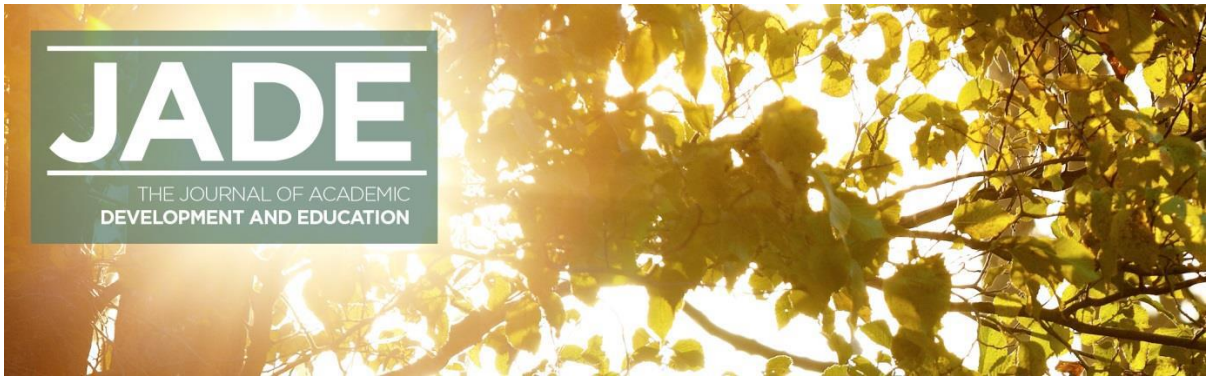

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Managing Editor
Dr. Russell Crawford

Administrator
Samantha Mottram

Telephone
+44 (0)1782 733007

Email
jade@keele.ac.uk

Web
http://jadekeele.wordpress.com/

Address
59-60 The Covert, Keele University, Keele,
ST5 5BG

Clickers: A Learning Technology Project Case Study

Dr Cheryl Byrne

Biology Teaching Fellow
School of Life Sciences,
Keele University,
Staffordshire, ST5 5BG

c.a.byrne@keele.ac.uk

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Dr Cheryl Byrne

Biology Teaching Fellow
School of Life Sciences,
Keele University,
Staffordshire, ST5 5BG

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This report is a summary of a project undertaken as part of the postgraduate Teaching and Learning with Technology course at Keele University. The project's broad aims were to explore the application of technology for teaching and learning in a higher education context. Clickers were chosen as they promised the potential for the development of active learning even within a lecture setting. Furthermore, as the devices are provided by the lecturer, are fully inclusive – not requiring students to have suitable devices such as laptops/smartphones. The design of the incorporation of clickers within a lecture also allowed assessment of learning and immediate, responsive feedback and discussion of any misconceptions, which should improve learning. These benefits from the use of clickers seemed particularly pertinent for the lectures involved in this project, as the subject matter, photosynthesis, is complex and requires understanding of a variety of concepts and so provides many potential hurdles to student learning.

The Problem

I was assigned to teach two lectures on photosynthesis, an important but complex topic on plant metabolism. The class comprised approximately 50 first year undergraduate students. The challenges I faced with these lectures in particular included:

- The topic involves a variety of concepts from physics, chemistry and biology
- The topic involves a complex series of biochemical reactions and long terms/names of chemical compounds
- There is significant potential for misconceptions to be already held by students, as despite many being taught it prior to university, many students still lack a basic understanding of the process (Parker *et al.* 2012)
- Students often find plants less engaging, compared to animal/human biology

I wanted to design the two lectures to engage the students with a potentially dry subject and best help them understand the main complex concepts.

Solutions?

Active learning has been put forward as a major principle of good practice in higher education, and supporters of this approach argue that students are more than spectators and that in order to learn, they must also do (Chickering and Gamson 1987, Bonwell and

Eison 1991). As such, I wanted to incorporate interactive activities into my lectures in order to encourage the students to be more involved and engaged with their learning.

As most students will have already learnt about photosynthesis prior to university, the lecture should very much be a recap of this theory. By covering somewhat familiar ground, students should be able to learn more about the topic, and hopefully understand more deeply. This is supported by the theory that the process of learning is *relearning* – where students examine a topic and are continually refining their understanding (Kolb and Kolb 2005).

