Preparing Students for Science Practical Sessions: Engaging with Digital Resources to Enrich the Learning Experience*

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Abstract

A key element in any science based module is its practical component. Here, students can acquire and develop hands-on skills in a powerful learning environment. In addition, during these sessions, they engage with group work, assessment including self-assessment, feedback, academic writing, problem solving and metacognitive skills.

Whilst many educators have focused on the design/format of their practical session and on the accompanying assessment strategies employed, only recently has the preparation for practicals come to the fore. Traditionally, students are required to read pre-prepared text in a paper-based laboratory manual before entering the session. The text provides background to the principle/theory/technique being examined. However, in the majority of cases, this text is not read leading to a lengthy compulsory pre-practical talk being required, reducing practical learning time.

Pre-lecture resources were previously shown to benefit learners by reducing cognitive load. In a study by Seery and Donnelly (2012), students engaged with introductory eResources and quizzes before lectures with results highlighting the approach made it difficult to determine which students had, or did not have, prior knowledge of the particular subject area. In the innovation described in this paper, the pre-lecture concept was transferred to the practical environment. A customised pre-practical video was recorded, edited and circulated to students prior to a laboratory session. Students were advised to view the video and complete a smartphone app-based quiz on the video content, before their practical session. Thirty-nine second year molecular bioscience students took part in the innovation and were invited to volunteer in the evaluation of the study via an anonymous online questionnaire. Twenty-seven students participated and provided feedback on their experience. Overall, there was significant engagement with the approach, with students recognising the value of viewing the pre-practical video and performing the quiz with regard to their learning and understanding. This paper presents an overview of the approach implemented, insights from its evaluation, and recommendations for educators aiming to implement the pre-practical concept.

Keywords: pre-practical, science education, online, mobile quiz, video, preparation.

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1. Introduction

In science education, classroom teachings are complemented with hands-on practical sessions. The practical plays a key component in learning and skill development. During these laboratory-based sessions, students can partake in group work, self-assessment, inquiry based learning, hypothesis development, protocol-following skills, hands-on training on equipment, academic writing, data analysis and interpretation in addition to assessment processes and feedback. Yet, even with this repertoire of important elements present in a "*powerful learning environment*" (Elen *et al.* 2007, p. 115), the practical does not always receive the attention it warrants with regard to [1] design, [2] assessment and [3] student preparation. Questions were posed previously regarding the effectiveness of practical sessions and whether they were reaching their learning potential (Bates, 1978; Roth, 1994), with a main focus being on the learning style employed; yet the exact same questions are still being asked today. In recent times, there has been a significant focus on certain elements of the practical, namely the learning style, assessment format and preparation approach being employed in the sessions. This report describes the implementation and evaluation of a pre-practical video in combination with a smartphone app-based quiz, with second year undergraduate science students. A description of the approach and insights gained from the evaluation, in addition to recommendations going forward, will be presented and discussed.

1.1 Learning styles in the science practicals

Traditionally, the learning style predominantly employed in practical sessions was expository (Bennett & O'Neale, 1998; Bennett, Seery, & Sovegjarto-Wigbers, 2009; Domin, 1999; J. Dunne & Ryan, 2012). Here, students follow pre-determined protocols to achieve pre-determined results in order to observe and understand a particular principle or law. While on one hand, this does merit its place in curricula (Johnstone & Al-Shuaili, 2001; Lagowski, 1990), there are several reports outlining some of its downfalls if relied on too heavily (Gunstone & Champagne, 1990; Hart, Mulhall, Berry, Loughran, & Gunstone, 2000; Hofstein & Lunetta, 2004). Indeed, reports on this style state it does not require the students to "think" and that it can't support meaningful learning (Gunstone & Champagne, 1990; Stefani, 1994). However, the style still remains cemented in many curricula, often due to the fact it complements the scheduling of short practical sessions where a correct result is expected to be obtained, increases in student numbers in addition to a lack of funding/resources (Johnstone & Al-Shuaili, 2001; Lagowski, 1990). In many college curricula, the expository style is now being complemented by more inquiry-based methods aimed at introducing opportunities for metacognitive activities and mental engagement to occur, leading to greater understanding (Hart et al., 2000).

