Teaching considerations for implementing a flipped classroom approach in postgraduate studies: the case of MBA

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Abstract

Higher education is increasing its focus on delivering student centred learning which can be achieved through the flipped classroom. As a teaching practice, the flipped classroom provides lecture material online pre-class, and then utilises the class time to facilitate higher level learning. Achievement of higher-level learning has, however, been shown to be to the level of academic study and the subject area. Therefore, further application of the flipped classroom practice in a variety of academic study levels and subject areas will aid the establishment of 'best practice'. This paper will use a systematic literature review to (1) draw conclusions on the effectiveness of the flipped classroom in postgraduate settings, and (2) provide guidance on the establishment of 'best practice' for the Master of Business Administration (MBA). Review of the literature revealed 12 publications within past three years on MBA flipped classrooms, this demonstrates limited research on flipped classrooms in MBA courses. Results showed increased student satisfaction in flipped classrooms and some evidence of improvement performance, but more research was needed. Any advantages of the flipped classroom can only be achieved if the assessment and content (inside and outside the classroom) are aligned. Furthermore, an emphasis on active learning is important which can be achieved through real world problem solving and peer-to-peer learning.

Background

Rise of technology enhanced teaching

Over the last decade, there has been a notable digital paradigm shift with the inclusion of digital content to supplement the traditional teaching model in Higher Education Institutions (HEIs). Commonly understood as blended learning, teachers would incorporate digital content (e.g., videos, games, digital libraries, and other online content) to enhance the traditional classroom experience (Ahmed 2016). Such practices have facilitated a greater degree of customisation, to provide more relevant and flexible content to enhance the student learning experience overall (Howitt & Pegrum 2015). Despite this potential, if merely embedding digital content into traditional teaching delivery methods, the increased technology adoption will only result in marginal benefits (Mallik 2019). Students are still passive learners in the classroom (Cundell & Sheepy 2018) and will therefore need encouragement and support to engage with this new type of content delivery. One instructional innovation to arise from the blending learning environment that attempts to change this is the flipped classroom (or inverted classroom) (Prashar 2015). The success of the flipped classroom is the realisation that the traditional teaching model is not always sufficient, particularly at the higher levels of study (Mallik 2019).

Flipped Classrooms

The premise behind the flipped classroom is to maximise the use of class time (Mallik 2019). This involves the use of technology to 'flip' the delivery; that is, the repositioning of the traditional lecture material to outside of the classroom would facilitate more class time for higher-level learning (Lundin et al 2018). The difference between traditional and flipped teaching is elegantly illustrated by Ahmed (2016) in Figure 1, who overlaid Bloom's Taxonomy with both teaching models. Within the traditional teaching model, class time is used to introduce new content (lower levels of learning) with homework done outside the classroom (higher level learning). The flipped classroom, however, reverses this by introducing new content outside the classroom and leaving the class time for higher level learning (Prashar 2015).

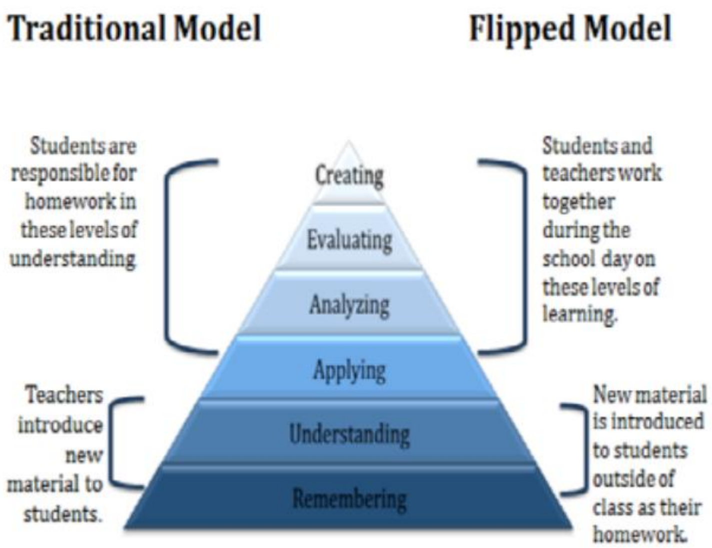

Figure 1: Bloom's Taxonomy related to traditional and flipped teaching

Source (Ahmed 2016)

A student's first experience with new content, therefore, is now not only outside of the classroom but also via electronic delivery (e.g., videos, readings etc.). This means that students can come to the classroom already familiar with the content (pretraining effect), so that the teacher can use the class time to engage them in higher levels of learning (Muller & Wulf 2020). This way of teaching has the benefit of more personalised contact with the teacher, and within a class time discussion setting, as opposed to a lecture hall (Mallik

2019). Another advantage of dedicating class time to higher-level learning is that students are more likely to create active learners who are engaged with and absorbing the content (Li & Pinto-Powell 2017).

Changing roles of the teacher and student

When a flipped classroom is adopted, the role of the teacher and student changes. The teacher moves from the centre of the classroom – from being the instructor – towards the periphery of the classroom – to become a facilitator of student-centred learning (Admed 2016). This requires the teacher to devise a clear structure for their students' learning, with emphasise on the linkages between the out-of-class and in-class learning materials and content (Dutta et al, 2019). To gain the most out of this student-centred learning approach, clear expectations need to be set for the students to establish good study habits (Avolio et al, 2019); the intention of a flipped classroom is to allow students to take control of their own learning (Admed 2016). Howitt and Pegrum (2015) warned that teachers who desire to convert from traditional to flipped classrooms should avoid perpetuating bad teaching habits. Pre-recorded (out-of-class) content needs to be granular by using bite size lecture recordings (which could be audio-only or audio-visual) and follow-on activities (in-classroom) that facilitate a deeper learning.

For the student, a flipped classroom approach sees their learning model flipped on its axis, with the preparation before the class becoming very important (Admed 2016). It is necessary for students to follow the clear structure set by their teacher to prepare before the in-class learning. Then, after the in-class learning, students need to demonstrate further discipline after the class by reflecting on what they had learnt (Avolio et al, 2019). If implemented effectively, this type of teaching approach will encourage more independent students (Howitt & Pegrum 2015). Howitt and Pegrum (2015) warned, however, that given the focus on technology for the out-of-class content, students will need adequate tools and training to access all the learning material.