However, students are likely to have developed significant misconceptions around the topic of photosynthesis (Parker *et al.* 2012). Therefore, I decided it was particularly important to informally monitor the students learning as we progressed through the lectures on photosynthesis and attempt to identify and address these misunderstandings. I hoped that by recapping and identifying gaps in student's knowledge and then by providing relevant feedback I could help correct such misconceptions.

If designed appropriately, technology has the potential to enhance teaching practice by providing opportunities to improve communication between teacher and students, and allow students to interact more in their learning and with others (Chickering and Ehrmann, 1996). My awareness of this potential developed my eagerness to use it as a tool to incorporate active learning and monitoring of learning within my teaching. However, I still had rather mixed feelings about the use of innovative information and communication technology in teaching. Whilst I am enthusiastic about embracing all the potential it may bring, I am concerned about its efficiency and relevance. I feel this reflects the very real issues concerning technology – it has become the norm in western society and can be used to great effect, but it also brings with it challenges, such as concerns over student's uncritical use of internet sources, the negative impact on spelling and grammar and inequalities between learners (Beetham and Sharpe 2007). Critical reflection should allow me to better reconcile some of these conflicts in my mind and improve my own teaching practice.

After discussion with colleagues, I decided to use electronic clickers, also known as student response systems within these lectures, as these are easily available in my school. I felt that I could use these clickers to get students to interact within the lecture by answering set questions and therefore promote active learning. Technologies such as mobile and wireless systems; "place learning firmly in the hands of learners" (JISC 2005). I would then also be able to monitor learning progress and give students automatic feedback, by discussing further their answers straight away – in particular anywhere many students selected the incorrect answers. Later in this report I discuss in more detail the benefits and challenges of this technology, which led to my choice of this technology.

Aim and Objectives

My aim was to design and implement an innovative technology in my teaching with a view to enhance the learning of my students and develop my professional development and practice. In order to do this, I planned to include a technology that enabled active learning by the students through interactions within the lecture setting and which allowed me to monitor learning progress and provide instantaneous feedback. This was proposed by the use of polling technology and the use of multiple choice questions during the second lecture of the two lectures on photosynthesis. Reflection and evaluation of the success of this teaching activity, in relation to my aims and objectives are provided in this report.

Innovating

Universities are not isolated entities, and as such we must respond to the changing social environment, whether that be in the guise of new technology, changing government policies or increasingly diverse student cohorts, for example (Cowan 2006). In other words, change is all around us, and so it is vital that we continually innovate and adapt as teachers in higher education.

Prior to my employment at Keele as a Teaching Fellow, I had not had any exposure to electronic voting clicker systems – neither as student or teacher, and so it was completely new and innovative for me. The development and implementation of clickers in my teaching sessions would allow me to develop my critical reflection on the use of technology in higher education, as well as provide a focus for me on which to develop active learning, monitoring of learning progress and the provision of informal feedback within my professional practice. This was the first time I had planned to use questioning of students in a lecture to assess their learning from the previous, preceding lecture and therefore this was an interesting exercise for me.

Newness in innovation need not only involve new knowledge, but can also be about developing an attitude towards an already known innovation (Rogers 2003). The design and implementation of the technology, along with reflecting on this experience would to allow me to develop my own opinions and attitudes. Ultimately it would allow me to decide whether it is a technology that I would like to continue using in my professional practice.

I had heard, through word of mouth from some colleagues that the clickers were unreliable and therefore they avoided them. However, I was willing to try it despite this, especially after speaking to another colleague who had used it successfully. This process brings to mind the theory of diffusion of innovation, which describes how innovation is adopted by society over time (Rogers 2003). Rogers (2003) states that one of the factors that influence how quickly an innovation is adopted is the perceived attributes of that innovation. In the diffusion of innovations model I would probably place myself as an early majority, fuelled along by my colleague who had used in successfully who I would be defined as an early adopter, who helped to bring the technology to me, over the chasm. One could remain as a laggard, but then all the potential benefits of the innovation would be lost.

