Can creative podcasting promote deep learning? The use of podcasting for learning content in an undergraduate science unit

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Abstract
This paper examines the effect of a podcasting task on the examination performance of several hundred first-year chemistry undergraduate students. Educational researchers have established that a deep approach to learning that promotes active understanding of meaning can lead to better student outcomes, higher grades and superior retention of knowledge over time. We attempted to promote such an approach by setting a task that involved student collaboration, contextualisation of content, and communication through new media, specifically creative podcasting.

Examination results were used as a source of empirical evidence of changes in understanding and retention that occurred for students who completed this task. In comparing results across 2 years on similar questions related to the podcasting topics, we found a statistically significant improvement after introduction of the podcasting task on the questions related to one of the topics on which students had actively created their own podcasts (“acids & bases”), but not on the other (“oxidation and reduction”). Improved learning outcomes in the form of better understanding and retention over time in at least one case suggest that under some circumstances creative podcasting may indeed help to promote a deep learning approach.

Introduction
Given the constraints of shrinking staff budgets and expanding student numbers, it is challenging to find ways to engage students in large undergraduate science classes, particularly the typically less motivated non-major students. This paper reports on the implementation of a student podcasting assignment that required 352 first-year undergraduate chemistry students to explore one of two set chemical concepts—either “acids & bases” or “oxidation & reduction.” Students were encouraged to contextualise and explain the concept in their own way in a collaboratively created podcast, which was then made available to peers to listen to and comment on. Our main aim in setting this task was to promote a deep approach to learning through an emphasis on collaboration, contextualisation, and communication through new media. In addition, we hoped to improve science communication skills and increase overall motivation.
This paper reports quantitative results and is a partner to previously reported qualitative results, in which students’ self-reported perceptions of the value of the podcasting task, their manner of tackling it and their degree of engagement and motivation suggested that a deepening of learning had taken place (Bartle, Longnecker & Pegrum, 2011). Given the relatively large number of participants involved, the current study explores the available quantitative data to determine the extent to which they reveal the same patterns as the qualitative data. Although it is difficult to obtain empirical evidence of deep learning, researchers have found that it can lead to improved student outcomes and grades. We therefore compared examination results across 2 years on similar questions relating to “acids & bases” and “oxidation & reduction” to establish whether there was quantifiable improvement in student understanding and retention in these areas. Any such improvement would be in line with our prediction that collaboration, contextualisation and digital communication of understanding can promote deep learning, and in line with the previously explored qualitative data that suggested that this had in fact occurred. In addition, we coded the content of students’ podcasts in an attempt to identify any direct relationship between contextualisation and improved exam performance.

Deep learning
Building on the pioneering work of Marton and Säljö (1976a, 1976b), educational researchers have established that there are two major kinds of learning approaches adopted by university students, one oriented towards reproducing information, and the other oriented towards understanding it (IAUL, n.d.). A surface approach to learning involves passive reproduction and focuses on
“the ‘signs’ of learning: the words used, isolated facts, items treated independently of each other” (Biggs & Tang, 2007, p. 23, with ref. to Marton), whereas a deep approach to learning involves active understanding of meaning and focuses on “what is signified” (Ramsden, 2003).

It has been found that deep approaches correlate with higher quality learning outcomes and higher grades (Biggs, 1990; IAUL, n.d.; Ramsden, 2003) as well as greater retention of learning over time (Ramsden, 2003). This may relate to a crucial difference between memorisation and understanding. Biggs and Tang (2007), summarising Entwistle and Entwistle’s (1997) work on student understanding, noted students’ view that:

The experience [of understanding] was irreversible; what is now understood cannot be “de-understood”. Students thought a good practical test of understanding was being able to explain to someone else or to be able to adapt and to use what had been understood. (p. 74)

Another important aspect of deep learning is the forging of connections between pre-existing and new knowledge, which in turn improves understanding, retention, and application of learning to real-world situations:

Simply stated, deep learning involves the critical analysis of new ideas, linking them to already known concepts and principles, and leads to understanding and long-term retention of concepts so that they can be used for problem solving in unfamiliar contexts. Deep learning promotes understanding and application for life. (Houghton, 2004, p. 9)

It is important to note that these approaches are not fixed characteristics of individuals but reflect choices made in particular contexts (Biggs & Tang, 2007; IAUL, n.d.; Ramsden, 2003). Although teachers cannot control all factors to guarantee students will take a deep approach, they can create conditions that maximise the likelihood of this occurring (Ramsden, 2003). Perhaps the major single influence on students’ choice to adopt surface or deep approaches is the nature of the assessment (Houghton, 2004; IML, n.d.). To encourage a deep approach, it is appropriate to adopt strategies such as the following (excerpted and abridged from a longer list in IML, n.d.), all of which played a role in the podcasting task we set for the chemistry students:

• designing assessment that rewards students for understanding, making connections, etc.;
• encouraging active engagement with learning tasks, eg, creative production;
• bringing out the structure of the subject explicitly and encouraging students to make connections with (or challenge) what they already know;
• giving students opportunities to discuss, debate and compare their understandings with each other and with the teaching staff;
• giving students opportunities to gain qualitative feedback, especially but not only on their assessed work, rather than just giving marks or grades;
• giving students opportunities to make reasonable choices about what and how they will learn; and
• teaching in ways which encourage students’ intrinsic interest.

Interestingly, recent research at the Open University has found a correlation between positive attitudes to using technology for studying and a deep approach to learning (Haigh, 2011), suggesting that it may be productive to foster student engagement with digital media through tasks such as the podcasting assignment set for our students.

Podcasting

Podcasting, strictly speaking, refers to a series of regularly produced audio files to which users can subscribe, but the term is increasingly used to refer to any digital audio files made available online for downloading to computers or portable media players. There are three main uses of podcasting in higher education, as described by McGarr (2009). Substitutional podcasting, sometimes also called courseworkcasting, consists of audio recordings of lectures or tutorials that are made available to
students so they can review the material as often as they wish, whereas supplementary podcasting involves the provision of additional material to help students deepen their understandings of particular topics. Creative podcasting, the least common form, involves students creating their own podcasts which, it is hoped, will help them develop their understanding of a topic (e.g., Bartle, Longnecker & Pegrum, 2011; Lee, McLoughlin & Chan, 2008). A step on from students passively listening to substitutional or supplementary podcasts, this represents a move towards two-way communication between teachers and students (Harris & Park, 2008) or, indeed, students and students. Such creative podcasting may be a more effective learning technique than substitutional or supplementary podcasting (Atkinson, 2006; Carvalho, Aguiar & Maciel, 2009; Frydenberg, 2008; Lee et al., 2008; Shamburg, 2009). While still limited, some empirical evidence of improved learning outcomes is beginning to emerge (Lazzari, 2009).

It has been suggested, specifically, that by turning students into “knowledge creators” (McGarr, 2009; cf. Rifkin, Longnecker, Leach, Davis & Orthia, 2010), creative podcasting helps develop a range of student competencies, including collaborative knowledge-building skills (Lee et al., 2008) and critical thinking skills (Frydenberg, 2008). Cane and Cashmore (2008) see key advantages as broadening of knowledge; enhancement of teamwork; greater technological skills; and motivation. They suggest, too, that there are benefits both for students who create podcasts and those who listen. For Schwartz and Digiovanni (2009), creative podcasting fits with a constructivist educational approach and, among other things, can improve “depth of understanding.” Lazzari (2009) found that creative podcasting encouraged “the development of reflective learning skills, stimulated students to go deep into the questions they had to face, and fostered positive collaborative behaviours” (p. 32) while leading to the development of skills and strategies associated with the deep learning approaches described earlier, including:

the ability of the students to assess their own understanding of the topics of the course and to deepen their competence beyond the walls of the classroom, through a metacognitive practice that enhances their learning process (Flavell, 1976). Students’ achievements in terms of domain knowledge acquisition are the result of a classic constructivistic educational process, where knowledge is produced through an active process by the learners themselves, is strictly linked to a real context and is achieved by means of forms of collaboration and social negotiation (Jonassen, 1994). (ibid.)

