Incorporating active learning with videos: *A case study from physics*

by Kester J. Lee and Manjula D. Sharma

Watching a video often results in passive learning and does not actively engage students. In this study, a class of 20 HSC Physics students were introduced to a teaching model that incorporated active learning principles with the watching of a video that explored the Meissner Effect and superconductors. Students would watch short sections of the structured video and then participate in guided group work, discussing and presenting their ideas to the class. The students received the treatment enthusiastically and the feedback from the classroom teacher was positive and encouraging. This teaching model showed a successful way in which constructivist theory could be applied to improve the active participation and learning of students watching a video. Further work is needed to verify whether the engagement and interest of the students can be replicated with other subject matter.

Introduction and rationale

Constructivism is a powerful educational theory where interaction with the learning situation is highly valued, and where the role of the learner in actively organising new concepts with old ideas is a key process (Pereira, 1996). The idea of the classroom video seems set against the philosophy of constructivism, as videos are an extension of a one-way teaching method where information is presented to students and their interaction is limited. This paper models one approach in which videos can be used in an active learning process.

This teaching model is based upon the ideas of Lloyd and Wallace (1996), which recognised five stages in the teaching and learning process. The orientation was the first step, where students would be presented with new material, then the elicitation followed, whereby students would explore and investigate this new material using their prior knowledge and skills of inference. The restructuring was the third step, where these fledgling ideas would be reorganised in accordance with the correct understanding, with guidance from the teacher. Students would then be able to apply this understanding to other situations and problems, and conclude by reviewing and reflecting upon their newfound knowledge. This paper attempts to demonstrate how these five stages can be realised within the framework of a lesson involving videos and group work.

Most constructivists would agree that it would be a mistake for the classroom teacher to assume that any educational video or DVD is best employed by simply turning it on and letting students take notes during its viewing while they sit and watch. While the video might pose challenging concepts to students in an interesting manner, the student is still essentially a passive learner. There is also the danger of a student being overloaded with information, as described by cognitive load theory (Sweller, van Merrienboer & Pass, 1998). The current understanding in constructivist educational theory places a greater emphasis on active learning (Nicol & Boyd, 2003), where learners are engaged to develop personal models of understanding through their own investigation.

Group work and student discussion are cornerstones of active learning. It is possible to combine this constructivist practice with the viewing of videos, which is often a source of passive learning. This active learning alternative involves showing the video in short segments, separated by times when students are asked to participate in group activities and discussions about what they have seen. This ensures that students are learning in an active manner, and also gives them time to organise new information so that they are not overloaded by continuous watching of the video. It is particularly effective when dealing with new material with which the students are unfamiliar, as there is a natural curiosity associated with such exploration and discovery.

The Meissner Effect is one such phenomenon, where a magnet levitates above a superconductor. It is one of the more spectacular demonstrations that can occur in the physics classroom, and can often provide the starting point for rich discussion about superconductivity, an important concept in the 'Ideas to Implementation' module of the New South Wales Physics Stage 6 Syllabus. Demonstration of the Meissner Effect requires liquid nitrogen and a ceramic superconductor. The

prohibitive cost of acquiring these can often mean that schools will employ a more cost-effective substitute – such as a video that showcases the phenomenon – so it seemed that the Meissner Effect and superconductors were a fitting topics for this study. The challenge of the physics teacher is to make this video an effective tool for active learning.

Implementation

The Sydney University Physics Education Research (SUPER) group has assembled a set of short videos based on the NSW Physics syllabus. Collectively the videos are called AMPS—Australian Multimedia for Physics Students—and range from topics such as Australian Physicists to Faraday's Law (http://www.hscphysics.edu.au). Some videos have been gathered into lesson plans as described in this study. The Lesson Plan on superconductors is divided into three main sections: exposition, theory, and discussion. The sections emulate Jerome Bruner's three stages involved in learning the structure of a topic: concrete demonstration in the Enactive stage, use of pictures and representations in the Iconic stage and abstraction using physical examples and applications in the Symbolic stage (Bruner, 1960, 1966).

