in science (Schraw et al., 2006). The capacity to select appropriate resources, and to reflect and evaluate their appropriateness, is particularly relevant to effective study at university. Also important is the
competence and commitment to reflect on what has been learnt through the completion of assignments, in terms of learning content as well as learning skills.

The aim of the present study was to examine the extent to which students could be induced, through designing a content quiz with a group of peers, to develop some basic skills for university study.

**Research methods**

**Participants**

Participants were first-year students (a mixed cohort of animal science, pre-vet and biomedical science) enrolled in a biology unit in the year 2010. Volunteers for the research project, embedded within the unit, were recruited in class. Students were informed that the study aimed to develop a better understanding of their experience of learning through the completion of one of the assessed tasks, the ‘content quiz group assignment’. They were told that participation would involve the completion of one questionnaire, as well as consent for researchers to access their written reflections on the content quiz group learning assignment, their group mark for the content quiz assignment and their overall mark for the unit. Sixty-five per cent of the class (94 students: 72 females, 22 males) volunteered to participate in the study. (This sex ratio was representative of the overall class; 69%: 31%). As not all students were present when the project was presented in class, the participants are highly representative of the whole class.

Students enrolling in this first year biology unit are typically in their first year of tertiary study, and many have entered university directly from completing secondary education. 80% of respondents were aged 20 years or under and 20% 21 or over.

The content of the unit provides an overview of 1) the structure and function of the animal body, including basic cellular biology and organ systems, and 2) the evolution and diversity of living animals. Assessment in this unit comprises standard assessment types: a short written essay; mid- and end of semester theory exams incorporating a variety of multiple choice questions; short answer and extended answer questions; and a practical exam.

**Procedure**

**The content quiz group assignment**

The content quiz group assignment was designed especially for this study and was used for the first time. The assignment had three specific learning objectives. Students were directed to use this task: firstly to make connections between lecture material and resources (including learning objectives and keywords) and laboratory activities and resources (including the veterinary anatomy museum); secondly to develop research skills, primarily text book use, including accurate referencing of appropriate sources; and thirdly to experience collaborative learning (through small group activity, use of student produced resources, and feedback/clarification via the online discussion board).

In practice, students were invited to form self-selected groups of two to four peers. Their task was to produce a five question self-test activity for the rest of class based on the unit content. Groups had two weeks in which to prepare their quiz questions in their own time (no teacher). A template for the format of the questions was provided to enable questions to be uploaded into the self-test tool of the online unit. The five questions (matching, short answer and multiple choice) had to incorporate at least three of the key words from the designated lecture topic (as specified in lecture summary document). Each group also had to include at least one image, typically a photo taken during laboratory class or in the veterinary anatomy museum, upon which the multiple-choice questions were to be based. It was expected that this would enhance the connections between lecture and laboratory material, encourage exploration of the museum as a learning resource and decrease the likelihood of students using questions from the internet or texts. Each group had to provide the answers to the questions they had developed, and also had to provide feedback on anticipated potential misunderstandings by other students. As for any assignment, appropriate referencing for all information and images was required. The group assignments had to be submitted within two weeks of the given lecture on which the questions were based in order to enable the inclusion of the questions to the weekly online self-tests. The online quizzes were an optional resource for peers to test their understanding of the topic and
formed part of their individual study program. Students received immediate feedback on their performance. Marks for this formative ‘self-assessment’ did not contribute to the overall unit mark of students.

Following their group submission, each individual student was required to complete a reflection exercise of approximately 150-200 words describing the extent to which they felt that they had achieved the learning objectives of the group assignment.

**Data collection and instruments**

Data sources were a questionnaire and written reflections completed at the end of the semester, and students’ individual marks for the unit.

**Questionnaire**

The questionnaire elicited information on: reported use of resources for completing the assignment and usefulness of those resources; perceived usefulness of the content quiz group learning assignment to enhance learning; and an open-ended question about possible change in learning on completion of the content quiz group assignment.

