Active learning precursors in multidisciplinary large group lectures: a longitudinal trial on the effect of imagery in Higher Education lectures

Journal:	*College Teaching*
Manuscript ID	24-17-094.R2
Manuscript Type:	Manuscripts
Keyword:	Pedagogy, Multimedia learning, lectures, images, PowerPoint, Visual learning, Cognitive load theory, active learning, Focus groups, Experiment

Active learning precursors in multidisciplinary large lectures: a longitudinal trial on the effect of imagery in Higher Education lectures

College and university teaching involves almost universally and hegemonically the large group lecture format. This ubiquitous learning and teaching space has, however, long been criticized for the production of passive learning in which the 'sage on the stage' transmits and students receive passively. This article reports on and evaluates a longitudinal multidisciplinary controlled experiment in which students were exposed to imagery and non-redundant text-narrative to assess the presence or absence of active learning principles. The trial found that students exposed to MML experienced 40-80% greater levels of active learning practices over those exposed to narrative and text. Given the physiological (cognitive) nature of MML predictions, the implications of the research impact upon all disciplines where lectures are a means of knowledge-sharing practices in Higher Education.

Introduction

This article is about the organic production of active learning practices in large group lectures. A key contribution is to demonstrate the unpredicted presence of AL characteristics in MML methods. By 'organic production', I mean that active learning practices in the abstract occur without deliberate intervention to produce them.

The intersection of active learning and large group lectures has been treated before in these pages. This work extends and builds upon that and other literature that has evolved in relation to social and technological globalizing forces ascendant since the end of the Cold War. Amongst the earliest, more than twenty years ago, Terry Savage and Karla Vogel (1996: 127) recognized that in conjunction with the rise of computer use in universities, 'the use of different media to convey information' as a departure from the dominance of text in most disciplines implied the potential for an interactivity that challenged the passivity of orthodox monomedia (text only) approaches to teaching. They had spotted the potential that new hardware and software presented for the dissemination in teaching of an expanding array of academic content. It is far more the case now, as the world wide web now connects an almost unending array of resources that digital devices can communicate to student audiences, and that those students can engage and interact with. That potential has been amplified as new software presentation platforms like PowerPoint, Keynote and Prezi allow the merging and projection of multiple media, and professionalize the appearance of such projections. For example, still images, film, documentaries, music and animation can all be integrated into contemporary projection platforms in lecture theatres with relative ease. This article is specifically concerned with the use of full-slide, high quality images used not as an appendage to lecture content offering 'a respite from serious academic work' (Thomas, Place and Hillyard, 2008), but instead as a primary complementary pedagogic medium that enhances text-dominant practices to organically generate active learning practices among students.

Early consideration of Multimedia Learning (MML)

College Teaching has already engaged with the debate about the use of images and video in teaching. Drawing from Margaret Mackey's research (2003), Elizabeth Thomas et al (2008: 24) grounded their research in the idea that visual images were valuable for 'promoting polysemic understanding, or the ability to make sense of texts with multiple channels of information'. This means that a given scholastic tome, dense in text and meaning, may be communicated using media other than just text. Their view (2008: 74)

was that such an approach could serve to 'promote… active learning', and was informed in some part by the work on Multimedia Learning (MML) of Richard Mayer and others. Understandably, given space limitations, the authors could not provide a more thorough exploration of why images might work in such circumstances. Further, their insightful experiment was understandably limited in scope to trials within their own institution over the short-term. For these reasons, although a sound experiment, the data is limited and the explanatory potential constrained. This article proceeds by exploring Multimedia Learning theory in greater depth with a view to considering why images might work well, and examines the wider social context of imagery in the digital era. It will then introduce a longitudinal three-year experiment and the results of control group testing of the effect of images on the organic development of active learning practices among students across nine disciplines at a UK university

Before we proceed, however, it's worth considering the nature of hegemonic lecture orthodoxy in Higher Education (HE). At least three elements are apparent. The first is logocentrism. Logocentrism here refers to the privileging of text in HE lectures, above all other media. This pattern is an extension of other scholarly conventions such as the textual character of the books and journals from which lectures are often drawn. These in turn are built on the notion that 'language constitutes our world, it doesn't just record it or label it. Meaning is always attributed to the object or idea by the human mind, and constructed by and expressed through language (Barry, 2009: 55). Second, our primary delivery platform, PowerPoint, discourages alternatives to text by privileging bullet points and text placeholders when new documents are opened. Although the platform is capable of great media diversity, its default setting encourages the use of text above other media (Adams, 2006). Third, this monopoly perpetuates the legitimacy of the 'sage on the stage', since s/he will monopolise comprehension of scholarly texts and permit their communication in text form only, foreclosing alternative media use that may make knowledge more accessible to student minds. This domination of a particular medium of knowledge communication perpetuates the passive tendency characteristic of HE lectures worldwide (Reinhardt, 1999; Alexander et al., 2002), where there is limited critical interactivity with the academic content of a lecture.

It is in this context, of the persistence and hegemony of logocentric lecturing, that we must consider a further aspect of 21st digital life before we consider MML, and this is the rise of the visual. Mitchel (2002) and Felten (2008) both point to a 'pictorial turn' in human evolution brought about by the digitization of photography, the capacity of the web to disseminate digital imagery, and the evolution of computers and software to access, manipulate, catalogue and disseminate digital imagery. The production and consumption of images has never been greater, making our students 'the most visual of all learning

cohorts' (Coats, 2006: 126). Their experiences of communication, engagement, learning and understanding before and after their time with us are shaped extensively by an increasingly visual culture; but their time with us remains dominated by the Gutenberg Press. We operate an eccentrically logocentric lecture system in an increasingly ocularcentric world.