- Exposition: This section showcases the Meissner Effect, performed with a ceramic superconductor cooled with liquid nitrogen and a rare earth magnet. This section does not provide an explanation of the phenomenon, and is 1.4 minutes in duration.
- Theory: The theory behind the Meissner Effect is explained, as well as the general theory regarding superconductors. Other ideas relevant to superconductors are explored, such as BCS theory and lattice structure. This section is 5 minutes in duration.
- Discussion: The discussion focuses on applications of superconductors in the wider world, such as maglev trains, SQUIDs, and more efficient electrical transmission. This section is 6 minutes in duration.

See Sharma, Muller, & Project Team (2008) for the specific videos. The guiding principle behind the use of these videos was to provoke discussion by pausing between the segments and engaging the students in activities based on what they had just seen.

Implementation of the Superconductors media tools was undertaken at an independent boys school in Sydney's southwest. The lesson took place in a one-hour morning class, with twenty HSC Physics students in attendance. Students were asked to organise themselves into groups of four and given butchers paper to note their observations and responses throughout the lesson.

The class began with a short brainstorming session of five minutes during which each group had to write down anything they knew about superconductors and then share this with the rest of the class. The students had received no formal instruction in the topic, but displayed some understanding of the underlying concepts, with a few students guessing that superconductors were concerned with high conductivity when the temperature was low.

After this, the Exposition segment was shown, demonstrating the Meissner effect without explanation. Students subsequently undertook a second discussion of 10 minutes where they had to come up with their own explanation of the Meissner effect, using their current understanding of physics. Encouraged to draw diagrams to illustrate their explanations, students then presented their group's ideas to the class fielded questions from the other groups about their model.

An example of one of these models is provided below in **Figure 1**.

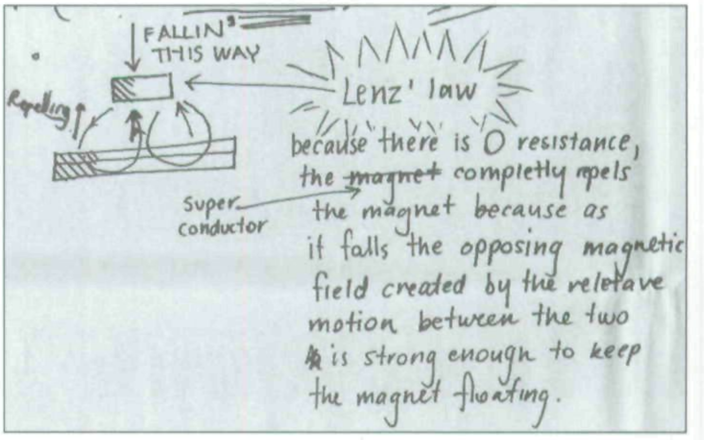

Figure 1. *A group's initial explanation for the Meissner Effect.*

Students were encouraged to take notes during the second section, the Theory segment of the video, which explained the correct theory behind the Meissner Effect. After this second video had concluded, students were allowed to correct their earlier models of the Meissner Effect, discussing what alterations had to be made within their groups. An example of how a group amended their model is shown below in **Figure 2**.

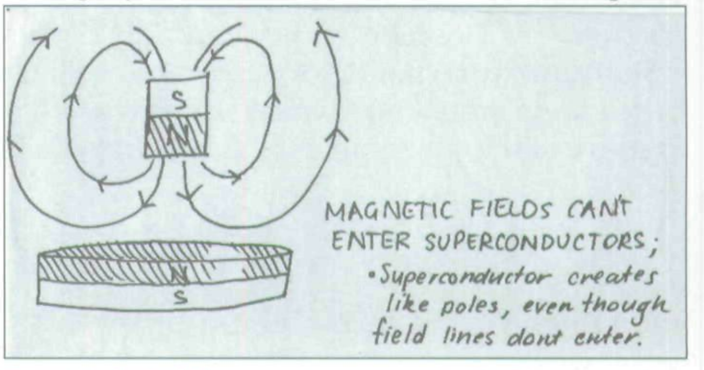

Figure 2. *Part of the group's response to the Theory section of the video.*

The third section, the Discussion, examined the applications of superconductors, such as maglev trains. After the conclusion of this third video, general questions about superconductors were fielded by the teacher associate from the University of Sydney and the regular classroom teacher. The lesson concluded with a worksheet that was completed by students for homework.