**Reported use of resources for completing the assignment, and usefulness of those resources.** Students were asked to rate the extent to which they used a number of resources (list provided) from 1 (not at all) to 4 (a great deal), with the option of adding other resources. Table 1 describes all the resources presented for rating. These are divided up into three broad categories: core, accessory and optional.

<table>
<thead>
<tr>
<th>TABLE ONE ABOUT HERE</th>
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Following use ratings, students were asked to indicate which three resources they found the most useful sources of information.

Students were also asked to rate the extent to which completing the group assignment encouraged them to use a variety of resources, and if in the process they had discovered new resources for learning.

**Perceived usefulness of the content quiz group learning assignment to enhance learning.** Students were asked to rate the extent to which this assignment had enhanced their learning, more specifically lecture content, level of detail required in the unit, learning skills for the unit, learning skills to revise content for exams and learning skills for university study overall.

Furthermore, in relation to content (core resource), students were asked to rate the extent to which the assignment helped them see and make connections between the different learning materials, link the information presented in the lectures and activities conducted in the labs, and enhanced their understanding of the structure and function of the animal body.

The extent to which they used the online quizzes from their peers’ group assignments within their revision practices was also elicited. All questions were rated on a scale of 1 (not at all) to 4 (a great deal).

Finally an open-ended question invited students to comment on how they had changed their learning or study technique as a result of completing this assignment, if at all.

**Written reflections**

In order to encourage reflection on how this assignment helped achieve the stated learning objectives, all students were required to prepare a short written submission at the end of the activity. Their reflections were expected to include some discussion of the resources they found useful, their group work skills, and any changes they might make to their strategies for group work and content learning in the future. Students were expected to write between 100 and 200 words although some students wrote considerably more.

**Results**
**Use of resources to complete the content quiz group learning assignment and relationship to achievement**

*Use of resources.* Students’ reported use of learning resources to complete the content quiz group learning assignment is presented on the left hand side of Table 2, organised in descending order within the core, accessory and optional categories, and Figure 1 illustrates the findings.

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**TABLE TWO AND FIGURE 1 ABOUT HERE**

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Online lecture notes summaries online were the most heavily used among the core learning resources. This was expected, given that to complete the assignment students were required to identify the learning objectives from the lecture summary. However, the fact that not all students utilised these resources is cause for concern, and highlights the fact that even when clear instructions have been provided, students do not necessarily follow them.

Second most heavily used resources were the online unit lecture presentations (a complete set of PowerPoint slides presented in lectures). Heavy use of this learning resource was also expected, as the PowerPoint presentation would be highly valuable for review of key concepts presented in the lectures. It would also hopefully relate them to the context in which they were used in the content quiz assignment.

Interestingly, the next most highly used resource was not the recommended unit textbook (third core resource) but websites, recommended by the teacher as only an optional resource. Websites appeared to be used quite broadly. This was not unexpected, though potentially injudicious use of non-peer reviewed or non-'academic' material from the Internet may lead to misconceptions relating to content. As illustrated in Figure 1, the unit textbook, considered a core resource by the teacher, appeared to be used a little or not at all by 40% of the students.

Considering accessory unit resources, the finding that half the class used the laboratory manual was pleasing in that it suggests that students were reviewing the manual and seeking connections with the lecture material. Limited spontaneous use of the veterinary anatomy museum in its physical and online versions was not unexpected from a class of first year students, who had thus far only been recommended these resources.

Among the optional (non unit) resources and apart from the websites, the findings that approximately 40% of the class spontaneously consulted library or digital reference books was noteworthy since students had not been given any direction regarding the use of such resources.

Finally, very few students reported consulting journal articles. This was not surprising since the requirements of the content quiz group learning assignment focused on basic concepts.

Overall, the data on reported use of resources highlight the fact that most students referred to the core resources to complete the content quiz group assignment, albeit not always the textbook, which would have provided valuable complementary information. The widespread consultation of websites may need closer examination in future research to discover what types of websites are consulted and how the information is used. First year students should benefit from guidance as to how to select reliable web resources for their study. The findings also indicate students used a diversity of other resources, perhaps more diverse than anticipated for first year university level. The extent to which first year students are aware of the range of resources available to them, and how these can be used to enhance their learning, needs to be addressed in future research.