Multimedia Learning (MML)

Multimedia Learning is concerned with the idea that, when presenting content to an audience, a balance of text and images is better for conveying meaning, knowledge and information than text alone (Mayer, 2014). It represents an argument for balance, whereby we balance delivery content between the two key processing channels we possess, as opposed to maintaining an imbalance where we deliver nearly everything down one channel and ignore the other. MML's relevance and importance is connected to our students' inner and outer worlds. By this, I mean that, on the one hand, MML presents cognitive visual capacity as complementary to cognitive audio-textual ability. It considers how our brains process information through our eyes. On the other, MML is particularly suited to the pictorial turn in human evolution, because images are amongst the primary subject of study. Combined, MML demonstrates how our visual capabilities to absorb knowledge can be enhanced by communication with apposite images, as distinct from forms of graphic representation that titillate more than teach (Sung and Mayer, 2012). It argues that human beings are dual processors of information (Mayer, 2014; Mayer and Sims, 1994) who interrogate the world around them through two channels (Paivio, 1971; Paivio, 2014; Lewis, 2016; Ayres, 2015). One channel processes audio-textual information, while the other processes imagery. From this perspective, it is a falsehood that only a certain proportion of people learns visually. All sighted people do (Mayer and Moreno, 1998; Paivio, 2014; Sorden, 2013)

The conclusions MML comes to from such understanding are at least twofold. First, using both available cognitive channels presents an opportunity for students to increase their ability to interpret and understand the world around us (Ayres, 2015; Beetham and Sharpe, 2013). Second, continuing only to use one is by default harmful, because it underutilises some of our learning mechanisms. So, adding images enhances interpretive potential, whilst continuing to depend on text alone or primarily underexploits our capacity to understand. Each channel has limited capacity, both of which can be overloaded, preventing students from processing excessive data. Presently, one is overloaded while the other is underused (Paivio, 2014; Sorden, 2013). MML literature makes the case that persisting in using text the way we do overloads our students' ability

to process the content we are giving them, the way we give it – on PowerPoint slides full of text and bullet points (Lewis, 2016; Mayer and Moreno, 2003; Sweller and Chandler, 1991). MML literature posits that, because cognitive loading is better balanced when a combination of images and text are used, audiences will experience higher levels of engagement with academic content.

We tested and confirmed this proposition but the qualitative methods used to complement the quantitative investigation revealed an unanticipated outcome: the presence of organically-generated active learning processes. By this, I mean that data from the qualitative focus groups we used revealed that the use of images in large group lectures was prompting student interrogation of visual academic content, drawing on pre-existing knowledge to generate new meaning, understanding and conclusions. In the words of David Perkins (1992: 49), students were 'engaging, grappling, and seeking to make sense of things'. This evidence came about incidentally as focus groups created to address questions of engagement identified processes otherwise associated with active learning scholarship, without prompting. These unintentional findings prompted a repeat of the experiment around active learning. The following section outlines how imagery was applied in large group lectures and describes the experiment that evaluated their impact as it relates to the characteristics of active learning. Before this, however, I'll outline what I refer to here as active learning.

Active Learning

A central contribution of this article is to demonstrate the unpredicted presence of AL characteristics in MML methods. These are precursors to active learning identified in leading AL literature. It is not suggested as a discussion of learning per se but concerns the agentic activities that are pedagogic necessities for learning to become active. Active Learning (AL) is cast in opposition to the idea of passive learning, in which recipients are 'on receive' in an uncritical and inactive mode (Reinhardt, 1999; Harper and Quaye, 2008). In passive learning, knowledge development is unidirectional, controlled by a 'sage on the stage' (McWilliam, 2008). We should be quite careful here. Just because an audience is on 'receive' does not mean it is necessarily uncritical and inactive, or that it is pedagogically wasteful. There is an abundance of literature to suggest otherwise (Webster, 2015) (Puttee and Mezzina , 2008; Tokumitsu, 2017). But AL principles in the abstract are specific about the nature of activities students must be engaged with. Glenda Anthony (1996), for example, maintains that learners are engaged in knowledge construction and are conscious of it., building on existing knowledge. Furthermore, that knowledge construction is known to be occurring to the learner. They are conscious of realization. Similarly, Michael Prince

(2004) argues that AL occurs when a student is learning, as opposed to hearing, for example. They will be considering teaching content critically, instead of simply reducing and/or regurgitating what we teach them. For John Savery (2006), an important part of generating such activity is the presence of a problem in need of resolution or transformation, a position also taken by Linda Torp and Sara Sage (2002), Joel Michael (2006) and others (Zepke, 2013; Zepke and Leach, 2010).

Further, AL is claimed to occur when learners replace or adapt existing understanding and knowledge with deeper comprehension (Hmelo-Silver, 2004; Stes et al., 2012; von Stumm and Furnham, 2012; Ellis, 2016). Developing AL further, Philippa Levy (2012) maintains that successful inquiry-guided learning (as the interrogative aspect of AL that stimulates transformative learning) is characterised by an interrogative process that pushes students to create their own answers to problems, instead of answers being provided by academics. For Daniel Edelson et al (1999), this means that learners become autonomous agents of discovery who can identify new knowledge, use it to build on their existing knowledge structures, and then use that to solve problems. At the heart of the matter lies the questions that students must find answers to, with guidance: AL requires the injection and stimulation of a process of student inquiry. No absolute prescription is claimed for the form a problem should take; the objective is the stimulation of interrogative inquiry on the part of students (Bradfield, et al., 2015). Summarising, the key characteristics of active learning identified in the abstract by leading scholars concern:

- Stimulation of curiosity and a desire to know more
- Provocation of inquiry
- Presentation of problems to be solved
- New knowledge construction from existing foundations of knowledge

The exit survey questions in this study are meant to capture this data. I turn now to the introduction of image-based lectures in operational undergraduate modules in nine disciplines, and their impact on the production of active learning practices over the course of three years.

Development and application of MML

My subject interests often involve popular social, economic, environmental and political issues. After realizing how compelling the expanding range of advertising for third sector interests had become, and recognising how complex messages were being effectively conveyed in such advertising and marketing campaigns, I began to consider the extent to

which images might be useful in my teaching. Four years ago, I started using in my modules full-slide images taken from the Internet and from my own collection from my field research. These modules are taught in lecture theatres, with students face to face as part of the regular degree curriculum. I began with a handful of images per lecture, each of a minimum 800 x 600 pixels (for clarity and quality). I built on this and presently use images in more than 70% of all lectures in all the modules I teach at all levels in all the disciplines I work in. These include Peace and Conflict Studies, History, Postcolonial Studies, Critical Feminisms, Business Studies, Politics, International Political Economy and International Relations.