Aim and objectives

As established in the discussions above, what constitutes higher-level learning is dependent on the level of study and in some cases the study area (Mallik 2019). The aim of this paper is to conduct a systematic literature review to catalogue and evaluate the current flipped classroom teaching practices with specific attention to the Master of Business Administration (MBA) programme at the University of Hertfordshire (UoH). The MBA programme is at the postgraduate level (Level 7) and serves to enable students to "develop the critical and reflective strategic leadership skills [they] need to succeed in an uncertain work, challenging [their] assumptions, cultivating flexible thinking, effective decision making and responsible management" (UoH 2020 https://www.herts.ac.uk/courses/postgraduate-masters/master-of-business-administration2). It is important to further distinguish that the focus of the paper will be on the traditional MBA programme not the more recent MBA (degree apprenticeship) programme. Specifically, the two objectives of this paper are therefore:

1. To determine the effectiveness of a flipped classroom teaching approach at the postgraduate level; and,
2. To provide ‘best practice’ recommendations for implementing a flipped classroom teaching approach in the MBA at the UoH.

Methods

To achieve the research objectives, a systematic literature review was conducted. This method could assist to fill the void of knowledge in MBA teaching practice. Lundin et al. (2018) further suggest that there is a “need to develop systematic knowledge around flipped classrooms” (p.4), and that a “systematic review should be of use for practitioners, scholars, and stakeholders” (p.4).

For transparency, this paper followed Lundin et al.’s (2018) procedure for conducting a systematic literature review which involves nine tasks. These tasks can be divided into two categories: collecting the literature and analysing the literature. The first category of collecting the literature involves five stages: (1) establishing the review question(s), (2) creating inclusion criteria, (3) define the research strategy, (4) applying criteria to the literature, (5) mapping the review process. This section of the paper describes the application of these stages in the current project on MBA practice. The second category of analysing the literature involves four further stages: (6) gathering descriptive data, (7) reviewing the relevance/ quality of the remaining publications, (8) synthesising the contributions of the remaining publications, and (9) applying the remaining publication. The next section of the paper describes these stages with respect to the current project.

Collecting the literature

In the first stage, two review questions were established to align with the purpose of the paper (as previously set out). These were:

- What is the effectiveness of a flipped classroom model in MBA programmes?
- What are the MBA-specific teaching practices that improve student outcomes?

The term ‘effectiveness’ refers to the ability to improve student outcomes compared to the traditional classroom model. These student outcomes can be improvements in grades, attendance, or satisfaction, as well as positive changes in the students’ opinions of the programme and/or teacher.

In the second stage, two inclusion criteria were developed to prepare for the data (literature collection). Firstly, only literature published from 2017 onward were to be included.

Considering the rapid advances in technology (Schlegelmilch & Bodo 2020), finding best practice for flipped classrooms which is reliant on technology for delivery should be focused on newer publications. Secondly, only literature discussing MBA flipped classrooms were to be included. As mentioned by Mallik (2019) maximising class time will depend on the level of study so to have relevant teaching practices, only MBA flipped classrooms should be considered.

In the third stage, having set the inclusion criteria, the actual literature database was decided. The UoH's online library was selected because UoH staff and students have unlimited access to all of the literature housed within the library. Part of the research strategy was to restrict the literature database on two accounts. (1) Only those publications written in English to ensure comparability between the findings. (2) Only those publications that were identified as research papers, conference proceedings and reports. This was to ensure that the information drawn upon for the current study had been through the peer-review process (excludes student dissertations for example), with reports and conference papers included to capture wider dissemination of teaching practice. The search was conducted in November 2020.

In the fourth stage, 'MBA flipped classroom' was entered as the search term into the UoH online library, with the search conducted in November 2020. To apply the first criteria, an automatic time filter was selected from 1st January 2017 to 10th November 2020. This resulted in 123 publications to review. To apply the second criteria, a manual word search was performed on the main text of the publication; the words utilised were 'flipped' or 'inverted' in addition to 'MBA', 'executive', 'master(s)'. If a publication had the words 'executive' and 'master(s)', the publication was reviewed in more detail with final inclusion based on whether the context of the paper was MBA specific. This resulted in 12 publications to review. Appendix 1 contains the full listing of the 12 publications, which will subsequently be discussed.

Please refer to Figure 2 which depicts the initial database search results and subsequent results from the application of the two inclusion criteria (demonstrates stage 5).

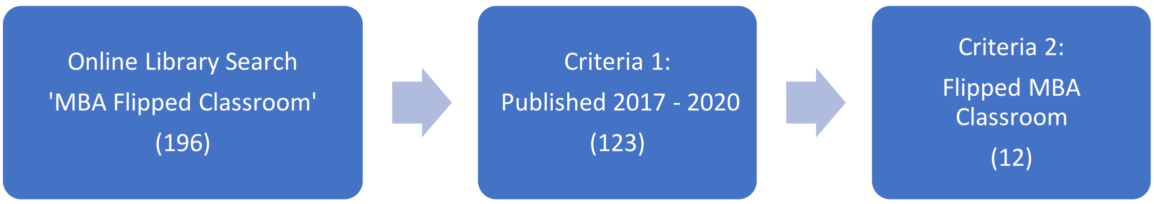

Figure 2: Flow chart of review process

Analysing the literature

Following Lundin et al.'s (2018) procedure for conducting a systematic literature review, this study will now present the findings for the stages of the second category, analysing the literature:

- Stage 6 – gathering descriptive data
- Stage 7 – reviewing the relevance / quality of the remaining publications
- Stage 8 – synthesising the contributions of the remaining publications and Stage 9 – applying the remaining publications.

Descriptive profile of the literature

The results of the systematic literature review show congruence with recent studies; that is, limited application of the flipped classroom was found in postgraduate courses and even less in MBA courses (Swart & MacLeod 2020; Scafuto et al, 2017). Lundin et al. (2018) who performed a systematic literature review on flipped classroom literature for all disciplines found that the majority of the papers were in education and education technology and focused on higher education. Of the 12 publications identified for this study, five were focused on education and education technology in MBA courses (or MBA was at least part of the higher education discussion). The remaining seven publications were evaluations of student performance in flipped classrooms. These evaluations occurred across students of different disciplinary backgrounds; Business Analytics (Swart & MacLeod 2020); Dentistry (Roberts et al, 2020); Medicine (Li 2017); Management Science and Management Information Systems (Wengrowicz et al, 2018); and Operational Management (Bayley & Hurst 2018; Klotz & Wright 2017). This implies that although there is research at the higher education level, this has not really extended into postgraduate. Furthermore, there was limited dispersal to other disciplines.