Electronic Voting Technology

Electronic voting systems are an example of a wireless technology that is particularly effective at adding an interactive element to sessions with large numbers of students (JISC 2005). The clicker system entails providing each student with an electronic polling handheld device that wirelessly sends their responses to a receiver connected to the main computer. Once polling is finished, software (in my case Turning Point Technologies software) then summarises the class' responses onto the main projector screen. These can also be saved for later analysis.

Educational research has shown that students enjoy using electronic voting systems, and therefore engage well with the technology and learning (Martyn 2007). Martyn (2007) did not find any significant difference in learning outcomes between students using clickers vs class discussion (an alternative form of active learning). However, although again not statistically significant, students who were exposed to clickers rather than class discussions more often perceived the session to improve their learning, interactions and enjoyment of the sessions. Perhaps the pedagogic approach of active learning is important for learning but technique (clicker or discussion) is less important. Although the clickers did seem to evoke a safer, more enjoyable environment for students – which I think is an important aspect of enabling learning to take place.

There are a variety of advantages and disadvantages associated with using electronic voting technology, as summarised below.

Advantages

- **Readily available** - the devices could be booked for use from the School or AVS, so are readily available at my institution.
- **Simple logistics** - provides logistically simple way to ask questions to a large group of students.
- **Institutionally acceptable** - as a dedicated learning technology, rather than a "leisure" item, such as a mobile phone or PDA, that may be considered by some to not be appropriate for a learning environment (JISC 2005).
- **Setting-up quite quick** - setting-up questions on Turning Point software is relatively quick to convert from an PowerPoint presentation.
- **Inclusive** – by the teacher providing the devices there is no need to rely on students possessing any equipment. This is compared to using personal equipment, such as smartphones, which not all students may have access to and therefore may not be able to participate.
- **Device simple to use** - so all students can be included, irrespective of digital literacy. One of the major challenges of embedding technology in learning is resistance to complex technology due to poor usability of handheld devices (JISC 2005).
- **Device quick to use** - as the device is very simple, students require little technological instruction and so can get onto teaching topic quickly.

- **Engaging -** uses a "game approach" (similar to "Who wants to be a millionaire" for example) which may be more appealing for students (Martyn 2007).
- **Involves all students simultaneously -** everyone can be directly involved, compared to discussion for example, where a few individuals may offer most interaction whilst others remain just listening.
- **Anonymous** - so promotes increased participation, especially from those shyer students.
- **Limited scope for misuse** - no free text, so limited way of students misusing/abusing technology, so requires little monitoring by teacher.
- **Displays class' answers** - can see student's answers, gauge understanding and address misconceptions through informal feedback.
- **Quick feedback** - teacher can instantly view student's answers and respond immediately.
- **Promotes discussion** - the presentation of class responses should provide a springboard to allow discussion between teacher and students.
- **Provides responses data** - can store answers and compare across years/groups etc.

Disadvantages

- **Device and software cost** - requires initial institute financial investment, as well as maintenance costs and replacement of broken/lost devices.
- **Potential non-inclusion of students with certain requirements** – the student body is increasingly diverse and it is entirely possible that the devices may not be usable by some students, such as those with visual impairments for example. Consideration of any special needs must be undertaken prior to the session, and suitable measures put in place to mitigate this.
- **Logistics** – need to book devices in plenty of time to ensure available during required session, and time needed to collect/return.
- **Training** – first time users will need to invest in some time to learn how to set-up and work the technology. This would be most efficient if provided from other member of staff, rather than self-learning.
- **Technical errors** – concerns over whether the technology would work, as from word of mouth head that it can be unreliable.
- **Set-up time** – whilst this is quite quick, it does require extra time to be set-up the questions in the Turning Point software
- **Risk of overuse** – the novelty value may wear off if technology is used too often.
- **Anonymous** - so cannot monitor any students who not taking seriously or engaging. Also, cannot identify which students gave which answers, so cannot use the technology to assess which students may need further help
- **Simple** – For example, there is no free text capability, so provides limited capabilities compared to other interactive technologies, such as Lecture Tools, for example.