I combine this approach with spreading text content across more slides to reduce cognitive overload, so there is rarely more than one line of text per slide. Remaining text is inserted into the 'notes view' part of PowerPoint, accessible to students through the Virtual Learning Environment but not visible when I present the slides. I developed this method by combining scholarly work on slide design (Kosslyn, 2007; Duarte, 2008) with 'real world' work used routinely beyond the academy (Reynolds, 2011; Kawasaki, 2012). I use two categories of image, illustrative and metaphoric, but there is another I have identified as 'paradox' images that present as a problem by, for example, containing seemingly contradictory elements, like the blood on the diamond, below. Some images combine all aspects. I use illustrative images to describe an issue or event. These can be quite straightforward: an Asaro Mudman, unfamiliar to many, can be rendered apparent and thereby provide an anchor for spoken words, recall and text as well as a point of focus for student attention. I use metaphoric images to help students connect with the unfamiliar through pre-existing knowledge. Martin Eppler (2006: 204-205) proposes that visual metaphors 'support learners in connecting what they already know (the properties of the metaphor domain) with new content (the domain unto which the metaphor is being applied)'. According to Edward McQuarrie and David Mick (1999), easily-recognizable metaphorical images prompt complex cognitive processing. Below are some examples of the images I have used, with supporting text

Figure 1 Crashed UN helicopter, Cambodia, 1993. Copyright of author

This illustrative image supported the idea that UN peacekeeping operations normally take place in situations of fragility and complexity. It underpinned a discussion of how fragile peacekeeping interventions can be.

Figure 2 9-11 from within. Copyright of author and 123RF

This illustrative image describes 9-11 from the inside. It presents a version of events otherwise invisible to the mind

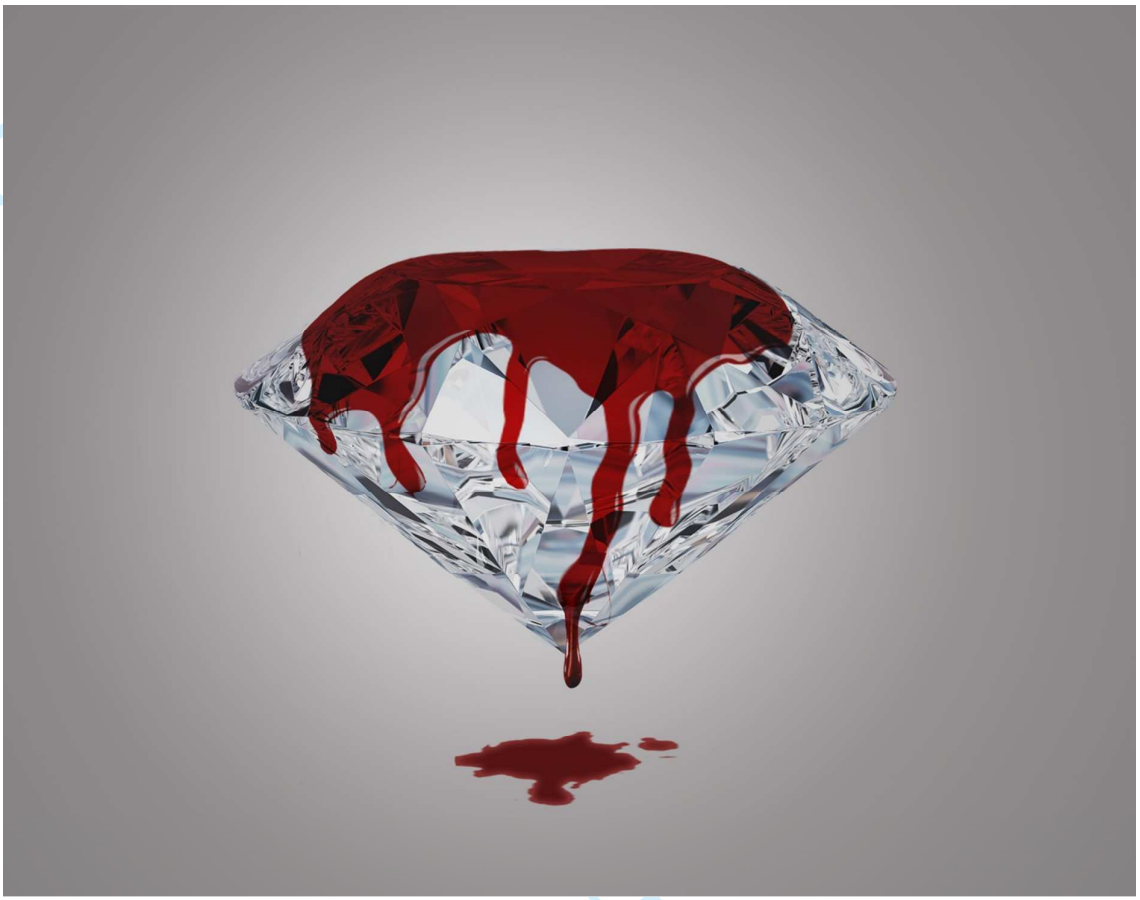

Figure 3 Blood diamond. Copyright of author

This metaphoric image supports several conversations. It has been used to encourage interrogation of capitalism and structural violence (diamond conflict, diamond mining); honour killing, or the murder of a betrothed partner; and domestic violence in the UK and US.