*Relationship of resource use to achievement.* To address this issue, two resource use scores were computed for each student: a total resource use score, representing the sum of usage score for all ten resources, and a core resource use score representing the sum of the three core resources. No significant relationships were found between core resource use and individual marks in the unit (r=-.02) or group mark for the assignment (r=.09). With regard to total resource use, no relationship was found with individual marks for the unit (r=.01) but a
moderately significant relationship with group marks for the assignment ($r=.21, p<.05$) was detected.

Overall, these findings suggest that use of resources does not necessarily mean appropriate and effective use. The moderate relationship between total resource use and group marks for the assignment, however, suggests that students’ extensive use of multiple resources had some positive impact on the quality of their group assignment.

**Perceived usefulness of sources of information to complete the content quiz group learning assignment**

The right hand side of Table 2 shows the percentage of students who rated the different resources as their first, second or third preference. The three core unit resources were considered to be the most useful resources to complete this assignment by the majority of the class. The highest scores for first preferences were the lecture summaries, lecture presentations, websites and recommended textbook (in decreasing order). From a teacher’s perspective, the high scores for the core unit resources is a positive result and suggests that these references are useful and appropriate to the learning objectives of the unit. Of the non-core and optional resources available to students, websites were highly utilised and ranked as one of the most useful resources by a large proportion of the class. As noted above, as the choice and content of websites were not moderated by the teacher, the accuracy of the material presented within those websites could not be validated.

**Overall resource use.** Quantitative (Table 3) and qualitative data (comments about resources) suggest that students did perceive a change in how they used resources subsequently to completing the assessment task.

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**TABLE THREE ABOUT HERE**

Seventy five percent of respondents agreed that completing the assignment encouraged the use of a variety of resources (mean score of 3.01). Students commented that they,

- Use a variety of sources now.
- Investigate all resources available, and compare all the notes I have (own notes, presentations, summaries).

More than 50% of respondents identified additional resources, some specifying that they,

- Learnt how to access more library resources for study.

Further, some students showed an awareness of the importance of using reliable sources of information:

- I am also confident that we have referenced reliable sources of information in order to assure the accuracy of our quiz questions and answers.

**Perceived usefulness of the content quiz group learning assignment to enhance learning**

**Content learning.** Table 4 presents the mean rating scores for student perceptions of different aspects of learning as a result of completing the content quiz group learning assignment.

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**TABLE FOUR ABOUT HERE**

More than 80% of the class indicated that this assignment was a useful tool to enhance understanding of lecture content and concepts within the unit. The strongest ratings of perceptions of student learning were that the content quiz contributed to enhancing their understanding of the lecture content (mean 3.29) and of their understanding the animal body (unit content; mean 3.34).
Over 70% said that the assignment helped them to see the connections between the different teaching and learning activities within the course (mean 2.94). One of the aims of the content quiz group learning assessment was to highlight to students that laboratory classes were designed to support and illustrate the information presented in the lectures. With this in mind, students were encouraged to produce images of specimens that highlighted the concepts within their chosen topic. In this way students were deliberately encouraged to look for links between their chosen lecture topic and laboratory activities.

**Learning skills.** The extent to which students thought they had developed generic learning skills alongside content learning, through completing the content quiz group learning assignment was examined. Sixty-seven percent of respondents indicated that completing the assignment resulted in the development of learning skills that would be helpful to revise for exams in this unit (mean 2.91). This finding is illustrated in students’ comments presented in the next section.

To a lesser extent students reported development of transferrable learning skills for the unit (mean 2.65) and more broadly for their university study (mean 2.62). Interestingly, there was no difference between their perceptions of learning skills for the specific unit (course) and for university study in general. The perceived transferability of skills was encouraging, although somewhat surprising as students often report study techniques that are discipline-specific, in this instance studying biology perceived as different from learning in mathematics or chemistry.