In summary, well-designed creative podcasting tasks may lead to the kind of active knowledge building and engaged collaboration that are associated with deep learning. Given the lack of empirical research to date, however, more work is needed on whether and how this may occur.

Research methodology
Following an earlier qualitative study of students’ reactions to and engagement with the podcasting task, the current study examined the effect of the podcasting task on examination results. In addition, students’ podcasts were coded according to their contextualisation levels to determine any possible link between contextualisation and improved examination performance.

Participants
The subjects were first-year students in an undergraduate chemistry unit offered at The University of Western Australia (UWA). The unit is one semester in duration and designed for students with little or no relevant background who need to gain an understanding of basic chemistry.

Two groups of students participated in this study. Because it was considered unethical to offer the potential benefits of podcasting to only some students, cohorts were instead compared across years. Cohort 1 \( (n = 276) \) consisted of students enrolled in 2009, before the podcasting task was implemented. There were 155 males (56.1\%) and 121 females (43.9\%). Cohort 2 \( (n = 352) \) consisted of students enrolled in 2010, the first group to complete the podcasting task. There were 192 males (54.5\%) and 160 females (45.5\%). In both cohorts, students belonged to degree...
programmes across all faculties at UWA, although the majority were associated with the Faculty of Life & Physical Sciences (231, or 65.6%, in 2010) and the Faculty of Natural & Agricultural Sciences (52, or 14.7%).

Design
First implemented in 2010, the podcasting task was worth 5% of the unit mark, which was equivalent in weighting to a laboratory task, which it effectively replaced. As described in Bartle, Longnecker & Pegrum (2011), students were divided into groups of three by the unit coordinator based on their assigned benches in their practical lab classes, with the topic of “acids & bases” being randomly assigned to half the groups and the topic of “oxidation & reduction” given to the other half. These topics are core concepts in the unit, but students often struggle with them, as shown by past examination performance as well as anecdotal evidence. Students were required to work collaboratively to create a 3-minute podcast on their assigned concept, explaining it clearly and comprehensively, but concisely, for a general educated audience with basic chemistry knowledge. They were encouraged to approach the task creatively, e.g., presenting analogies or practical applications of the concept. Students submitted their completed podcasts through the WebCT learning management system. During the week prior to end-of-semester examinations, these were made available to all students, who were asked to listen to and comment on six podcasts produced by their own practical class (three about “acids & bases” and three about “oxidation & reduction,” with their own included in the total of six). Because students created a podcast on only one topic, and simply listened to podcasts on the other, this provided a comparison group for each topic.

The task was specifically designed to promote collaboration, contextualisation and digital communication of understanding and, through these, deep learning. Collaboration was built into the design, with all students working in groups and receiving equal marks except in one case of extreme, unequal contributions. Broader collaboration was introduced in the feedback phase, where students commented on each other’s podcasts on WebCT discussion boards. Contextualisation was integral to the creative approach students were urged to take, namely developing an analogy to convey important aspects of their topic, or locating it within an application from their home disciplines. Communication occurred in digital format through the creative podcasting task. It was hoped that this task would foster knowledge building through critical discussion and reflective thinking in a teamwork context, as detailed in the creative podcasting literature cited above (e.g., Cane & Cashmore, 2008; Frydenberg, 2008; Lazzari, 2009; Lee et al, 2008; McGarr, 2009).

Data collection and analysis
Bartle, Longnecker & Pegrum (2011) found that in general students taking the unit perceived the use of podcasting to be valuable and motivating, suggesting that deep learning had occurred. This report goes a step further in investigating whether deep learning did in fact occur: it seeks quantitative evidence of improvements in student understanding and retention of knowledge, as well as seeking correlations between students’ use of contextualisation and any such improvements.