1.2 Migrating away from traditional assessment practices

As with certain learning styles, traditional assessment practices can also be found cemented in science curricula. For example, students are regularly required to submit a laboratory report after each practical session, developing skills in data interpretation, presentation and academic writing. From a student point of view, writing multiple reports with similar requirements across several modules is not a very exciting task.[A1] Its repetitive and persistent presence can consume students with their quantity, with quality sacrificed – a serious concern. The work of many in the assessment field has allowed science educators to begin addressing this, incorporating new assessment approaches to the practical environment; examples include formative assessments, self-assessment tasks, incremental marking systems, approaches geared at improving feedback uptake, oral presentations, poster presentations, collation of portfolios, introducing rubrics, electronic lab reporting and the use of other technologies such as apps, videos etc. (Bree, Dunne, Brereton, Gallagher, & Dallat, 2014; Crowe, Dirks, & Wenderoth, 2008; DeBourgh, 2008; Dervan, 2014; Donaldson, 2016; Downing, 2016; Haldane, 2014; Hand & Keys, 1999; Hughes, 2004; Hunt, Koenders, & Gynnild, 2012; Johnston, Kant, Gysbers, Hancock, & Denyer, 2014; Mc Donnell, O ’Connor, & Seery, 2007; Murphy & Barry, 2015; Nicol, 2009; Open-University, 2016; Pickford & Brown, 2006; Reddy & Andrade, 2010; Rudd, Greenbowe, & Hand, 2002).

1.3 Realising and harnessing the power and potential of pre-practical exercises

An important area for any aspect of learning, and life, is preparation. In the traditional practical environment, students are asked to read a laboratory manual to familiarise themselves with the theoretical background of the principle/law being analysed in addition to looking over the protocol and any health and safety notices (see Figure 1). However, the author’s experience suggests this rarely occurs. With regard to the sessions, there is normally a pre-practical talk before any experimentation commences and many of the key points are covered here by the lecturer. However, science educators are now realising the potential of pre-practical preparation for learners to contextualise and introduce background information. Specifically, they can assist learners in acknowledging their prior knowledge on a topic, allowing new connections and linkages to be developed - reducing the cognitive load of novice learners (Johnstone, 2001; Sirhan, Gray, Johnstone, & Reid, 1999; Sirhan & Reid, 2001). Seery and Donnelly (2012) previously demonstrated the motivational and learning power of pre-lecture resources for students without prior knowledge of a particular subject area.

In general across society, we have become *au fait* with viewing online videos to teach us new things. Like society, educators and students both rely on videos to illustrate a concept, or provide a quick overview of a study topic - at the viewer's own pace (Chan, 2010; Whatley & Ahmad, 2007). Video has the strength to capture students' attention and motivate their learning (Chua Hean, Oh, Wee, & Tan, 2015; Whatley & Ahmad, 2007). With regard to the science practical and similar sessions in other disciplines, video based objects have become a common and popular media for preparing and learning pre-practical (J. Dunne & Ryan, 2012; K. Dunne, Brereton, Bree, & Dallat, 2015; Meade, Raighne, Gregan, Naydenova, & Pedreschi, 2015; Zwickl, Finkelstein, & Lewandowski, 2013).

1.4 Research questions

This intervention centres on five research questions. In addressing the questions, there is the potential to generate recommendations for curriculum design of the practical sessions, enhancing the scholarship of teaching and learning.

1. Would generating customised pre-practical video content for students improve the level of preparation for practical sessions?
2. Would implementing the video in combination with a multiple choice question (MCQ) & True/False, smartphone app-based, quiz improve the level of understanding and learning before the session?
3. Can the implementation of the accompanying quiz identify areas that need further attention at the beginning of the practical session?
4. Will implementing this approach result in redundancy of the full pre-practical talk?
5. Will the students engage and identify value with the pre-practical preparation approach?

2. Methodology

2.1 Study design

This intervention was performed with second year science undergraduate students at Dundalk Institute of Technology who were performing the 'Molecular Bioscience' module (on the B.Sc in Pharmaceutical Science, B.Sc in Applied Bioscience and B.Sc (Hons) in Environmental Bioscience programmes which collectively comprised 39 students). The students were provided with an information session on the pre-practical concepts involved in the intervention. Students were instructed to view an online video recorded by the author prior to attending a particular practical session. This represented the first time they performed this form of preparation for a practical (as compared to traditionally being expected to read text/diagram based lab manuals). The video was introduced in combination with a formative app-based quiz designed using the 'Socrative' smartphone app (see socrative.com and Dervan (2014)). The ten-question quiz was made up of a combination of MCQs and True/False questions, based on the content of the pre-practical video. No summative grade was assigned to this aspect but students were advised that watching the video and answering the quiz's questions were part of the preparation for the session, in place of solely reading text in the lab manual (see Figure 1).