Results and discussion

The most encouraging result was the interest and enjoyment of the students. The group work facilitated vibrant discussion, and even after the lesson had concluded, many students stayed behind to ask more questions. Clearly the lesson provoked an interest and curiosity in students about the physics regarding superconductors, and a selection of these questions is provided below:

- Why can the magnet still levitate if it is spinning?
- Why do they have to form Cooper pairs, and not three or four electrons grouped together?
- What is it about ceramics that makes them good superconductors?
- Can we now create even more powerful magnetic fields than ever before?
- Does this mean that in theory we can also generate electricity much more efficiently, as well as transmitting it more efficiently?

Group work

After the first video, when the students were asked to explain the Meissner Effect using the physics that they already knew, it was clear that without the theory behind superconductors, the students' only recourse for explaining the Meissner Effect lay in their knowledge of Lenz's Law. Lenz's Law forms a key component of the Stage 6 Physics Syllabus in New South Wales, as it is contained in the mandatory module of 'Motors and Generators' (New South Wales Board of Studies, 2002). It is thus hardly surprising that the application of Lenz's Law would be a common misconception with regard to the Meissner Effect and superconductors.

By the time they had finished viewing the second section of the video—which correctly explained the theory behind the Meissner Effect—the students had been alerted to the nature of the Lenz's Law misconception. The exercise that followed—that is, the subsequent group work where students were asked to make any alterations to their first explanation—is an example of explicitly refuting a common misconception, a practice favoured by science educators (Muller, Sharma & Reimann, 2008). The effectiveness of this refutation can be seen by the observation that only two of the 15 collected worksheets bore any reference to Lenz's Law, compared to the students' models before, where all had mentioned Lenz's Law in some form. This is an example of the third stage of the Lloyd and Wallace (1996) teaching model, as students were challenged to reorganise and restructure their ideas based upon the correct guidance provided by the second video.

Teacher feedback

The class was conducted by a teacher associate, with the regular classroom physics teacher in attendance. The classroom teacher was asked to complete a feedback survey, where they indicated that the teaching model was 'very easy to incorporate into my class plans', and that they would like to share these tools with their colleagues. Below are several quotes:

- 'The group discussion was focused and rigorous, promoting good learning'.
- 'You could tell the students had a lot of fun.'
- 'The animations can be developed to accommodate a 'predict-observe-explain' lesson structure.'
- 'My students asked if we would be using the tools again soon!'

It is clear that from the classroom teacher's point of view that the learning activity was a success and that if the opportunity arose, the type of learning experience would be repeated with another class or a different topic.

Future direction

This paper has detailed one way in which this teaching model can be employed. Further investigation is needed to determine if the model is suitable for other subject areas and age groups. It can be argued that the students who were involved in this study started with a large amount of interest and engagement in the lesson. In particular, the students were HSC students in Term 3 who had high motivation for learning from the subject material. Extra interest and engagement might also have been created by the inherent novelty value of having a workshop session with a new and unfamiliar instructor, namely the researcher from the University of Sydney.

The production of appropriate multimedia is another concern related to this teaching model. Most of the existing videos have not been designed with this model in mind and are intended for continuous viewing from start to finish. They may not necessarily lend themselves to the sectionalising that is essential for the strategy of keeping the viewing in small blocks broken up by group work. This can hopefully be alleviated in the future with the production of more multimedia tailored to this learning model.

Conclusion

While this active learning strategy with videos is not suited to all topics, it is clear that there are distinct benefits to be had when exploring new material that students have not had experience with before. Above all, the interest of the students and their engagement in stimulating activities of short duration is the most worthwhile benefit, closely followed by their demonstrated strength in grasping the concepts at hand when asked to translate their learning into a more conventional pen-and-paper worksheet. By combining videos with group work discussion, it is possible to create engaging and stimulating activities for students that draw upon their resources as active learners. This study shows that constructivist theory and active learning ideas can be successfully incorporated into a lesson that normally would have consisted of a simple video viewing.

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