- **Potential for not being future proof** – future technological advances/updates may impact on compatibility and result in technology not being usable

Overall Lectures Design

I was assigned two lectures, each 50 minutes, to teach first year undergraduate biology students photosynthesis, as part of the compulsory module Diversity of Life. I decided that I would divide these two lectures broadly into:

Lecture 1

- Introduction to photosynthesis
    - Put topic into context and explain relevance and importance of photosynthesis to life on Earth and its practical applications
- Overview of the process
    - General summary of the overall biochemical process, without going into too much detail, but to set the scene for further detail in next sections
- Detailed coverage of light dependent stage
    - Details of the metabolic pathways of the first main stage of photosynthesis

Lecture 2

- Recap quiz 1
    - Content from lecture 1
    - Using electronic voting system
    - Along with feedback on student response
- Detailed coverage of light independent stage
    - Details of the metabolic pathways of the second main stage of photosynthesis
- Alternative photosynthesis pathways
    - Examples of how plants have adapted photosynthesis in certain environmental conditions

Recap Quiz Design

For the quizzes, I decided to keep it simple and use a multiple choice question format, especially as one of the assessments for this module was a MCQ exam and so it would also help the students prepare for the summative assessment.

In recap quiz 1 I provided a total of nine MCQs. For each question, a slide was created via the Turning Point presentation (which is very similar to PowerPoint, except includes the student response capabilities). I planned to display the question and potential answers and then give the students time to answer the question. Once all students had responded I would then display the class' response with a bar chart that showed the percentage of the class that chose each answer. Then I would highlight on this slide which was the correct answer and provide any further relevant feedback. An example of a question and then the student responses slides can be seen in figure 1.

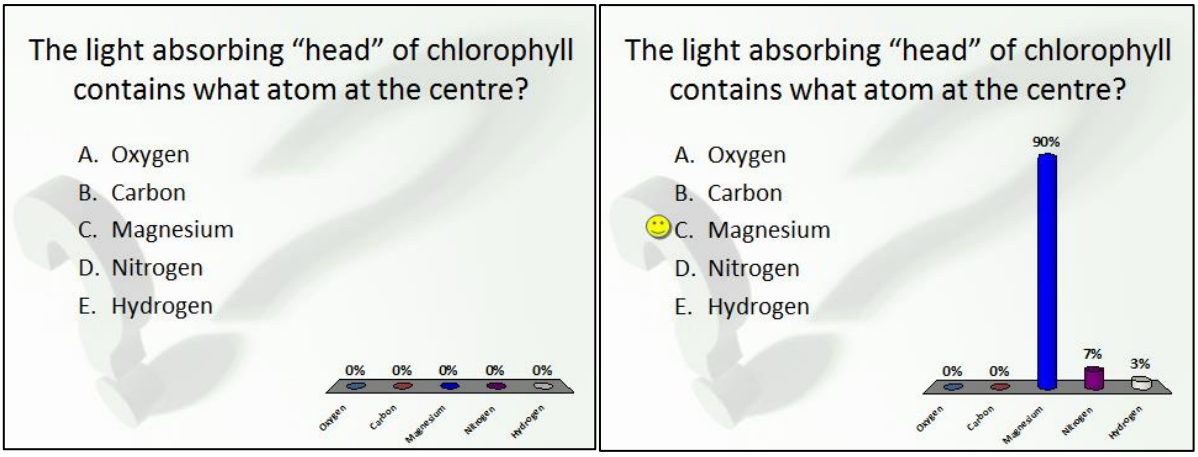

Figure 1. The left hand slide shows a recap quiz question slide and the right hand slide shows the student class' responses, with a smiley face which highlights the correct answer. In this example you can see that 90% of the class correctly answered the question.

Implementation and Evaluation

At the start of the lecture when I was planning to use the clickers I handed the devices out to students as they entered the lecture hall. A couple of students appeared to be pleased to see these, and therefore I assume there was an element of, dare I say it, excitement about using the clickers. Therefore I assume they had used them before in other classes. Either way, I feel that students were receptive to the technology and this should generally enhance learning by engaging students with the activity.

I briefly outlined how to use the devices, but this did not take very long. I did worry I hadn't explained sufficiently, but the students very easily picked it up and used the devices successfully, so I feel that my anxiety was probably more driven by my concerns of the technology failing rather than any need for more instructions.

I feel that the act of recapping the previous lecture helped students to get back in the right mind set and focus on the topic at hand. This is especially important when covering a topic over two lectures, as students may have forgotten information they needed to remember in order to make sense of the second lecture content.