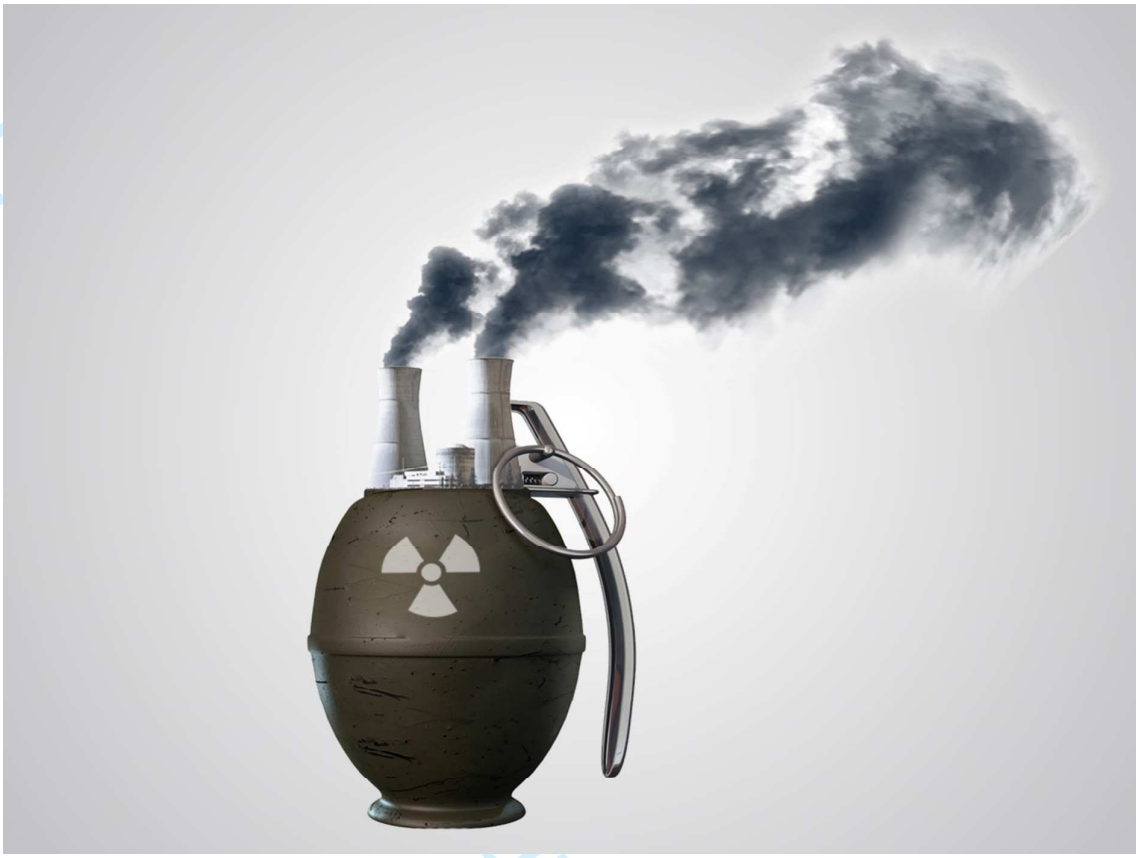

Figure 4 Danger of nuclear energy. Copyright of author

This metaphoric image connects the idea of planetary decay to human industrial intervention.

Figure 5 Danger of nuclear weaponry. Copyright of author

This metaphoric image helps me talk about the blinkered (hypermasculine) tendency to choose nuclear options every time, regardless of opposition and alternatives (represented by peace doves) all around. It is an example of a more complex visual metaphor illustrating much of the debate in one image.

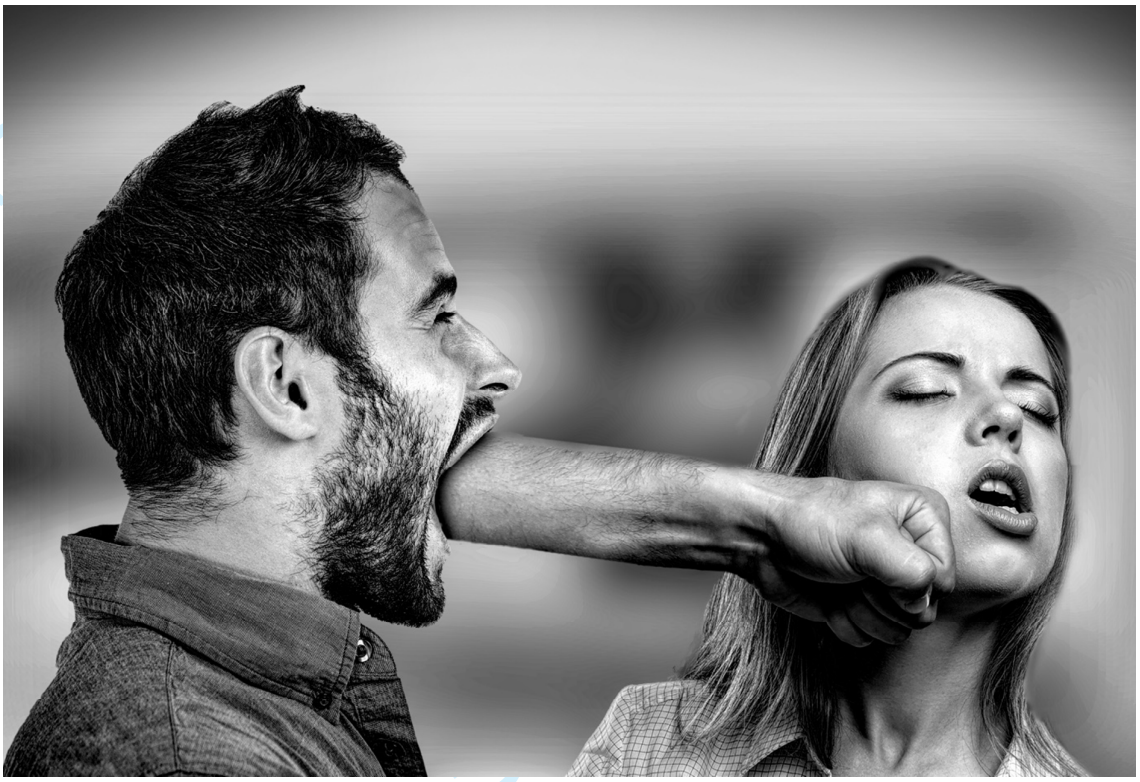

Figure 6 Domestic violence as verbal. Copyright David Roberts/123RF

This image helps express the idea that domestic violence can take the form of verbal assault.