Contributions of the literature

MBA courses and considerations for implementing flipped classrooms

Despite the limited amount of research, there is agreement that the implications of flipped classrooms differ for MBA courses compared to other levels of study. Scafuto et al (2017) offer one explanation in that the MBA market is an 'experience-quality service market'. This implies certain expectations around the delivery (experience) and scope (content) of the course. For students, there needs to be extensive linkages between the content and real-life situations (Scafuto et al. 2017), and a degree of flexibility when accessing content due to concurrent employment arrangements (Cundell & Sheepy 2018). Teachers, furthermore, have the expectation that students are more independent, with self-discipline and good time management. This is reflected in different teaching formats, typically involving necessary student preparation before class (Avolio et al, 2019). Avolio et al. (2019) also suggest that the work experience of the students provides a unique opportunity where an exchange of experiences amongst the students can provide a much richer learning environment.

Given these expectations, a flipped classroom approach seems apt for MBA courses. MBA students are already accustomed to pre-lecture preparation. Therefore, the premise of accessing learning material online and pre-class would be suitable to these students and their employment commitments. Furthermore, through students sharing their employment experiences – with the teacher highlighting the connections to the pre-class material and thus linking theory to practice – higher-level learning could be achieved. Overall, an MBA course is typically seen as more advantageous to other post-graduate courses, with a degree of prestige, which could be facilitated through a flipped classroom approach.

Effectiveness of a flipped classroom approach for MBA courses

The effectiveness of flipped classrooms is measured using student satisfaction and/or student achievement. Across the seven publications that evaluated student performance, all agreed that student satisfaction improved in flipped classrooms compared to traditional classrooms. Increases in satisfaction were accompanied by higher perceived quality of the content and teacher (Scafuto et al, 2017). The benefits of flipped classrooms were present regardless of whether the face-to-face classes were online or in a classroom (Swart & MacLeod 2020; Wengrowicz et al, 2018).

In regard to student achievement, the majority of the seven publications found positive associations with flipped classroom. For instance, Swart & MacLeod (2020) and Klotz & Wright (2017) observed increases in student grades, whereas Bayley & Hurst (2018) reported increased student understanding of the topic, and Roberts et al (2020) found students were more prepared for the real world. Li & Pinto-Powell (2017), however, found the link between flipped classrooms and student achievement to be inconclusive. This supports the viewpoint of Muller & Wulf (2020) who conducted a literature review on technology enhanced teaching practices and highlighted that currently there was not enough research to gauge the effectiveness of flipped classrooms on MBA student learning.

An important consideration when measuring the effectiveness of flipped classrooms is the idea of 'active learning'. Flipped classrooms are designed to facilitate deeper learning during face-to-face classes; this is achieved by creating an active learning environment. On the surface, student achievement is linked to teacher competency, especially technological competency (Muller & Wulf 2020) and communication effectiveness (Wengrowicz et al. 2018). Whilst this is indeed true, considerable effort is required from the teacher in not only planning the face-to-face activities, but also in aligning these activities to the online, pre-class content. In flipped classrooms, however, the teacher should only ever be the facilitator; it is the students that must drive their own learning. Wengrowicz et al (2018) suggest that peer-to-peer communication was the most important factor for student achievement. Li & Pinto-Powell (2017) agree by highlighting that the focus should be on a teaching format which includes engaging and interactive classes to achieve active learning; they believe that the more students that interact, the more effective the learning will become.

Recommended teaching practice for MBA courses (in using a flipped classroom approach)

Collectively, the 12 papers highlighted that the MBA student cohort is in the best position to benefit from a flipped classroom approach. The following section will therefore consider the practices that were identified as most effective for MBA teaching by flipped classrooms. It is recognised, however, that this guidance could be broadly applied to flipped classrooms across different subjects.

With respect to delivery, both the online content and face-to-face (in classroom) content have different roles to play. Allen (2020) suggests that both the teacher and student need to have technological competence for pre-class activities; the teacher is the facilitator of the learning and therefore must design and 'publish' the content in an accessible manner, whereas the student needs to commit to accessing it in the way that it was designed. Several studies also advocated for more active forms of learning. Cundell & Sheepy (2018) found that passive online activities were not as effective; students preferred a 50/50 split between online and face-to-face activities. Furthermore, Muller & Wulf (2020) advocate that it is likely to be the high achieving students who will benefit most from self-learning, and therefore, learning activities should focus on interactions between student and teacher in the classroom (Dutta et al, 2019) and amongst students in both the classroom and online (Cundell & Sheepy 2018). The opportunity for off-site meetings with students in also recommended (Allen 2020).

Secondly, when considering the content, there appears to be a more diverse array of effective teaching practice. On one level, Dutta et al (2019) promotes the value of the teacher's role in creating content with Muller & Wulf (2020) suggesting that the content needs to be relevant to the background of the students. The most important aspect of course design, however, is the alignment of content; the pre-recorded materials, in class activities and assessment need to be linked and feedback off each other (Muller & Wulf 2020). Classes need to be planned around the millennial/postmillennial student, who is interested in experiential learning, having timely feedback, and thinking outside the box (Dutta et al. 2019). Furthermore, the in-class activities should provide opportunities for learning about realistic business situations where students must create solutions themselves (Wengrowicz et al 2018). When planning the assessment, it is important to make it diverse (Dutta et al, 2019). Cundell & Sheepy (2018) found that those assessments where students had to collaborate were the highest graded pieces, and Dutta et al (2019) suggest assessment that creates experiential learning through technology and group activities. Overall, the course content (and its assessment) should reflect student centred learning (Muller 2020).

Conclusions and Reflections

This paper aimed to determine the effectiveness of a flipped classroom approach in postgraduate teaching practice and to provide 'best practice' for MBA courses specifically. The systematic literature review revealed that limited studies have been conducted on MBA flipped classroom teaching; between 2017 and 2020, there were only 12 publications available in the University of Hertfordshire's Online Library. In my opinion, the recommendations provided were a bit broad and could apply to any flipped classroom. This may imply that best practice for MBA is the same as any flipped classrooms, however, more research is needed to make this determination. Regardless, I can draw some insight from these recommendations – which can be categorised into (1) delivery and (2) content recommendations – and make modifications in my teaching to suit.

Flipped classrooms were effective at increasing student satisfaction and there was evidence of increased student achievement, however, more research is needed. All things considered, flipped classrooms should be well suited to MBA courses because students are accustomed to do the pre-class preparation and their work experience would enrich the face-to-face classes. Delivery revolves arounds technology competency; the teacher needs to provide accessible content and the students need to be able to access it. When constructing the Canvas module site, I have paid attention to the accessibility of content and flagging where it is and when to access it. All asynchronous materials – recordings and preparatory activities were made available on Canvas with similar formats, layouts, and links with other content. These materials were made available four weeks before the in-class activities to provide plenty of lead time.