**Metacognitive experiences in the content quiz group learning assignment activity**

A number of students commented in the open-questions (questionnaire and assessed reflections of the assignment) that completing the assignment made them more conscious of focusing their study around the learning objectives given for each lecture, rather than indiscriminately trying to learn everything that was covered in a lecture.

- I think it was a great assignment to do as it made us pinpoint the key points we needed to learn and expand on them.
- I read and understand the learning objectives and key words for each topic now.
- [I] learned to refer to learning objectives.
- I think I've become better at picking out the key point from each lecture and topic instead of trying to learn every little detail.

These are positive outcomes from this assignment. Clearly, as teachers implicitly expect students to organise their learning around the learning objectives they have supplied, it is evident that without guidance only some students will make these connections. By making these requirements explicit, students in this study learned where to look for information and how to appropriately prioritise their learning activities.

Students also reported that completing the assignment allowed them to identify how they might change their study behaviours to enhance their learning. For example,

- It became apparent [that] I needed to study the information in greater detail
- Summarising notes, creating practise questions.

Other students commented that completing the assignment highlighted the importance of good note taking during lectures (in addition to simply having printed out the PowerPoint slides):

- [I] must be able to take more comprehensive notes.

Such comments also reveal that some students were developing an awareness of their learning processes (metacognition), and that targeted assessment strategies were a useful tool in enhancing this awareness. The development of learning skills leading to deep-level engagement with the content was also identified, for example,

- Being required to formulate questions for others generated ownership of the topic. It encouraged me to master the topic. It required more time but the learning was more deeply entrenched than if I were just trying to read about a topic.

**Discussion and conclusions**
The results of this small scale study provide evidence that learning skills development embedded within an undergraduate content unit has potential to help first year students' transition to more self-directed forms of study.

The content quiz group assignment investigated in this study was successful in helping students develop some basic skills for self-directed learning at university. Firstly, students were required to identify and use key learning resources (in particular lecture summaries). Although not all students referred to lecture summaries to guide their learning, most identified these summaries as very useful in completing the assignment and subsequently as an important tool to structure their self-guided study. Secondly, students were induced, through the development of their content quiz, to make connections between lectures, laboratory classes and key resources. The need to produce images of specimens from the laboratory sessions or veterinary anatomy museum, and to include them in their content quiz directed them to make greater connections with the key learning concepts. Thirdly, students had to demonstrate their capacity to use research skills, through their critical evaluation of resources and appropriate referencing. There was evidence that students consulted a wide range of resources and strategically used them in producing their content quiz questions.

While promoting self-directed, active forms of learning can enhance content understanding (Bary and Rees 2006; Dynan et al., 2008; O’Shea, 2003; Blumberg, 2005) and the development of both discipline-specific and transferrable learning skills, it has been argued that in order to become self-directed learners, many undergraduate students need structured support (Credé and Kuncel, 2008; Dynan et al., 2008; Hattie et al., 1996; Jansen and Suhre, 2010). Central to successful self-directed learning is the ability to seek, recognise, effectively use and evaluate appropriate resources. As argued by Railton and Watson (2005) the directive to students to ‘go and read’ is fraught with difficulty when students might not know what or how to ‘read’ and what to do with their knowledge. The content quiz assignment addressed this issue by examining the value of giving students a clear purpose and immediate application for their study of specific concepts. Having to formulate questions to test their knowledge and to provide appropriate answers and explanations was instrumental in that regard. Engagement in such activities is important in light of evidence that while many university students lack skills for effective study, most are reluctant to attend generic study skills workshops because of a perceived lack of relevance (Durkin and Main, 2002). The present study demonstrated that the development of effective learning skills could be fostered when embedded in content learning. By embedding specific skills development within discipline units, the relevance of such skills is made more explicit since it is directly linked to the acquisition of content knowledge. Such an approach is consistent with Railton and Watson’s (2005) recommendations for ‘teaching autonomy’.