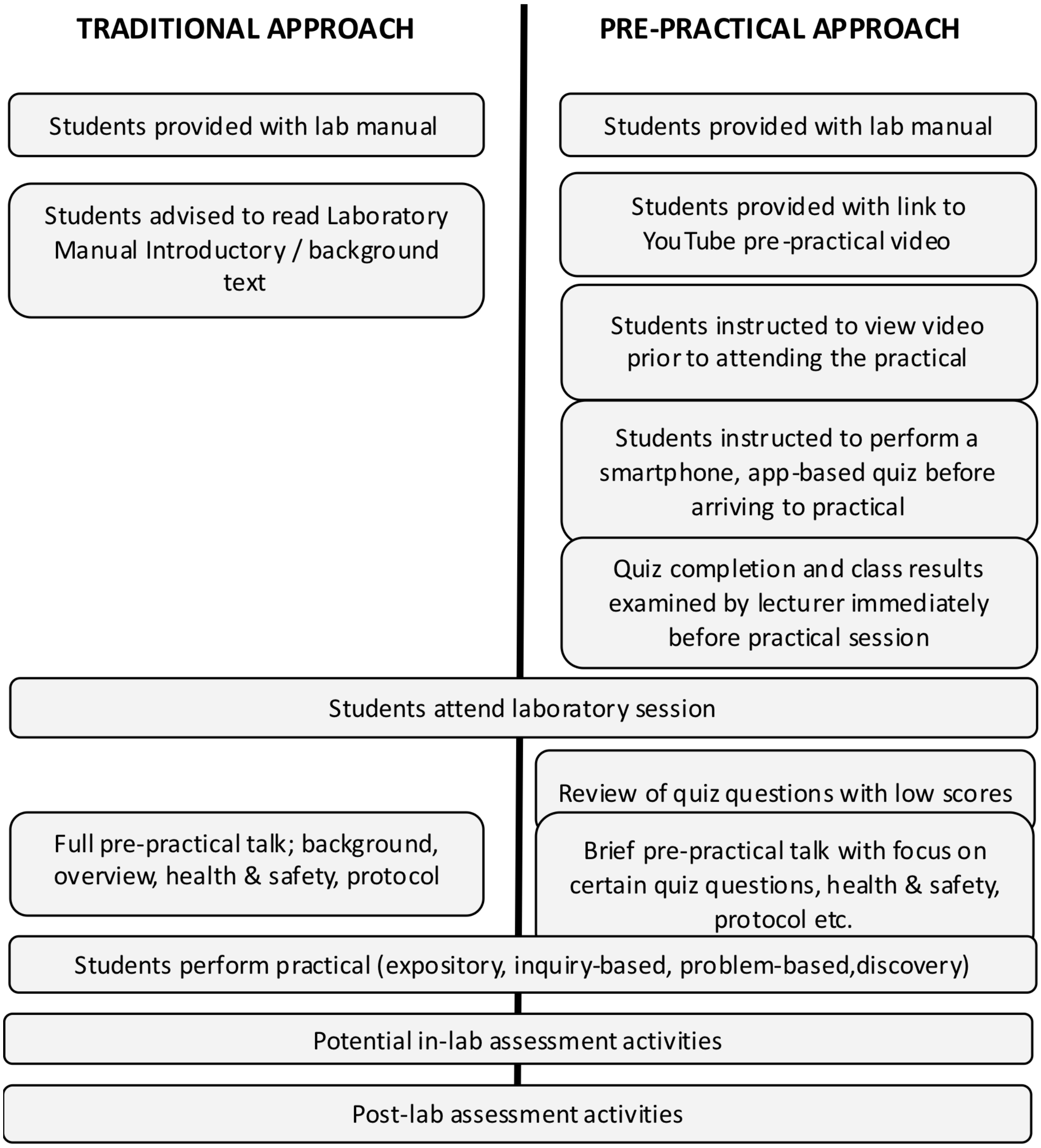

Figure 1: A comparison of the common and different elements of the traditional approach of a practical session versus the pre-practical focused intervention performed in this research study.