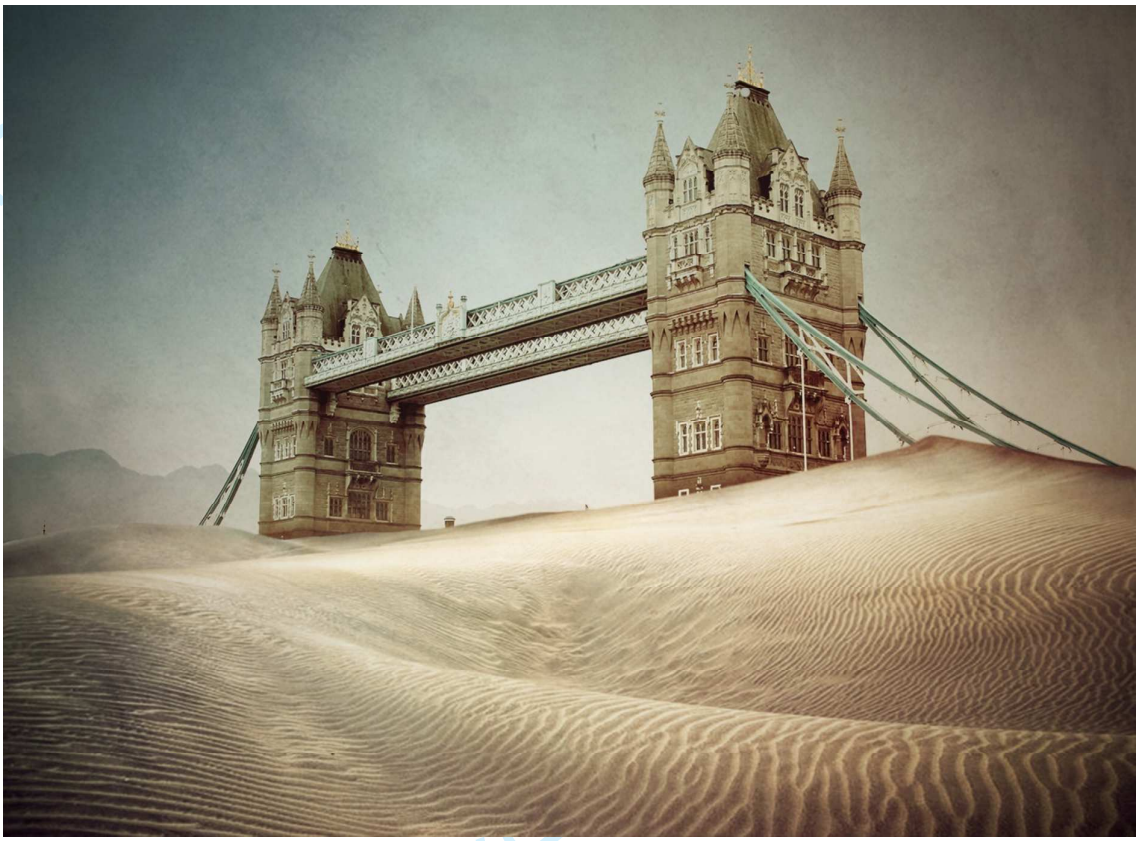

Figure 7 Desertification. Copyright David Roberts

This is an example of a paradox image. London's Tower Bridge should not be in the middle of sand dunes or a desert. It builds on the familiar and generates conflict that needs to be reconciled. By presenting two elements that should not be simultaneously coterminous, the mind is 'brainjacked' into unscrambling meaning.

Evaluation

Four years ago, I began evaluating this method using control group methods to develop quantitative data and focus groups to develop qualitative data. At the time of this work, Barbara Fenesi et al (2014) were arguing that to further research on MML methods and effectiveness, the best way forward would be to combine controlled experiment methodologies with a 'best practice' approach, using, for example, real course content. This approach was used for the ensuing experiments. It should be noted that several years earlier, Tom Schrand (2008) was proposing this kind of research into the potential of animations and images to generate active learning processes, although he published no further elaborations of his propositions. The quantitative approach chosen bore in mind the proposals of Fenesi et al and Schrand (above), and was adapted from Chanlin (1998), McKay (1999) and Kleinman and Dwyer (1999), who designed control group methods for the assessment of another experiment concerned with images.

The quantitative experiment involved control and test groups numbering 79 students in total. Each group was exposed to one of two 10-minute PowerPoint mini-lectures on global warming. These were separate from the regular curriculum in which the MML method was developed and practiced. The subject of global arming was chosen because it was considered that most participants would have at least some familiarity with the subject through exposure to news media over their lifetimes. It was unlikely to be a subject new to many. Allocation was randomized on the day. The control group watched a PowerPoint presentation using slides with 4-5 bullet points of text. The experiment group watched a PowerPoint presentation that used full-slide images with one line of text chosen to summarise the point of the slide. No additional text in 'notes view' was used, unlike in the regular lectures. Both presentations used identical, recorded narration by this author. Volunteers came from the students taking the regular curricula. All students were under 21 and male volunteers outnumbered females in all sessions. All signed university-supported ethical consent forms. After each presentation, the students individually completed an online exit survey. The survey questions concerned the effect of the slides, as opposed to asking about text or images. The experiment has now been placed online, participant identities and cohorts as well as survey questions can be adjusted to reflect ongoing research needs. Future participation will be achieved by email invitation and randomization is achieved through embedded code that mutates the URL to each presentation.

Data from the quantitative experiment, aggregated over the three-year trial, appears in Table 1.

[Table 1 here]

Table 1. 2014-2016 average for active learning. The blue bars represent the control group's reactions to standard slides. The yellow bars represent the reactions of the experimental group to imagery. Questions appear across the X axis and reflect the characteristic precursors to AL identified on page 8

The questions asked of students were drawn from the AL literature outlined above, and appear at the bottom of the graph. The darker bars represent students shown slides with text only. The lighter bars represent the responses of students exposed to images and reduced text. The comparative presence of AL characteristics in slides using images and text is substantially greater than in those slides using text alone, and is not predicted in the MML literature. The data are not surprising. Cognitive load is better balanced when

information is bifurcated and distributed more evenly across both audio-textual and visual processing channels. But the reasons for increased presence of AL characteristics are better explored using focus groups. The exit survey data provided information on scale but lacked exploratory and explanatory capacity, so focus groups were added to the methodological repertoire to help understand what was happening for students in this process. Focus groups involve 'an in-depth, open-ended group discussion of 1-2 hours' duration that explores a specific set of issues on a predefined and limited topic' (Robinson, 1999, p. 905). For Sue Wilkinson, focus groups encourage 'the production of more fully articulated accounts; and offer an opportunity to observe the process of collective sense-making in action' (Wilkinson, 1998, p. 181; Stewart & Shamdesani, 2014). They foster an environment in which group members are encouraged to engage with one another. This method continues our adoption of Participatory Action Research (Chevalier & Buckles, 2013).