Students commented that accessibility and layout of content was good, however, the lead time between the asynchronous materials and in-class activities was too long. Some students would review the content during the week of release and lose some of that knowledge over the four weeks before the in-class activity. Given the student feedback I am hesitant to reduce the lead time of asynchronous materials, however, will highlight this issue so students can make a more informed decision when they access the asynchronous materials.

An overall recommendation for implementing a flipped classroom was that the content needs to be tailored to the students' background to keep it relevant. In reflecting upon my own teaching practice, I felt that none of these 12 publications evaluated MBA student cohorts that matched my students' backgrounds or module content. The students in my module mostly come from the public sector, especially the NHS so it is important that real world examples and discussions revolve around public sector issues. All guest speakers were advised to use public sector and specifically NHS examples where possible and given the public sector decisions around Covid-19 they found no shortage of recent examples. Students found these examples very engaging, and the subsequent in-depth discussions were enlightening. Furthermore, it is important that the pre-recorded materials, in-class activities, and assessment are aligned, and that active learning can be achieved.

For instance, with my module on Collaborative Governance, my knowledge is formed based on an academic and research perspective, not necessarily from relevant real-world business contexts (particularly for the UK). Therefore, I have prepared the pre-class learning in terms of academic foundations but have invited guest speakers (both academic and industry professionals) to deliver the ‘real-world’ content. Using their own experiences / knowledge, they can provide the real-world activities for active learning, through introducing cases of collaborations in their pre-recorded material and then using groups in the classroom to solve real-world problems for one case that they have extensive knowledge on (to facilitate a ‘deep-dive’ discussion).

Whilst, this content could be provided through a selection of videos, students really appreciated the face-to-face connection with these professionals. In fact, students commented that the ability to ask questions and engage in discussions with these professionals was one of the highlights of the module. To align the content, I have secured guest lectures that have been involved in the module before but have provided instructions in terms of how to create the pre-class material and the face-to-face session (as they previously delivered through a traditional lecture format) I, therefore, have oversight of the different guest speakers’ content to ensure it is complementary, not duplicative, and that the learning outcomes and module assessment can be achieved (e.g. learning conversation on one type of collaborative partnership). This module runs twice a year and I will collect feedback from the student cohorts to improve the student experience in the following year.

References

Ahmed, H. (2016). Flipped Learning as a New Educational Paradigm: An Analytical Critical Study. European Scientific Journal, 12(10): 417-444.

Avolio, B., Benzaquen, J. & Pretell, C. (2019) Global Challenges for Business Education and the New Educational Agenda: Graduate Attributes and Teaching Methods. E-Journal of Business Education & Scholarship of Teaching, 13(2): 80-99.

Bayley, T. & Hurst, A. (2018). Teaching Line Balancing through Active and Blended Learning. Journal of Innovative Education, 16(2): 82-103.

Cundell, A. & Sheepy, E. (2018). Student perceptions of the most effective and engaging online learning activities in a blended graduate seminar. Online Learning, 22(3).

Dutta, N., Bhat, A., Bhattacharya, K. & Mahesh, J. (2019). Attracting students to the classroom with innovative pedagogies. South Asian Journal of Business and Management Class, 8(3): 241-250.

Howitt, C. & Pegrum, M. (2015). Implementing a flipped classroom approach in postgraduate education: An unexpected journey into pedagogical redesign. Australasian Journal of Education Technology, 31(4): 458-469.

Klotz, D. & Wright, T. (2017). A Best Practice Modular Design of a Hybrid Course Delivery Structure for an Executive Education Program. Journal of Innovative Education, 15(1): 25-41.

Li, S. & Pinto-Powell, R. (2017). Revisiting the merits of a mandatory large group classroom learning format: an MD-MBA perspective. Medical Education Online, 22(1).

Lundin, M., Rensfeldt, A., Hillman, T., Lantz-Andersson, A. & Peterson, L. (2018). Higher education dominance and siloed knowledge: a systematic review of flipped classroom research. International Journal of Education Technology in Higher Education, 15: 20.

Mallik, A. (2019) Flipped Classroom at MBA-Effective Teaching Innovation Model for Strategic Management. Global Journal of Management and Business Research, 18.

Muller, F. & Wulf, T. (2020). Technology-supported management education: a systematic review of antecedents of learning effectiveness. International Journal of Education Technology in Higher Education, 17(1): 1-33.

Prashar, A. (2015). Assessing the Flipped Classroom in Operations Management: A Pilot Study. Journal of Education for Business, 90(3): 126-138.

Roberts, B., Roberts, E., Brachvogel, W. & Stein, A. (2020) Practice management curricular changes may lead to enhanced preparedness for practice. Journal of Dental Education, 84(8): 887-894.

Scafuto, I., Serra, F., Mangini, E., Maccari, E., & Ruas, R. (2017) The impact of flipped classrooms in MBA's evaluation. Education + Training, 59(9): 914-928.

Schlegelmilch, B. & Bodo, B. (2020). Why Business schools need radical innovations: drivers and development trajectories. Journal of Marketing Education, 42(2): 93-107.

Swart, W. & MacLeod, K. (2020). Flipping online analytics classes: achieving parity with their face-to-face counterparts. Journal of Innovative Education, 18(1): 119-137.

Wengrowicz, N., Swart, W., Paul, R., MacLeod, K., Dori, D. & Dori, Y. (2018). Students' Collaborative Learning Attitudes and Their Satisfaction with Online Collaborative Case-Based Courses. American Journal of Distance Education, 32(4): 283-300.

Appendix 1: List of Publications for Analysis

First Author	Purpose of paper	Study sample	Relevant findings
Muller, F (2020)	Literature Review on technology supported management education	N/A	Not enough research on the effectiveness of flipped classrooms on improved learning.
Roberts, B (2020)	Evaluating student performance when using flipped classrooms for MBA Dental students	University’s Dental School that provides a dual degree with MBA	Flipped classrooms increased student perceptions of preparedness for practice.
Schlegelmilch, B (2020)	Exploring higher education strategies for MBA programmes	N/A	The changing competitive environment of business education providers requires changes in teaching and learning.
Swart, W (2020)	Evaluating student performance when using flipped online classrooms for Business Analytics	East Carolina University’s business analytics students (both undergraduate and MBA)	Flipped classrooms resulted in improved student satisfaction and grades. There was parity in student performance regardless of if class time was online or face-to-face.
Avolio, B (2019)	Reviewing challenges with current business education teaching methodologies	N/A	Identified MBA specific challenges for both the teacher and student.
Dutta, N (2019)	Exploring pedagogy changes in MBA programmes to attract students	Institute of Technology and Sciences' engineering MBA students	Design classes around the millennial/postmillennial student, who are interested in experiential learning, having timely feedback, and thinking outside the box.