Student performance on exam questions related to “acids & bases” and “oxidation & reduction” was compared for the two cohorts enrolled in the unit in consecutive years, 2009 and 2010. The unit was coordinated and taught by the same staff member (Bartle) in both years; and the cohorts received similar lecture content and supporting resources, with the main difference being the introduction of the podcasting task in 2010. The examination paper in both years contained a mixture of multiple choice and short answer questions, with approximately 15% related to each topic. The questions were written and marked by the unit coordinator in both years. Because the 2009 examination paper had not been released to students, questions for these topics were very similar in the 2009 and 2010 papers and results for the 2 years could be compared.
Additionally, an analysis of the podcasts was conducted in three stages. Firstly, all podcasts were marked during the semester. The marking criteria were provided to the students in their assignment handout and comprised:

- beginning—the introduction sets the scene and tells the listener what the podcast is about;
- middle—the concept is clearly and accurately explained to a general audience in a context that is relevant to them;
- end—the conclusion clearly summarises the main points presented in the podcast;
- structure—the podcast is well structured, flows and holds listeners’ interest; and
- technical—sound quality is good, voices are clear and easy to understand, volume is appropriate, and the podcast is 3 minutes or less.

Podcasts were given a maximum score of 1 for each criterion (<0.5 = inadequate, 0.5 = passable, 0.6 = good, 0.7 = very good, 0.8 = excellent, 1.0 = cannot be improved) for a total of 5 marks.

In the next stage of podcast analysis, all three researchers listened to and discussed nine podcasts and developed a coding scheme with three categories: (1) passive reproduction of facts provided in class, with no contextualisation; (2) contextualisation using examples provided in class; or (3) contextualisation using a new context not covered in class. Finally, the unit coordinator listened to each podcast again and categorised it based on her knowledge of what had been covered in class. Examples of each category are given in Table 1.

Finally, statistical analysis of exam results and podcast marks included t-tests and analysis of variance using GenStat version 12.1.0.3338 (http://www.vsni.co.uk).

Results and discussion

Effect of students creating podcasts

Assessment can be a major impetus for students to adopt a deep learning approach (Houghton, 2004; IML, n.d.). The most striking finding of this study was that within the 2010 cohort, students who created podcasts on “acids & bases” scored higher marks on questions relating to this topic in the end-of-semester exam than students who had not created podcasts on this topic. The difference in average exam marks between these two subgroups was statistically significant (Table 2). On the other hand, within the 2010 cohort, there was no significant difference in exam marks on “oxidation & reduction” questions for students who created podcasts on this topic, as compared with students who did not. This should encourage instructors to consider adopting creative approaches, such as the use of podcasting assessment tasks, that have a demonstrated positive impact on students’ learning in at least some cases and produce no negative effect in others.

Looking more closely at the results for the “acids & bases” exam questions, it can be seen that although creative podcasting about this topic improved student understanding, many students obviously still struggled with it. The average exam mark on the topic, even for those who created podcasts on it, was still below 50%. Moreover, there was no statistically significant difference between average exam marks for the “acids & bases” questions in 2010 compared with 2009—that is, when the combined results of both 2010 subgroups (those who created “acids & bases” podcasts and those who created “oxidation & reduction” podcasts) were considered. This does at least confirm that implementation of the creative podcasting task did not negatively affect students’ learning. In fact, the average marks for the “acids & bases” exam questions were slightly higher overall in 2010 than in 2009 (as seen in Table 2); however, the marks distribution in 2009 was highly variable and so the overall difference was not significant.