The inclusion of a short reflective task was also instrumental in encouraging students to think metacognitively about their learning skills as well as their developing content knowledge. Zepke and Leach (2010) recommend that institutions promote students’ development of self-competence in order to enhance engagement, motivation and success. However, it has also been noted that students who are unsuccessful in first year may be over confident of their study skills (Goldfinch and Hughes, 2007). In any case, the ability to accurately self-assess one’s own learning progress, and to link learning outcomes to learning strategies, is essential for successful study. Consequently, encouraging students to reflect on their learning strategies and study skills is likely to contribute to their development of more autonomous forms of learning.

The inclusion of metacognitive reflection exercises within science content units at university is not common practice. Yet, recent research revealed students’ capacity for valuable, in-depth reflection on their learning processes (Thurman et al., 2009). The present study showed that short reflections were a simple and non-threatening way of helping students think about and hopefully further develop their learning skills. For increased benefits, more emphasis should be placed on metacognitive reflection across units of study in the hope that this would further enhance self-direction in learning. Fostering permanent shifts towards deep learning strategies might be more challenging (Wilson and Fowler, 2005), yet worth pursuing, embedded within existing methods of assessment. It should be stressed that the content quiz assignment used in this study would be easily adapted to use in a range of disciplines.
This study has a number of limitations. First, it was modest in scope, being undertaken with only one cohort of students, in the context of one unit at one university. The cohort, however, was quite diverse in terms of students' course of study and academic background. Students were enrolled in a range of biological science based courses and represented a wide range of academic abilities (based on large variations in the average entry level scores for these courses). Other limitations were methodological, including the absence of control group and the reliance on self-report data collected at the end of the activity. Furthermore, students' prior experiences of learning autonomy were not accounted for as part of the research, and may have impacted perceptions of the usefulness of the activity. Data collection of prior learning experiences, including a survey of study skills confidence, would provide a better understanding of prior experience. Although the use of volunteers may not provide a balanced view of all students' experiences and perceived outcomes, the fact that almost all students who were present when the data was collected opted to participate brings some confidence in the representativeness of perceptions within this student population. One aspect not examined in this study, given the small sample, is the extent to which small group dynamics had an impact on student experiences and perceptions, since data from within groups is not completely independent. The findings of this study, therefore, should be interpreted with caution and will necessitate replication with other cohorts, other units and across disciplines.

A number of unanswered questions may provide the impetus for further research. What emerged from this small study is that the development of basic self-directed learning skills required for university study can be fostered successfully, when embedded within content units. The range of ways in which this can best be achieved, however, is yet to be investigated. This study examined only one possible instructional strategy for the development of a limited number of study skills. Other instructional strategies, equally adaptable across units and disciplines of study, could be developed and their usefulness established from the perspective of students and teachers alike, and using both subjective and objective measures. Offering first year students the opportunity to practise self-direction embedded within their content units, with a group of peers and under the close guidance of the teacher is promising and should be investigated further.

Acknowledgements
We are grateful to the Editor and two anonymous reviewers for their comments and helpful suggestions.