Bayley, T (2018)	Evaluating student performance when using flipped classrooms for Operations Management	Canadian University's Operations Management students (both undergraduate and MBA)	Flipped classrooms improved student engagement and lead to a deeper understanding and appreciation of the content.
Cundell, A (2018)	Explore effective design of activities in online environments	Centre for Teaching and Learning's Graduate Seminar in University Teaching programme	Online activities should focus on learner-to-learner interactions to promote higher level learning.
Wengrowicz, N (2018)	Evaluating student performance when using online flipped classrooms for Management Science/ Management Information Systems	MBA students in a university in the South-eastern United States	Online flipped classrooms enhance the student experience but only if both the teacher and students well versed in the online tools available.
Klotz, D (2017)	Evaluating student performance when using flipped classrooms for Operations	Fordham University's Operations Management MBA students	The introduction of flipped classrooms resulted in higher student grades and satisfaction.
Li, S (2017)	Exploring flipped classrooms in MD-MBA programmes	N/A	Flipped classrooms have positive perceptions, however, active learning is more important than teaching format.
Scafuto, I (2017)	Evaluating student performance when using flipped classrooms for MBA programmes	MBA students from five universities in Brazil	Identified MBA specific teaching considerations for a flipped classroom. The teacher is important for student perceptions of quality.

QR codes in Engineering Laboratories – Improving Student Safety Engagement

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Abstract

Engineering is a practical discipline and laboratory work is a fundamental necessity of engineering curricula and majority of engineering modules run by universities have significant elements of practical work embedded in them (Feisel et al 2005 and Rathod et al, 2016). It provides an active learning avenue that provides students with hands-on experience to support and strengthen in-lecture learning by enhancing the student's understanding of theoretical concepts (Nikolic, 2015). Laboratory safety is an important and continuous focus within academic institutions where a lack or lapse could sometime lead to serious or even fatal consequences. Using Quick Response Codes (QR Codes), students can access, on-demand, the necessary training and safety instructions for them to use specialised engineering equipment and/or carry out specially designed procedures, imbuing them with specific knowledge to execute laboratory activities confidently and securely. Mobile devices in teaching have been a topical issue and the use of QR codes aims to create an independent learner through the engagement using personal technology like smartphones and tablets with the intention of improve the level of engagement during active laboratory activities by using a medium that the students are au fait with. This paper outlines the delivery method used in the implementation of QR codes within 1st year engineering laboratories to aid basic safety training for engineering practical activities. It also discusses the potential use of QR codes in engineering laboratories to deliver on-demand information and capture training needs at the time and location that is required.

Introduction to Laboratories in Engineering Education

Engineering is a practice-based subject where doing is key. Laboratories are used through all levels and disciplines in engineering education as a way to demonstrate basic information and gain hands on practical skills to compound their understanding of theoretical concepts and implement application-based practice (Sedghpour et al, 2013)

The ability to successfully accomplish a practical task is an important professional skill requirement, designated by The Engineering Council (2014) as a key competency required of an engineer. The engineering profession requires manipulation of resources for the benefit of humankind. To accomplish this, engineers must have knowledge that goes beyond theory, a knowledge that is normally achieved in hands-on, practical laboratories.

Laboratories are hence an indispensable aspect of developing these disciplinary, practical skills required, e.g., from learning to use modern engineering tools and equipment to the ability to conduct experiments, and one of the core elements of these skills includes the ability to conduct the task and themselves in a safe and effective manner. Being a practical profession, labs also support and develop their self-identity as an engineer (Edward, 2002). Student satisfaction must be at the core of any laboratory experience and Nikolic (2015) has demonstrated that resources that provides details on how to satisfactorily conduct a task have yielded the highest satisfaction scores.

Types of engineering practical are dependent on specific engineering disciplines with different emphasis on the type of core knowledge and skillset required, for example, an electronics student might need to be familiar working with soldering irons while a mechanical student would need to be handy with mechanical hand tools. However, the hands-on aspect of practical work often has significant safety related risk associated with it, which must be prioritised and addressed accordingly in order to provide an immersive experience for the student to learn in a safety environment (Shariff et al, 2012). The practical aspect of health and safety is critical in engineering and there is an identified need to ensure that students leaving university are equipped with the knowledge and principles of safe working (EU-OSHA, 2010).

Safety in Engineering Activities

Accidents in laboratory setting are a concern for universities (Ismail et al, 2015). A typical engineering laboratory setting, for example, contains multiple hazards - acids and chemicals, hazardous equipment, pressurised gas, poisonous fumes etc. There is hence a concern that students often face a variety of risks and threats whilst working and participating in laboratory activities. Whilst we acknowledge that serious accidents in academic laboratory environments are fortunately rare in the UK, they are by no means uncommon. Ensuring the safety of students under our care is not only our legal obligation but also a moral one. By providing the necessary training and education to work to prevent harm in practical activities, we are thereby helping the student to fully benefits from the hands-on learning activities.

Accidents in labs can be the result of many factors, with the lack of appropriate knowledge and attitudes toward safety and unsafe personal practices being pertinent factors that are beyond the control boundaries of supervising staff or control measures put in place (Abdullah and Aziz, 2020).

QR Codes for Safety Learning

Engagement with learning using mobile devices is exciting for students (Lynch, 2015). Students tend to respond more positively to the stimulus when using mobile devices and they tend to stay focus on the task thereby enabling them to self-correct as they proceed

(Lynch, 2015). Mobile devices also provide students with the opportunity to engage with the activity outside the lab and possibilities to prepare prior to sessions. Personal technology is an "anywhere, anytime" learning tool to support the development of self-regulated learners, encouraging independent learning through engagement (Mueller 2011). Kolb (2008) discussed a 'disconnection' between how students learn outside of school and how they learn in the classroom, and as faculty, we have little appreciation for the skills that students use outside of the classroom. We tend to think of devices such as cell phones as "toys" and see these technologies as distracting and even harmful. Kolb (2008) urges the recognition that smart mobile devices can be a powerful tool for education and to find ways to integrate them into the classroom. With the changing educational landscape, it is important to recognise that students learn in many ways and therefore the delivery of educational content should adapt accordingly. Joordens et al. (2012) have reported that most students show a higher level of willingness to learn when technology enabled learning practices are employed.

QR (Quick Response) codes, small matrix like codes, can be readily accessed, usually with an app, using most smartphones or smart devices that have integrated cameras. QR codes are also easy to generate, implement and manage. Information can be updated at point source hence reducing the need for changing the information individually. QR codes provide immediate valuable and relevant information to the user at the point of contact and are highly trackable. Users are able to scan these codes and get access to the timely, knowledge and information at the specific location, for a specific lab equipment or at the point of need (Walsh, 2010). QR codes are used to provide a link to content found on the Internet, are increasingly seen in many places, with point of need information successfully employed in libraries and museums (Ashford, 2010, Pulliam et al, 2010 and Shultz, 2013) and it is this point of need information that is highly relevant to what this project is aims to achieve.