On close examination of the results for the “oxidation & reduction” exam questions, it can be seen that the marks for this topic were slightly above 50%, even without podcasting. A likely explanation is that “oxidation & reduction” was one of the last topics covered in the semester, nearer the
<table>
<thead>
<tr>
<th>Contextualisation level</th>
<th>Contextualisation description</th>
<th>Per cent of podcasts</th>
<th>Examples of contextualisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Passive reproduction of facts provided in class, with no contextualisation</td>
<td>43</td>
<td>• described different theories (eg, the Bronsted-Lowry theory states that acids are proton donors and bases are proton acceptors) (AB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• described characteristic reactions (eg, when an acid reacts with a base, the products are a salt and water; when an acid reacts with a metal, the products are a salt and hydrogen gas) (AB)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• provided fundamental definitions (eg, oxidation reactions involve the loss of electrons and reduction reactions involve the gain of electrons) (OR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• explained fundamental processes (eg, steps to balance redox half-reactions in acidic and basic solutions) (OR)</td>
</tr>
<tr>
<td>2</td>
<td>Contextualisation using examples provided in class</td>
<td>39</td>
<td>• explained the action of acid-base buffer systems in the human body (AB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• mentioned that high-profile criminals throughout history have used the properties and reactions of acids and bases to assist with their crimes (AB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• explained the principles of redox reactions in rusting processes (OR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• mentioned the use of plane crash wreckage to make a lemon battery and produce electricity (OR)</td>
</tr>
<tr>
<td>3</td>
<td>Contextualisation using a new context not covered in class</td>
<td>18</td>
<td>• described 24 hours in the life of an 18-year-old, showing acids and bases used in everyday life (AB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• used a boxing match as an analogy to explain an acid-base titration reaction (AB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• explained the chemical basis of how bleaching agents work (OR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• rewrote the lyrics of “Ice Ice Baby” (Vanilla Ice) as “Redox Redox Baby,” describing everyday applications of redox (OR)</td>
</tr>
</tbody>
</table>
time of the final exam. It is not unusual for students to have better recall of material covered more recently. Students also completed a laboratory exercise on this topic, and active engagement with a learning activity, such as in a practical session, is known to reinforce content (Read, 2006). “Acids & bases,” on the other hand, was covered in mid-semester, so the improved marks for students who created podcasts on this topic may be because they were obliged to go back and do more thorough revision of the concept before the exam. It is also possible that creative podcasting was more effective for “acids & bases” because it was a concept that was generally more poorly understood.

**Effect of listening to other students’ podcasts**

The activity of listening to podcasts, as opposed to creating them, had no measurable effect on the students’ exam marks in this study. Students were required to listen to six podcasts, including their own, and assess them using a pre-established rubric (Bartle, Longnecker & Pegrum, 2011). They were also encouraged to go beyond this core requirement and provide qualitative feedback to their peers through comments posted on the WebCT discussion boards. Without exception, these were positive, as reported previously (for sample comments, see ibid.). Overall, students engaged in many of the activities included in the IML (n.d.) list cited above, but it may be that active production of content is the key. Despite some claims to the contrary in the research literature, our study suggests that having students passively listen to podcasts may not lead to improved learning outcomes.

**Effect of contextualisation**

The structure of the creative podcasting assignment encouraged students to use a deep approach to learning, involving contextualisation of their assigned chemistry concept. It was found that many did adopt such an approach, with positive effects for their motivation and assignment marks, but no direct significant effect on their exam performance.

Overall, 57% of students used some contextualisation in their podcasts, including 18% of the cohort who employed original contexts that had not been covered in class (as shown in Table 1, which includes examples of contexts). Students who provided new contextualised explanations of the topics in their podcasts received better marks for their assignments than those whose podcasts only used material that had been covered in lectures, either including lecturer-provided contextualisation or simply restating facts (Table 3). This supports the importance of constructing knowledge for oneself.

Interestingly, the podcasting assessment task appeared to motivate some students who were otherwise generally disengaged from the unit learning activities. For example, one group developed a creative analogy to describe an acid–base titration in terms of a boxing match. The group members adopted the role of ringside commentators and their narrative introduced each of the

<table>
<thead>
<tr>
<th>Year</th>
<th>AB questions</th>
<th>OR questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>45.1</td>
<td>57.5</td>
</tr>
<tr>
<td>2010 Podcast topic</td>
<td>AB</td>
<td>OR</td>
</tr>
<tr>
<td>2010</td>
<td>49.4***</td>
<td>46.8</td>
</tr>
</tbody>
</table>