2.2 Video Recording

The pre-practical video was recorded using a combination of a Canon 100D DSLR on a tripod, a head-mounted Go-Pro camera and an Apple iPad Pro. The footage was edited using Telestream's Screenflow software on an Apple Macbook Pro. An animation was sketched using Microsoft Powerpoint and edited into the video. A combination of video angles and clips of various equipment was included as to engage the viewer, rather than just having one person facing the camera for the entire video. The video was then uploaded to YouTube in a High Definition format. The length of the video was kept to 6 minutes to maximise attention retention. The video can be viewed at the following link: https://youtu.be/cLPJzRf3RTg or by scanning the following QR barcode (Figure 2). The corresponding socrative quiz questions can be viewed in appendix II.

Figure 2: QR barcode to view the pre-practical video.

2.3 Ethical considerations, Data collection and Analysis

Ethical approval was obtained prior to commencing the study. Each student was provided with participation information leaflets, an overview of the project and aims and details on the voluntary evaluation methods. Students could volunteer to take part in the evaluation of this intervention anonymously and confidentially. The lecturer would not know who did/did not participate in the evaluation. Anyone was entitled to withdraw at any stage and in the online survey, no questions were mandatory. It was stressed in all documentation that participation, or not, would have no impact on any grades. The piloted online questionnaire was structured with a combination of open ended, rating, dichotomous and multiple-choice questions as recommended by Cohen *et al.* (2007) and Adams & Cox (2008) (see appendix i) and circulated online. A non-probability convenience sampling method was applied. All data was transferred to, and stored in a password-protected Microsoft excel file for analysis. Any open ended responses were thematically analysed as described by Bree and Gallagher (2016). Final findings were also circulated to the student group.

3. Results & Discussion

This research implemented a pre-practical video and app-based quiz prior to the laboratory session taking place. Thirty-nine students were enrolled in the Molecular Bioscience module, with each participating in the relevant practical session and pre-practical/quiz intervention. Subsequently, twenty-seven voluntarily participated in the online evaluation questionnaire (yielding a 69% response rate).

3.1 Engagement and Accessing the pre-practical video

Of the 27 students who participated with the online survey evaluation, 100% (27 responders) stated they viewed the pre-practical video before the relevant practical session. With regard to monitoring the mode of accessing the video, 59.3% (16 responders) used a laptop, 37.0% (10 responders) used a smartphone while 3.7% (1 responder) used a desktop computer. This clearly demonstrates the presence of, and interaction with, mobile computing and how students currently access information in today's world. Educators need to be aware of this and adapt accordingly when considering technology enhanced learning approaches. With regard to finding and playing the video (which was circulated via the module's Microsoft OneNote classroom notebook facility and via a QR barcode in the lab manual), 7.7% (2 responders) did score the ease of finding it as Fair/Poor with 73.1% (19 responders) as Excellent/Good. - (See Table 1). Of the 27 students who viewed the video, 51.9% (14 responders) viewed it more than once - a true benefit of the video being available to the group online. 48.2% (13 responders) watched it once, 40.7% (11 responders) twice, 7.4% (2 responders) three times and the remaining 3.7% (1 responder) viewed it 5 or more times. It's also clear that mobile technologies were the primary modes of access amongst the group.

3.2 The impact and acceptance of the pre-practical video approach

Key success indicators for educational interventions include the engagement of students, its uptake and whether it is having a positive impact. As described in section 3.1, there was a significant engagement with the pre-practical video and quiz, with all students accessing the resources. Students had a week to watch the video before their session took place, an aspect 84.6% (22 responders) rated as Excellent/Good. In Table 1, 92.6% (25 responders) identified their level of preparation for the session after watching the video as Excellent/Good with 96.2% (25 responders) scoring it for assisting understanding of their topic as Excellent/Good. 96.3% (26 responders) classed the usefulness of the video as being Excellent/Good.