This project aims to engage engineering students through bespoke safety, instructional materials using embedded in QR codes during active learning practical sessions. Training will then be achieved through the incorporation of self-directed, user-focussed instructional materials with relevant information for equipment, instrument and technical procedures. This paper sets out the delivery method used in the implementation of QR codes within 1st year engineering laboratories to aid basic safety training for engineering practical activities. It also discusses the potential use of QR codes in engineering laboratories to deliver on-demand information and capture training needs at the time and location that is required.

Engineering courses often have big cohort sizes and often have either large practical classes or open access lab sessions. This makes it difficult to ensure that all students fully understand/remember the instructions given to them for a variety of different reasons. The instructional videos aim to give students another avenue to learn/review the instructions and use them as a recall tool should they require it. With this knowledge, the student is then able to safely carry out a task. This increases their confidence to perform the activity, thereby increasing their engagement with the task and their satisfaction when they complete the activities (Figure 1).

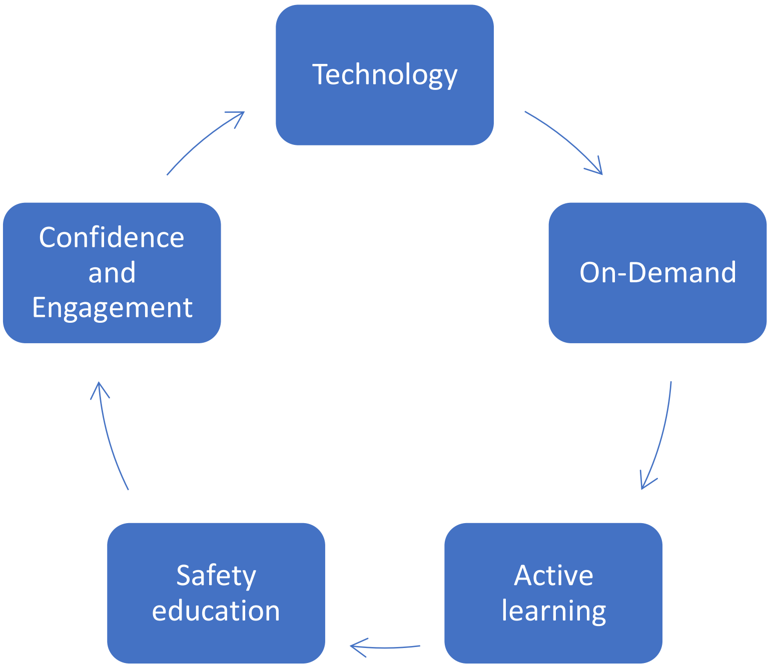


Figure 1: Project Motivation Factors.

Implementation Methodology

The implementation plan was carried out in three phases: equipment scoping, storyboard planning and material creation. Videos and materials created were uploaded onto Vimeo (https://vimeo.com/), which is a free online video sharing site. QR codes linking to the relevant videos were then generated using an online QR code generator (https://www.qr-code-generator.com/).

Project implementation was carried out in the laboratories within the Department of Engineering. The project team consisted of academic staff, technical staff, apprentices and two second year Aerospace students. The rationale of engaging the technical staff was for practicality reasons, being familiar with the equipment and the safety measures required for use. Their knowledge of the equipment and lab activities contributed toward storyboard planning and the subsequent material creation. Students were consulted during the initial equipment scoping exercise to provide an insight to equipment that they have used in their studies and felt that would benefit from the QR code implementation.

Equipment Scoping

There are approximately over 100 individual pieces of equipment and related activities in engineering that are in constant use by staff and students for teaching and research purposes. It was hence important to identify equipment and its associated activities that would benefit the most from this implementation. There are several factors that determined which equipment would be adopted for a pilot implementation, the inherent safety of the equipment, frequency of use by students, ease and effectiveness of training using a video medium. Two initial scoping meetings were held with students to discuss options and also to gather information on what students identify as essential in the video. Outcomes of these meetings have identified the following,

1. Clear and unobstructed view of the demonstration, with emphasis on safety or how to achieve a safe state when performing key tasks within the activity.

2. Narration or voice over to help them understand what is going on.

3. Short video length to aid attention retention and cognitive loading.

Three common, first-year activities have been identified by the students for the pilot implementation, soldering, balsa wood manufacturing techniques using hand tools and laser cutting. These activities form the most basic of skills required for the majority of engineering students over the course of their studies.

Storyboard Planning

Storyboards are used to map out the entire video, frame by frame, before the start of filming. Storyboarding is an efficient and effective project planning tool to help identify and illustrate the various steps needed to complete a given project in a sequential manner (Barakat, 1989). Storyboards provides a structure link between the content authors and video creators before production process ensuring that key messages do not get lost in translation and errors are eliminated before production starts (Okur et al, 2010). Storyboarding is the focal point for planning and starts with determining the learning outcomes for each activity, the key skills demonstrated to students and the relevant control measures to ensure the activity can be performed safely (see Table 1). Length of videos was an important consideration and storyboarding allows us to determine the time required for each scene.

Table 1: Example of activity planning.

Activity	Learning Outcome	Demonstratable skill	Safety Measures Demonstrated
Soldering	Safe soldering practice and use of extraction	• Using a soldering iron • Soldering with extraction	• Extraction use and check • Awareness of hot soldering tip.

Material Creation

The aim is to equip students with knowledge and training to safely perform their lab activities using bespoke instructional videos. These user centred videos focussed on safe working principles were recorded in engineering laboratories by technical staff for each of the activity. Narrations and captions for the videos were added post-production. QR codes were generated for the videos and the codes then placed on or in the vicinity of the equipment for ease of access (Figure 2).