The quiz also allowed me to make an assessment of learning and to provide feedback and re-cover material that the class demonstrated that they did not understand well. The quiz did well at highlighting areas of poor class knowledge – some questions the majority of the students answered correctly (see figure 1), but in other questions it was clear that there was a gap in the class' knowledge, with many students selecting incorrect answers (see figure 2). This allowed me to identify which areas I needed to cover again in more detail. Hopefully it will also highlight to individual students where they lack understanding and need to do further self-study.

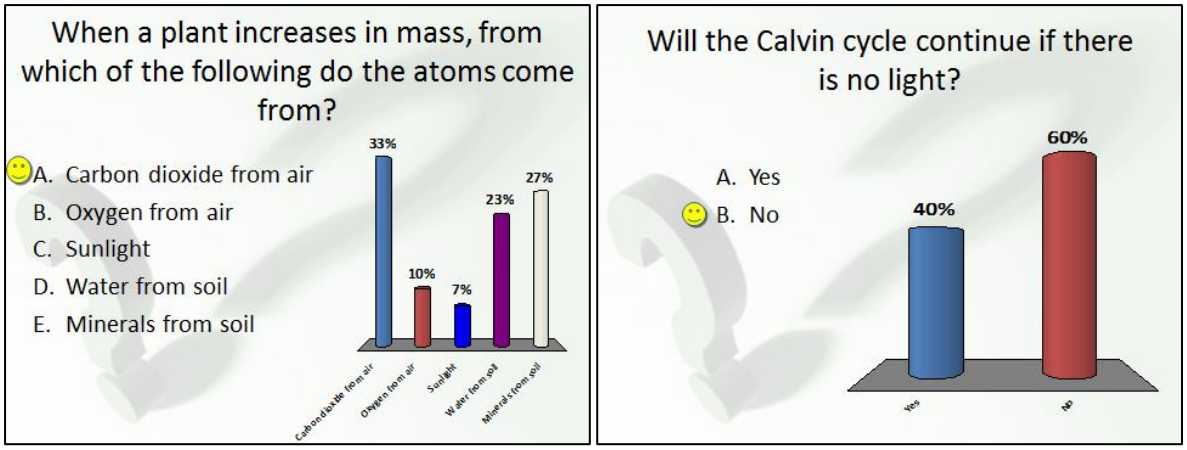

Figure 2. Two quiz questions with the student class' responses – with many students selecting incorrect answers it was clear that these topics needed further discussion.

The questions that required further discussion tended to be more conceptual, rather than knowledge that can be memorised and recalled. This was in line with the findings of Parker et al. (2012), who discussed how students struggle more with areas such as tracing elements through the metabolic pathways, rather than facts that can be easily memorised (but does not necessarily represent understanding). Therefore, this resulted in me spending time recapping areas that required deeper learning and understanding, which I feel was beneficial.

Whilst the exercise did seem to work well in identifying areas that needed further explanation, it didn't really promote any discussion with students. I was hoping it may help students to instigate further questions from me for clarification. However, they mainly remained quite passive. Whilst I could have promoted more discussion from group by making the quiz more verbally interactive, I felt that due to the limited time available, it was best to provide answers and explanations quickly in order to be able to cover the topic in the rest of the lecture. This seems to be a reflection of the balance between "providing all the information" using lecturing versus "active learning" through other activities. Whilst lectures are criticised pedagogically, they are a very efficient way of passing on lots of knowledge quickly to lots of students. This reminds me of the review by Sfard's (1998) of the two learning metaphors, the Acquisition Metaphor and the Participation Metaphor, which highlights the pros and cons of these two different modes of learning. That this review suggests that the best strategy is to incorporate them both within teaching design does indicates that my design of including lectures with some active learning probably was a good balance, and that I should take this mixture into more of my teaching.

A great advantage of the clickers over class discussions is that it is anonymous and all students can participate at the same time. Therefore, they provide a "safe" way for everyone to participate, with no fear of getting wrong in front of peers and/or the lecturer. It is also very useful for the more introvert students who prefer not to speak out in front of a class or struggle to be heard above more vocal students.