The following section distils the findings from six focus groups each consisting of between four and eight undergraduate students from nine disciplines held over the three years of the experiment, totalling in all 33. There was a bias towards those who had been in the experiment group of close to 2:1. Males outnumbered females three to one. I facilitated the groups' discussions with the intention of enabling participants to hold their own conversations around the same questions that were used in the exit survey. Although most of the participants were unfamiliar with the concept of AL, when probed, they identified its key characteristics as being elemental to the processes they experienced when engaging with imagery.

I was particularly interested in ascertaining whether the students felt they were engaged in an interrogative, interpretative and problem-solving exercise. To widespread agreement, one student declared:

> I start not knowing what the image is. Watching a confusing image makes me want to hear what the lecturer has to say about it. I need to work the image out, whereas if it's just text I'm bored. I don't need to work anything out; I just rewrite what I'm being shown on the slides. Being confused like that keeps you stimulated the whole lecture, especially since we know there will be more images like this and more puzzles to understand. It keeps us on our toes.

One student claimed that 'when you're looking at a picture you're trying to figure out what the artist intended. It's an interpretive process…. They grab your attention because you want to know what it is you're looking at'. Thinking about an image that showed human evolution in one

slide, one remarked, to group consensus, that he 'had to map the content, assemble its component parts from what [he] already knew about evolution'. The image 'puzzled at first', then there was 'relief' in understanding its message. There was group agreement when one member declared: 'I didn't even realize what I was doing. I was just in the picture, thinking about it whilst you talked'. This was an interactive process: students were drawn into the image by their unresolved curiosity and then engaged in problem-solving to understand the image's meaning, whilst audio-textual cognitive processing was free to hear the non-redundant (not repeated on the slide in text form) spoken component discussing intellectual content. The images stimulated inquiry and resolution because they were 'illogical', 'irrational', 'wrong', 'surprising', 'perplexing' and 'needed to be reconciled'. They agreed they were 'working the problem'. One student said: 'I really like the problem-solving – what is going on in the image forces you to work it out because it presents a problem'. John Ingledew talks about this as 'brainjacking': the brain is hijacked by the paradox involved (2011: 9). The process seems organically to lead the mind into inquiry. It's worth recording a particular student comment at length. It concerned a student's reflection on an image of a transparent pill containing miniature skulls rather than medicine, because it paints the interrogative journey the student took when viewing it:

> I see the pill and think health, then I see the skulls and I think – that's not right. I see the pill and have thoughts about health; I see skulls and have thoughts of death. Then I try to link it with what the lecturer is saying, and it completes a circle and brings it to life. I can then understand more about the morality of Big Pharma charging poor people for life-saving medicine or something like that. The confusion the image creates makes me try to reconcile the content, which means I am thinking of explanations myself whilst the lecturer is talking around it. I am asking, why is there an image that's created like that? It goes against what I thought I knew, what I'd been told, what I'd learned before.

This reveals also the student's journey in building on pre-existing knowledge; this was a common theme, where students built on what they knew and made connections across various knowledges, some new and some pre-dating their time at university. One student talked about an image used to support discussion of the Cold War. She noted that the image's 'clash' of elements (two opposing representations of the USSR and the US) challenged what she already brought to the lecture and brought about confusion and a more critical engagement. She said that the 'truth' she had come to the lecture with didn't stand up against the evidence being presented and forced her to think critically about the evidence upon which both views rested. It made her 'half the deal', wherein she wasn't 'just sitting silently on "receive"' but was instead 'working to understand, using my brain to ask questions'. She added that it was 'almost the opposite of a normal lecture'. She declared that with that image, she was no longer 'tied' to copying down lecture content and instead was free to 'bring [her] own brain to the table'; she was 'learning for

[herself] instead of being taught to'. Another commented that, during a regular curriculum lecture, when the lecturer discussed the elements and meaning of an image, it was different from someone telling them what it was. It 'nurtured' the 'process of coming to understand'.

Images were also considered emotionally impactful. One shows what the last moments before the airliners hit the Twin Towers might have looked like from the inside (figure 2). Participants each year agreed that they were 'blown away' by something they couldn't otherwise see or imagine. They said they could almost feel 'the end' for the victims. It drew their breath and made them 'ultra-focussed', 'angry as hell' and 'sad'. They were 'fully connected' to the lecture content and wanted to understand more about why the Towers had been attacked beyond the obvious rhetoric of 'terrorism', They wanted to understand what would motivate a group of people with their own families to go to war with the most powerful country in the world in such a calculated fashion.. Another image prompted laughter, surprise and the need to understand more. This showed Tower Bridge, over the Thames in London, half buried under sand drifts. The subject was desertification. One student declared she 'had no idea [desertification] looked like that. I could understand why it would be seen as a threat to people. It really got my attention because I could see the consequences for the first time. I never thought a picture of sand would impact me so much'. Another image, concerning pollution (figure 5), left an 'indelible' mark on students in the group, prompting one to remark that the image 'says everything about the safety problems of nuclear power stations'. Another said the act of pulling the grenade's pin suggested a 'man-made disaster', easing understanding of the theme of the lecture, which was to outline an introduction to theories of social constructivism. In another session, I referred to the celebrated image of the young Viet Namese girl, Kim Phuc, burned by napalm and an air raid continuing behind her. To agreement, one declared: 'I could understand why people in the south hated the American forces. I understood in that picture why America lost the war. Reading the books on the war became easier'.

It was also important to get a sense of whether illustrative or metaphoric produced different responses. Broadly speaking, both were valued differently. Illustrative images served two purposes. They described in a complementary fashion a subject enunciated verbally or with text; and they alleviate the 'pain' of slides full of text. Metaphors were 'journeys', 'problems to be solved' and 'stimulants' among other things. It is clear from these groups that apposite images that convey relevant description and/or meaning, serve the dual purpose of exploiting students' visual processing capabilities whilst also eliminating the harm of excessive text. Metaphors stimulate AL, including intellectual curiosity, and prompt a co-productive symbiosis between these students and their lecturer. A telling remark has much value: 'most of my lecturers just put text up. I'm instantly bored by text. I'm instantly drawn to a picture. Images up the ante and give me autonomy, make me active in the lecture, instead of text that spoon-feeds me'. The view was unanimous in each focus group in each year. One student put it thus: 'if your brain is engaged enough to be asking, "what is that?", then you are definitely active in the learning process. I'm involved in these lectures. I'm busy'.