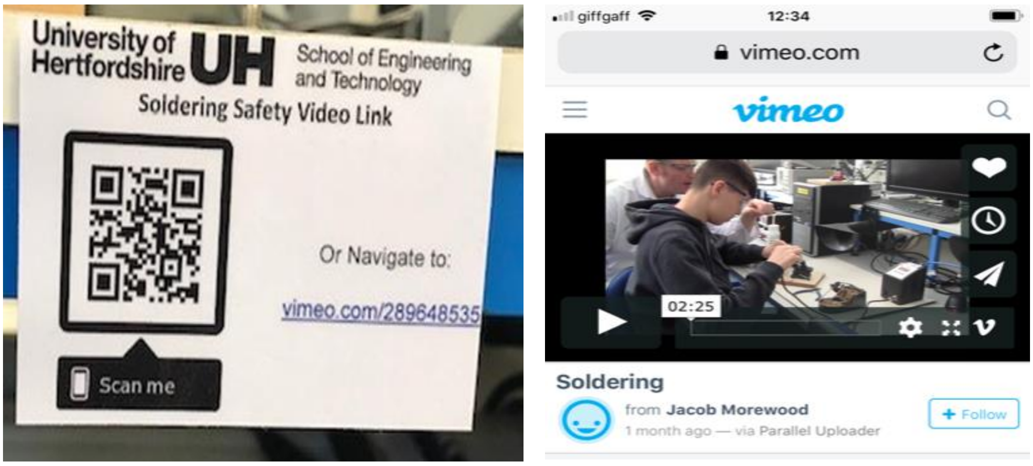
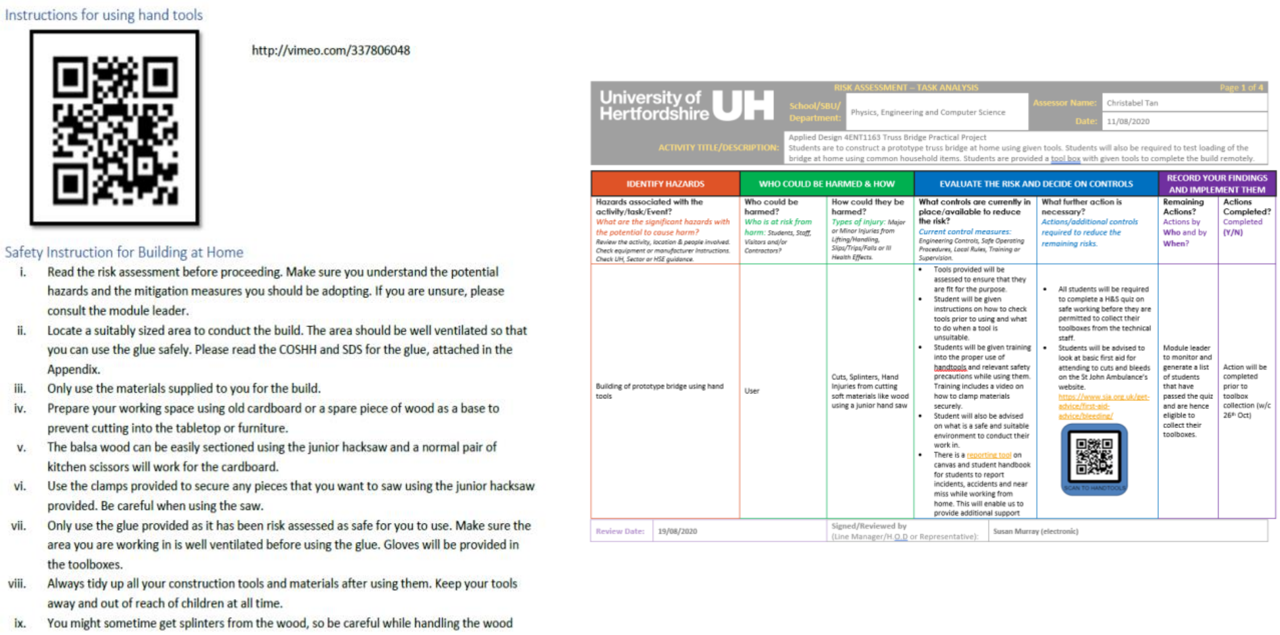


Figure 2: QR codes for soldering in electronics lab.

The QR codes will embed in them, links to bespoke instructional videos and/or training materials for the safe use of equipment and demonstrate procedures for specific activities that are deem hazardous to perform with prior specific training and/or instructions. These codes are located on the equipment itself or in a nearby location. It must also be recognised that not all students own a smartphone or want to download the free QR reader app, hence it is anticipated that all information will also be available on Canvas or in any relevant information provided to students. This academic year, due to the need to supply tools for students to complete practical work at home, QR codes have been included in the relevant risk assessments and project information handbook for students (Figures 3 and 4).



Instructions for using hand tools

http://vimeo.com/337806048

Safety Instruction for Building at Home

i. Read the risk assessment before proceeding. Make sure you understand the potential hazards and the mitigation measures you should be adopting. If you are unsure, please consult the module leader.
ii. Locate a suitably sized area to conduct the build. The area should be well ventilated so that you can use the glue safely. Please read the COSHH and SDS for the glue, attached in the Appendix.
iii. Only use the materials supplied to you for the build.
iv. Prepare your working space using old cardboard or a spare piece of wood as a base to prevent cutting into the tabletop or furniture.
v. The balsa wood can be easily sectioned using the junior hacksaw and a normal pair of kitchen scissors will work for the cardboard.
vi. Use the clamps provided to secure any pieces that you want to saw using the junior hacksaw provided. Be careful when using the saw.
vii. Only use the glue provided as it has been risk assessed as safe for you to use. Make sure the area you are working in is well ventilated before using the glue. Gloves will be provided in the toolboxes.
viii. Always tidy up all your construction tools and materials after using them. Keep your tools away and out of reach of children at all time.
ix. You might sometime get splinters from the wood, so be careful while handling the wood

University of Hertfordshire UH — RISK ASSESSMENT – TASK ANALYSIS — Page 1 of 4

School/SBU/Department: Physics, Engineering and Computer Science
Assessor Name: Christabel Tan
Date: 11/08/2020
ACTIVITY TITLE/DESCRIPTION: Applied Design 4ENT1163 Truss Bridge Practical Project. Students are to construct a prototype truss bridge at home using given tools. Students will also be required to test loading of the bridge at home using common household items. Students are provided a tool box with given tools to complete the build remotely.