I did mention to the students that as the quiz was MCQs that they were examples of the types of questions that would be in the exam. As well as increasing relevance and engagement with the quiz teaching activity, this in itself would hopefully be helpful examination preparation.

Problems and Remedies

Despite my aim to test the technology prior to using it, due to another class being in the lecture hall preceding my lecture I was unable to have sufficient time to carefully test the quiz to ensure it was all set-up correctly. This meant that when I started the quiz with the class I had not realised that I had failed to reset it properly. Therefore, before we could start I had to do a reset, and although this did not take too long, it made me feel unsettled as was wasting time and felt I looked unprofessional in front of the class. However, on reflection it was only a very short time and did not really impact on the session greatly. In the future I will be aware of this and be sure to press reset before the class starts.

On the first question it became clear that only about two thirds of the clickers were working, as the total number of responses was too low. I carried on regardless, as the students shouldn't be able to work out which ones were not working, but it was frustrating. If students did realise it was their device that is not working they may become more disengaged.

One uncertainty I had was how long to give students to answer, otherwise it risks becoming slow and drawn out. This was particularly a problem as not all the clickers were working and so I could not know when everyone had answered. One solution would be to have a countdown timer so students know how quickly they need to answer and so will be motivated along.

Discussion and Recommendations

Overall, I was pleased with how the teaching activities went and I feel that the use of the clickers significantly helped me to achieve my aim and objectives. Compared to a straight lecture, there was increase student engagement and interaction; the quiz-style activity allowed me to monitor student learning progress and I was able to provide feedback on areas that the class demonstrated poorer understanding.

However, in order to make better use of the technology to encourage further interactive learning I could incorporate more group discussion work, alongside the use of the voting system. This social constructivist learning approach has been used successfully in Strathclyde University to increase active collaboration between students (JISC 2005). If I were to adopt a similar strategy, it could potentially work by having one session as a lecture and the other a tutorial session where there is much more time devoted to group activities that supports the information given in the lecture. However, this format would involve removal of a large proportion of the lecture content, and so I would need to carefully consider which is most important to student learning.

On reflection I could I have used the technology in an even more nuanced way to investigate how much I had actually taught the students compared to how much they already knew. For example, I could have questioned the students before as well as after my first lecture to test knowledge to assess what they already knew. As photosynthesis is a topic that most students should have covered in courses prior to their undergraduate courses, and so pre-testing would have allowed me to assess what areas of the subject I needed to focus on. With my current design there is a risk that I am wasting time covering areas they already understand. However, with an increasingly diverse undergraduate population, it is more likely that there will be a range of levels of understanding within the class and therefore a general recap does help to get everyone to a similar level.

The main problems with the technology were triggered by logistic issues – i.e. due to the booking system/others use of resources, I was unable to sufficiently prepare before the session. However, these problems were mainly minimal, and with experience I should be better placed to avoid them. Saying this, many of the devices were not working and so better monitoring/maintenance is also required and I recommended wherever possible that time is factored in for checks prior to the session. This of course adds time to teaching staff workloads. The potential for technical failure definitely remains one of the main concerns for me in using any innovative technology in my teaching. I think it is vital that the teacher feels they are in a safe working environment in order to create a quality learning experience, and teacher anxiety surrounding the use of technology is an important, but perhaps often overlooked issue.

Instead of one quiz, I instead could have scattered questions across the two lectures. This would have made them more interactive throughout. However, I do feel that the reason the clickers work well is partly due to their novelty value, and so it is important to not overuse.

Conclusion

This project has allowed me to gain a better appreciation of the potential of using technology for teaching and learning in higher education. From my initial, partially sceptical standpoint, undertaking this project has allowed me to better appreciate the pedagogical benefits of using technology in teaching, when used appropriately. These benefits can then be transformed into tangible improvements in teaching and learning, such as through facilitating feedback on common misconceptions. I hope that this project may inspire others to try incorporating innovative technology in their teaching – especially those who may be rather reluctant. Perhaps this project can improve the perceived attributes of clickers and so facilitate the wider adoption of technology in teaching, through the diffusion model suggested by Rogers (2003). On a more personal level, this project has opened my eyes to a wider range of teaching practices beyond the traditional lecture and inspired me to be a more innovative teacher and I look forward to using clickers and other types of technology into the future.

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