Conclusions

Anecdotal evidence shows an increase in the number of 'firsts' on my own modules increasing by 30 percent in the time I have developed this method. In the UK, a 'first' refers to assessment marks of 70% and above. Student feedback always remarks on their enjoyment of this teaching method. 'Real world' experiences discussed above are unequivocal about the use of images in large group lectures. Although MML scholarship does not predict that the use of apposite images in teaching will provoke AL in large group lectures, lectures using MML methods have been shown to increase the presence of AL characteristics by between 40 and 80% over slides using text only. Focus group testing has confirmed the presence of key characteristics of AL, including problem solving, drawing from previous knowledge and developing new knowledge in conjunction with the lecturer's input.

The implications are far-reaching, primarily because logocentric lecturing remains the hegemonic norm in HE bodies around the world for many reasons, not least of which is their economic (if not pedagogic) efficiency in a pervasively neoliberal climate. But in addition, the physiological nature of the method, wherein underused cognitive capacity is brought into play and overused processing is given a break, applies in all disciplines for all sighted people. The experiment covered 9 disciplines with no discrimination between disciplines, no deviation between them, and no difference in overall outcomes over the 3-year experiment. But much more importantly, we may argue that AL will work in all disciplines because the discipline is theoretically irrelevant. The MML method concerns and impacts cognition, not content. They concern physiology that applies to all sighted people who process information through two channels. What goes through the two channels is in some ways irrelevant. It's the existence and possession of the channels themselves that enables and predicts increases in AL, which is why we may reasonably predict benefits for all sighted students regardless of discipline. Indeed, methodologically-speaking we might be better off asking if we could find any disciplines in which AL was not positively affected by MML methods. In other words, using images in a range of disciplines stimulates AL practices organically, transforming traditional passive lecture theatres to spaces of active learning. Active learning is encouraged by the subtraction of excessive visible text (more text can be placed in 'notes view') and the addition of increasingly accessible apposite imagery.

There are obvious limitations to this research. One is that all the students came from the same institution, and from the same country/culture, reflecting a narrow demography. Second, they were already familiar with the visual method from lectures they had participated in as part of their regular curricula. Third, it is possible the focus groups captured to some extent students who were already enthused by the method. Fourth, participant numbers were low in each session, although the cumulative effect of longitudinal study in some ways compensates for this. Focus group commentary suggests probably the biggest reason for low participation was that it required them to come onto campus to see the presentations. For this reason, the test is now placed online, with a mutating URL created by one of the students ensuring a random and even distribution between control and experiment group volunteers. There is also a need to extend the research to the

science subjects, mirroring NASA's new visual arts project to make scientific complexity more comprehensible to wider audiences. The means to engage and involve students at other institutions is also needed, to take the research to students at universities reflecting different demographics and, indeed, other countries' higher education systems. For this reason, I instigated a Community of Practice which is now evolving that can connect researchers across the world and support diversification of participants. One other limitation is that so far, this research has only been conducted with one lecturer (or instructor) with implications for replicability; this was a key rationale for creating the CoP so colleagues could test the approach.

Introducing images and redistributing visible text balances cognitive work load and makes mental processing more efficient, more effective, more engaging and more active in the learning process. Socially, adopting MML methods brings academia more in line with our students' life-world experiences before, during and after their time with us, connecting us to the reality that has evolved beyond our doors. Life has become ultra-visual, but we have presently not. MML theory presents an opportunity to effectively transform that situation.

References

Adams, C. (2006) 'PowerPoint, habits of mind, and classroom culture', *Journal of Curriculum studies*, vol. 38, no. 4, pp. 389-411.

Alexander, J., McDaniel, G.S., Baldwin, M.S. and Money, B.J. (2002) 'Promoting, applying and evaluating problem-based learning in the undergraduate nursing curriculum', *Nursing Education Perspective*, vol. 23, no. 5, pp. 248–53.

Anthony, G. (1996) 'Active Learning in a Constructivist Framework', *Educational Studies in Mathematics*, vol. 31, no. 4, pp. 349-369.

Ayres, P. (2015) 'State-of-the-Art Research into Multimedia Learning: A Commentary on Mayer's Handbook of Multimedia Learning', *Applied Cognitive Psychology*, vol. 29, no. 4, pp. 631–636.

Barry, P. (2009) *Beginning theory: an introduction to literary and cultural theory*, New York: Manchester University Press.

Beetham, H. and Sharpe, R. (2013) *Rethinking Pedagogy for a Digital Age: Designing and Delivering E-learning*, London: Routledge.

Chanlin, L. (1998) 'Animation to teach students of differing knwledge levels', *Journal of Instructional Psychology*, vol. 25, no. 3, pp. 166-175.

Coats, J. (2006) *Generational learning styles*, River Falls, Wisconsin: LERN.

Edelson, D., Gordin , D.N. and Pea, R.D. (1999) 'Addressing the Challenges of Inquiry-Based Learning Through Technology and Curriculum Design', *The Journal of the Learning Sciences*, vol. 8, no. 3-4, pp. 391-450.

Ellis, R. (2016) 'Qualitatively different university student experiences of inquiry – associations amongst approaches to inquiry, technologies and perceptions of the learning environment', *Active Learning in Higher Education*, vol. 17, no. 1, pp. 13-23.

Eppler, M. (2006) 'A comparison between concept maps, mind maps, conceptual diagrams, and visual metaphors as complementary tools for knowledge construction and sharing', *Information Visualization*, vol. 5, no. 3, pp. 202-210.

Felten, P. (2008) 'Visual Literacy', *Change: The Magazine of Higher Learning*, vol. 40, no. 6, pp. 60-64.

Fenesi, B., Heisz, J.H., Savage, P.I., Shore, D.I. and Kim, J.A. (2014) 'Combining Best-Practice and Experimental Approaches: Redundancy, Images, and Misperceptions in Multimedia Learning', *The Journal of Experimental Education*, vol. 88, no. 2, pp. 253-263.

Harper, S. and Quaye, S.J. (2008) *Student Engagement in Higher Education: Theoretical Perspectives and Practical Approaches for Diverse Populations*, London: Routledge.

Hmelo-Silver, C. (2004) 'Problem-Based Learning: What and How Do Students Learn?', *Educational Psychology Review*, vol. 16, no. 3, pp. 235-266.