IDENTIFY HAZARDS	WHO COULD BE HARMED & HOW		EVALUATE THE RISK AND DECIDE ON CONTROLS		RECORD YOUR FINDINGS AND IMPLEMENT THEM	
Hazards associated with the activity/task/Event? What are the significant hazards with the potential to cause harm? Review the activity, location & people involved. Check equipment or manufacturer instructions. Check UH, Sector or HSE guidance.	Who could be harmed? Who is at risk from harm: Students, Staff, Visitors and/or Contractors?	How could they be harmed? Types of injury: Major or Minor Injuries from Lifting/Handling, Slips/Trips/Falls or Ill Health Effects.	What controls are currently in place/available to reduce the risk? Current control measures: Engineering Controls, Safe Operating Procedures, Local Rules, Training or Supervision.	What further action is necessary? Actions/additional controls required to reduce the remaining risks.	Remaining Actions? Actions by Who and by When?	Actions Completed? Completed (Y/N)
Building of prototype bridge using hand tools	User	Cuts, Splinters, Hand Injuries from cutting soft materials like wood using a junior hand saw	• Tools provided will be assessed to ensure that they are fit for the purpose. • Student will be given instructions on how to check tools prior to using and what to do when a tool is unsuitable. • Students will be given training into the proper use of handtools and relevant safety precautions while using them. Training includes a video on how to clamp materials securely. • Student will also be advised on what is a safe and suitable environment to conduct their work in. • There is a reporting tool on canvas and student handbook for students to report incidents, accidents and near miss while working from home. This will enable us to provide additional support	• All students will be required to complete a H&S quiz on safe working before they are permitted to collect their toolboxes from the technical staff. • Students will be advised to look at basic first aid for attending to cuts and bleeds on the St John Ambulance's website. https://www.sja.org.uk/get-advice/first-aid-advice/bleeding/ SCAN TO HANDTOOLS	Module leader to monitor and generate a list of students that have passed the quiz and are hence eligible to collect their toolboxes.	Action will be completed prior to toolbox collection (w/c 26th Oct)

Review Date: 19/08/2020 — Signed/Reviewed by (Line Manager/H.O.D or Representative): Susan Murray (electronic)

Figure 3: QR code in module documents.

Figure 4: Examples of QR codes developed in this phase that are currently available to students.

The Future of QR in Engineering Labs

Mass training sessions, whereby all students are trained regardless, are ineffective, resource and logistical demanding and do not cater to the specific needs of individual students. The QR codes hence act as bespoke training tools for the students that require the specific training. A well-prepared video or instruction helps avoid the issue of variability in quality which may arise when different staff members demonstrate techniques to different students. Time is also saved if students watch the videos as advance preparation for the sessions hence enabling them to have a more productive time during the session.

The potential of QR codes in engineering laboratories is endless, placed out-side of laboratories, QR codes could indicate lab information and facilities without having to enter, what class is taking place and what the class is currently working on to ensure that students are in the right place at the right time. Similarly, codes placed outside of research labs could link to sites describing the research conducted, providing contact information for the researchers and linking to further resources on research interests, such as past publications, to promote research within the body of students.

Impact from this will be from the enhanced engagement due to increased confidence with the practical tasks due to clearer instruction and training. This will result in a better and more efficient use of staff in these sessions as they can focus on giving assistance towards the task rather than teach students on how to operate machinery. After initial training, students can tend choose to access the materials again for refresher, as and when necessary or use it as a live demonstrator during laboratory sessions to help them get through areas that they are experiencing difficulties with.

Discussion and Conclusion

This paper has outlined how the implementation of QR codes containing safety training was designed and roll-out to students in Engineering. A total of three videos were identified and recorded for students. Although the focus of this project is primarily health and safety, the use of QR codes can be easily extended to also include other relevant information that can complement the learning experience, for example, linking reading list for enhance background reading or manufacturers information for further reference. The flexibility and ease of implementing this technology also means that it could be easily extended to other schools and for non-academic purposes, like information on artwork across the university.

References

Abdullah, K.H and Aziz, F.S.A (2020) Safety behaviour in the laboratory among university students. Journal of Behavioural Science, 15(3), pp. 51-65

Ashford, Robin, (2010) QR codes and academic libraries: Reaching mobile users. Faculty Publications - George Fox University Libraries.

Barakat, R.A, (1989) Storyboarding can help your proposal, IEEE transactions on professional communication, 32(1), pp 20-25

Beatrice Pulliam & Chris Landry (2010) Tag, You're It! Using QR Codes to Promote Library Services, The Reference Librarian, 52(1-2), pp. 68-74

Edward, N., (2002). The Role of Laboratory Work in Engineering Education: Student and Staff Perceptions. International Journal of Electrical Engineering Education. 39(1), pp. 11-19.

Engineering Council. (2014) UK Standard for Professional Engineering Competence, 3rd Edition, Engineering Council UK, London.

EU-OSHA (2010). Mainstreaming Occupational Safety and Health into University Education. European Agency for Safety and Health at Work. Luxembourg.

Feisel, L.D., and A.J. Rosa. 2005. The role of the laboratory in undergraduate engineering education. Journal of Engineering Education 94 (1), pp. 21–30.

Joordens, M, Chandran, J and Stojcevski, A (2012) Comparison of Technology Enabled Learning Practices (TELP) in engineering: a student's perspective. Proceedings of the 23rd Annual Conference of the Australasian Association for Engineering Education, ESER group, Swinburne University of Technology, Melbourne, Vic., pp. 186-194

Ismail, Z. S., Arifin, K., & Aiyub, K. (2015). Promoting OSHA at higher institutions: Assessment of level of safety awareness among laboratory users. Taylor’s Business Review,5(2), pp. 155-164.

Kolb, Liz. 2008. Toys to Tools: Connecting Student Cell Phones to Education, Eugene, OR: International Society for Teaching in Education.

Lynch, M. (2015) Do mobile devices in the classroom really improve learning outcomes? Available at: http://theconversation.com/do-mobile-devices-in-the-classroom-really-improve-learning-outcomes-38740

Muller, J. (2011) Students learning with mobile technologies in and out of the classroom. Education in a technological world: communicating current and emerging research and technological efforts, pp. 414-420

Nikolic, S (2015). Decoding Student Satisfaction: How to Manage and Improve the Laboratory Experience. IEEE Transactions on Education, 58(3), pp. 151-158.

Okura, M. R, Gümüúb, S (2010) Storyboarding issues in online course production process, Procedia Social and Behavioural Sciences 2, pp. 4712–4716

Rathod, S.S. and Kalbande, D.R. (2016) Improving laboratory experience in engineering education. Journal of Engineering Education Transformation, Special Issue 29(4).

Schultz, M.K (2013) A case study on the appropriateness of using quick response (QR) codes in libraries and museums. Library & Information Science Research, 35 (3), pp. 207-215

Sedghpour, B.S.; Sabbaghan, M.; Sataei, F.M. (2013) A Survey On The Pre Service Chemistry Teachers' Lab Safety Education. Procedia Soc. Behav. Sci.90, pp.57–62.

Shariff, A.M.; Norazahar, N. (2012) At-risk behaviour analysis and improvement study in an academic laboratory. Safety Science 50, pp. 29–38

Walsh A. 2010. QR Codes – using mobile phones to deliver library instruction and help at the point of need. Journal of information literacy, 4(1), pp 55-64