References


<table>
<thead>
<tr>
<th><strong>Classification</strong></th>
<th><strong>Label</strong></th>
<th><strong>Description</strong></th>
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</thead>
<tbody>
<tr>
<td>Core resources</td>
<td>Lecture summary document</td>
<td>Written summary of each lecture provided by the teacher (approximately 500 words), learning objectives for lecture (2-4), key words (5-10) for lecture, list of relevant reading, review questions (2-4) based on understanding rather than recall. Complete set of PowerPoint slides presented during the lecture</td>
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<td></td>
<td>Lecture presentation</td>
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<td></td>
<td>Text book</td>
<td>Recommended by the teacher</td>
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<tr>
<td>Accessory unit resources</td>
<td>Laboratory manual</td>
<td>Includes background information, diagrams, pre-lab questions and laboratory instructions for twelve laboratory classes designed to enhance students’ understanding of the unit content through practical, hands-on activities.</td>
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<td></td>
<td>Veterinary anatomy museum</td>
<td>Specimens including skeletons and organ systems for a range of domestic and wildlife species. The pre-lab exercises often included reference to specimens within the collection; students were expected to complete these in their own time before the relevant laboratory class.</td>
</tr>
<tr>
<td></td>
<td>Veterinary online anatomy museum</td>
<td>The website accessible to students includes photographs and labelled images of many of the specimens within the anatomy museum.</td>
</tr>
<tr>
<td>Optional additional resources</td>
<td></td>
<td>Various online and library based resources including online encyclopaedias, journal articles and websites. Students were not given any instruction as to the appropriate use of these resources, and due to the limitless volume of material on the web, the accuracy of the material presented within websites could not be validated by the teacher.</td>
</tr>
<tr>
<td>Resource Type</td>
<td>Resource</td>
<td>Mean rating</td>
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<td>-------------------------------------</td>
<td>-----------------------------------------</td>
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<td>Core unit resources</td>
<td>Unit Lecture note summaries online</td>
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<td></td>
<td>Unit Lecture presentations online</td>
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<td>Unit Recommended unit text book</td>
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<td>Accessory unit resources</td>
<td>Unit Laboratory manual</td>
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<td>Vet anatomy museum</td>
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<td></td>
<td>Journal articles</td>
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</tr>
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Table 3. Impact of the content quiz assignment on use of a variety of resources and discovery of new resources

<table>
<thead>
<tr>
<th>Description</th>
<th>N</th>
<th>Mean Rating</th>
<th>SD</th>
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<tbody>
<tr>
<td>Completing the Content Quiz Assignment encouraged me to use a variety of resources</td>
<td>93</td>
<td>3.01</td>
<td>0.84</td>
</tr>
<tr>
<td>In completing the Content Quiz Assignment I discovered new resources for learning</td>
<td>92</td>
<td>2.60</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Table 4. Students’ perceptions of learning with respect to the content quiz assignment

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<th>Degree to which learning was enhanced</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>A great deal</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Rate how completing the content quiz helped your learning in the following areas:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding the lecture content</td>
<td>1</td>
<td>9</td>
<td>46</td>
<td>38</td>
<td>3.29</td>
</tr>
<tr>
<td>Understanding the level of detail required in the unit</td>
<td>6</td>
<td>27</td>
<td>44</td>
<td>17</td>
<td>2.77</td>
</tr>
<tr>
<td>Developing learning skills for the unit</td>
<td>8</td>
<td>31</td>
<td>41</td>
<td>14</td>
<td>2.65</td>
</tr>
<tr>
<td>Learning skills to revise content for exams in the unit</td>
<td>4</td>
<td>23</td>
<td>44</td>
<td>23</td>
<td>2.91</td>
</tr>
<tr>
<td>Learning skills for university study overall</td>
<td>10</td>
<td>30</td>
<td>40</td>
<td>14</td>
<td>2.62</td>
</tr>
<tr>
<td>Rate the extent to which the content quiz enhanced your learning in terms of:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeing connections between learning resources</td>
<td>3</td>
<td>22</td>
<td>46</td>
<td>23</td>
<td>2.94</td>
</tr>
<tr>
<td>(lecture summaries, lecture slides, prelab questions, laboratory classes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making links between information presented in the lectures and the activities conducted in the laboratory classes.</td>
<td>9</td>
<td>24</td>
<td>36</td>
<td>25</td>
<td>2.82</td>
</tr>
<tr>
<td>Understanding the structure and function of the animal body</td>
<td>2</td>
<td>9</td>
<td>38</td>
<td>45</td>
<td>3.34</td>
</tr>
<tr>
<td>Rate the extent to which you used the online self-quizzes constructed by other groups of students</td>
<td>12</td>
<td>30</td>
<td>33</td>
<td>19</td>
<td>2.63</td>
</tr>
</tbody>
</table>
Figure 1. Overview of students’ reported of use of learning resources to complete the assignment

Note: To highlight the reported patterns of use, ratings of moderately and a great deal are shown above the x-axis, and ratings of a little or not at all are shown below the x-axis.

Biographical notes

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