Kleinman, E. and Dwyer, F.M. (1999) 'Analysis of computerized visual skills: relationships to intellectual skills and achievement', *International Journal of Instructional Media*, vol. 26, no. 1, pp. 53-69.

Levy, P. (2012) 'Developing inquiry-guided learning in a research university in the United Kingdom', in Lee, V. *Inquiry as a Way of Learning in Undergraduate Education. New Directions for Teaching and Learning*, San Francisco, CA: Jossey Bass.

Lewis, P. (2016) 'Brain Friendly Teaching—Reducing Learner's Cognitive Load', *Academic Radiology*, vol. 23, no. 7, pp. 877-880.

Mackay, M. (2003) 'Researching new forms of literacy', *Reading Research Quarterly*, vol. 38, no. 3, pp. 403-407.

Mayer, R. (2014) *The Cambridge Handbook of Multimedia Learning*, 2nd edition, New York: Cambridge University Press.

Mayer, R. and Moreno, R. (1998) 'A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory', *Journal of Educational Psychology,* vol. 90, no. 2, pp. 312-320.

Mayer, R. and Moreno, M. (2003) 'Nine Ways to Reduce Cognitive Load in Multimedia Learning', *Educational Psychologist*, vol. 38, no. 1, pp. 43-52.

Mayer, R. and Sims, V.K. (1994) 'For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning.', *Journal of Educational Psychology*, vol. 86, no. 3, pp. 389-401.

McKay, E. (1999) 'An investigation of text-based instructional materials enhanced with graphics', *Educational Psychology*, vol. 19, no. 3, pp. 323-335.

McQuarrie, E. and Mick, D. (1999) 'Visual rhetoric in advertising: Text-interpretive, experimental, and reader-response analyses', *Journal of Consumer Research*, vol. 26, no. 1, pp. 37-54.

McWilliam, E. (2008) 'Unlearning how to teach', *Innovations in Education and Teaching International* , vol. 45, no. 3, pp. 263-269.

Michael, J. (2006) 'Where's the evidence that active learning works?', *Advances in Physiology Education*, vol. 30, no. 4, pp. 159–167.

Mitchell, W. (2002) 'Showing seeing: a critique of visual culture', *Journal of Visual Culture*, vol. 1, no. 2, pp. 165-181.

Paivio, A. (1971) *Imagery and verbal processes*, New York: Holt, Rinehart, and Winston.

Paivio, A. (2014) *Mind and Its Evolution: A Dual Coding Theoretical Approach*, Oxford: Psychology Press.

585 Perkins, D. (1992) 'Technology meets constructivism: Do they make a marriage?', in Duffy, T. and
586 Jonassen, D.H. *Constructivism and the Technology of Instruction: A Conversation*, Hillsdale, NJ:
587 Lawrence Erlbaum.

588 Place, N., Hillyard, C. and Thomas, E. (2008) 'Students and teachers learning to see. Part 2: Using
589 visual images in the college classroom to enhance the social context for learning', *College*
590 *Teaching*, vol. 56, no. 2, pp. 74-77.

591 Prince, M. (2004) 'Does Active Learning Work? A Review of the Research', *Journal of Engineering*
592 *Education*, vol. 93, no. 3, pp. 223-231.

593 Puttee, C. and Mezzina , K.E. (2008) 'In Defence of the Lecture: Strategies to Assist in Experiences
594 in Accounting Units.', *E-Journal of Business Education & Scholarship*, vol. 2, no. 2, pp. 28-38.

595 Reinhardt, L. (1999) 'Confessions of a techno-teacher', *College Teaching*, vol. 47, no. 2, pp. 48-50.

596 Savage, T. and Vogel, K. (1996) 'Multimedia: a revolution in Higher Education?', *College Teaching*,
597 vol. 44, no. 4, pp. 127-131.

598 Savery, J. (2006) 'Overview of Problem-based Learning: Definitions and Distinctions', *The*
599 *Interdisciplinary Journal of Problem-based Learning*, vol. 1, no. 1, pp. 9-20.

600 Schrand, T. (2008) 'Tapping into active learning and multiple intelligences with interactive
601 multimedia: a low-threshold classroom approach', *College Teaching*, vol. 56, no. 2, pp. 78-84.

602 Sorden, S.D. (2013) 'Cognitive Theory of Multimedia Learning', in Irby, B., Brown , G. and Lara-
603 Alecio, R. *Handbook of Educational Theories*, Charlotte: Information Age Publishing Inc.

604 Stes, A., de Maeyer , S., Gijbels, D. and an Petegem, P. (2012) 'Instructional development for
605 teachers in higher education: effects on students' perceptions of the teaching-learning
606 environment', *British Journal of Educational Psychology*, vol. 82, no. 3, pp. 420-435.

607 Sweller, J. and Chandler, P. (1991) 'Cognitive Load Theory and the Format of Instruction',
608 *Cognition and Instruction*, vol. 8, no. 4, pp. 293-332.

609 Thomas, E., Place, N. and Hillyard, C. (2008) 'Students and teachers learning to see Part 1: Using
610 Visual Images in the College Classroom to Promote Students' Capacities and Skills', *College*
611 *Teaching*, vol. 56, no. 1, pp. 23-27.

612 Tokumitsu, M. (2017) *Jacobin*, 26 February, [Online], Available:
613 https://www.jacobinmag.com/2017/02/lectures-learning-school-academia-universities-pedagogy/
614 [26 May 2017].

615 Torp, L. and Sage, S. (2002) *Problems as possibilities: Problem-based learning for K-16 education*,
616 Alexandria, VA: Association for Supervision and Curriculum Development.

617 von Stumm, S. and Furnham, A.F. (2012) 'Learning approaches: Associations with typical
618 intellectual engagement, intelligence and the big five', *Personality and Individual Differences*, vol.
619 53, no. 5, pp. 720-723.

620 Webster, R. (2015) 'In defence of the lecture', *Australian Journal of Teacher Education*, vol. 40, no.
621 10, pp. 85-105.

622 Zepke, N. (2013) 'Threshold concepts and student engagement: Revisiting pedagogical content
623 knowledge', *Active Learning in Higher Education* , vol. 14, no. 2, pp. 97-107.

624 Zepke, N. and Leach, L. (2010) 'Improving student engagement: Ten proposals for action', *Active*
625 *Learning in Higher Education*, vol. 11, no. 3, pp. 167-177.

626

627