Notes:
In 2009, 276 students were enrolled and were not assigned a podcast task; in 2010, 352 students were enrolled and created podcasts on either “acids & bases” (AB) or “oxidation & reduction” (OR). ***refers to statistical difference in average mark in 2010 ($p < .001$).
boxers (chemical species), offered a comparison of their relative “fighting abilities” (relative reactivity of strong/weak acids/bases) and provided commentary on the “fight” (the reaction between the acid and base), with the match overseen by a “referee” (the indicator, phenolphthalein). This particular group was disengaged during the practical laboratory sessions in the unit, often not completing the related assessment tasks, and also performed poorly on the end-of-semester examination. Another group, who often verbally expressed their disinterest in the content to the unit coordinator, prepared a podcast on the topic of “oxidation & reduction” by telling the story of the reaction between two atoms and their “desire” to share electrons, built on an analogy with the characters Bella and Edward in the *Twilight* film saga. This suggests that creative podcasting is a way of engaging chemistry non-majors, even if it does not improve results on other kinds of tasks.

At the opposite end of the spectrum, the creative podcasting task was also positively received by students who were highly engaged with the unit content, as they welcomed the opportunity to put chemistry into a relevant context. For example, one group of engineering majors, who finished the semester near the top of the class overall, used their podcast as an opportunity to research new battery technology that was being developed in Germany, and related this to the underlying principles of oxidation and reduction.

However, in this study, we found no specific effect of contextualisation on improvement of exam marks, either in total marks or in those questions dealing with “acids & bases” or “oxidation & reduction.” This unit is intended to provide students with the fundamental chemistry understanding required for future studies in their home disciplines. The exam questions are designed to test students’ knowledge and understanding of core chemistry concepts rather than specific discipline contextualisations, as the cohort contains students from across all university faculties. This may account for the lack of relationship between the level of contextualisation and exam performance. The process of understanding content is irreversible (Biggs & Tang, 2007) and hence the skills developed while completing the podcasting task—especially the ability to contextualise and apply core chemistry concepts to different disciplines—are still likely to be of benefit to students throughout the rest of their degree programmes and in their working lives.

### Conclusion and implications

Our previous qualitative study, covering students’ perceptions, task completion, and motivation and engagement, concluded that the podcasting task appeared to have led to some deepening of learning. The current study, taking a quantitative approach, has provided additional support for this conclusion. It reveals that creative podcasting can foster deep learning in an appropriately structured task and may improve learning outcomes under some circumstances.
assignment resulted in a significant improvement in examination marks for students who created a podcast on a topic that had been covered in mid-semester (“acids & bases”). There was no significant difference in examination marks for students who created a podcast on a topic that was covered towards the end of semester (“oxidation & reduction”).

Some science lecturers resist including communication activities such as this in their assessments because they suggest that students will spend too much time on them, which will distract them from learning “the facts”; or, even worse, that students may misinform each other (Rifkin, Longnecker, Leach & Davis, 2012). Our results show that there was at least no negative effect as a result of creating podcasts (demonstrated by no decrease in exam marks for “oxidation & reduction”) and that under the right conditions—perhaps including the right topic, delivered at the right time—there can be an enhancement of students’ understanding and retention (demonstrated by increased exam marks for “acids & bases”).

Encouraging contextualisation using new media may motivate students who are otherwise disengaged from course content, making such tasks a useful teaching activity in bridging units where many students show a low level of interest. The opportunity to put content into a relevant context within their home discipline is also welcomed by more engaged students, which is of benefit in science bridging units where the cohort consists of students enrolled in degree programmes across multiple faculties. Moreover, creative podcasting is relatively easy for unit coordinators to implement and is thus a good way to offer engaging learning opportunities for students in large undergraduate science units, particularly where staffing and resources are limited.

In conclusion, it seems that creative podcasting offers the potential for students to achieve a new and deeper understanding of at least some course material. Further research is needed to explore whether this deeper understanding of material translates into knowledge retention throughout a degree programme and into the workplace.

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