		Excellent	Good	Average	Fair	Poor	Total Responses
My level of preparation for the practical session after viewing the PCR pre-practical video	%	*51.85%*	*40.74%*	*7.41%*	*0.00%*	*0.00%*	*100.00%*
	Responses	14	11	2	0	0	27
The ability of a pre-practical online video to assist understanding of the PCR practical topic	%	*61.54%*	*34.62%*	*3.85%*	*0.00%*	*0.00%*	*100.00%*
	Responses	16	9	1	0	0	26
How easy it was to find the PCR video	%	*50.00%*	*23.08%*	*19.23%*	*3.85%*	*3.85%*	*100.00%*
	Responses	13	6	5	1	1	26
How easy it was to play the PCR video	%	*55.56%*	*37.04%*	*7.41%*	*0.00%*	*0.00%*	*100.00%*
	Responses	15	10	2	0	0	27
Lead up time to view the PCR video	%	*50.00%*	*34.62%*	*15.38%*	*0.00%*	*0.00%*	*100.00%*
	Responses	13	9	4	0	0	26
My understanding of the PCR topic after viewing the video	%	*51.85%*	*48.15%*	*0.00%*	*0.00%*	*0.00%*	*100.00%*
	Responses	14	13	0	0	0	27
The usefulness of the PCR video	%	*66.67%*	*29.63%*	*3.70%*	*0.00%*	*0.00%*	*100.00%*
	Responses	18	8	1	0	0	27
The usefulness of pre-practical videos in combination with online quizzes	%	*55.56%*	*33.33%*	*11.11%*	*0.00%*	*0.00%*	*100.00%*
	Responses	15	9	3	0	0	27
My overall experience of the PCR practical session after viewing the pre-practical video	%	*51.85%*	*40.74%*	*7.41%*	*0.00%*	*0.00%*	*100.00%*
	Responses	14	11	2	0	0	27

Table 1: An overview of the students' ratings of the pre-practical video approach. The abbreviation 'PCR' stands for Polymerase Chain Reaction, which was the focus of the pre-practical video and practical session.

When provided with certain statements about the resources and asked to select those that felt appropriate from their experience of participating in this intervention, students highlighted an improved level of preparedness (88.9%; 24 responders – see table 2). 55.6% (15 responders) showed they enjoyed watching the video before the practical while 44.4% (12 responders) enjoyed the session more due to feeling more prepared.

Statements to select (asked to click all that apply)		Selected by
I felt more prepared for practical sessions (in comparison to sessions without pre-practical videos)	%	*88.89%*
	Selected by	24/27
I enjoyed watching the PCR video before the session	%	*55.56%*
	Selected by	15/27
The PCR video content was pitched at the right level	%	*59.26%*
	Selected by	16/27
The PCR video helped me with my practical lab report as I could still view it after the session	%	*51.85%*
	Selected by	14/27
Combining quizzes with the pre-practical PCR video was beneficial	%	*77.78%*
	Selected by	21/27
I enjoyed the practical session more due to feeling prepared	%	*44.44%*
	Selected by	12/27
The PCR video was the right length	%	*74.07%*
	Selected by	20/27

Table 2: Further details on how the video and quiz innovation was

3.3 Combining smartphone quizzes with the pre-practical video

As shown in Table 2, 77.8% (21 responders) identified combining quizzes with pre-practical videos as being beneficial. In order to capture more reaction to this combination, open response questions were provided in the online survey. There were several general responses on the approach: "*brilliant idea*"; "*Useful tool to prepare for practicals*"; "*good way to test understanding of the topic before the lab*"; "*it reinforced the information*". In addition, the presence of the quiz "*made sure you were paying attention to the video, made sure you picked up the important information*". Aspects of learning were also clear: "*helps you to know what you've learned from the video*", "*helped me assess my own understanding"* (evidence of self-assessment and reflection evident in this comment) and that the quiz "*made sure I knew the method after watching the video, rather than just watching the video and forgetting it*". The latter comments emphasise how students reflected on their level of understanding and the impact watching the video combined with the quiz had on them. Self-assessment has long been a goal in education, with Boud (1990) describing it as fundamental to all aspects of learning. Providing immediate feedback to students via the quiz also allows reflection to occur as they can compare their work to model answers, an example previously described by Nicol (2009). The majority of the open comments relate directly to the aims of the innovation. Students have grasped the purpose of why the quiz was included in the innovation. With regard to the quiz format, one responder mentioned "*questions need to be easy to build confidence*", a very valid point. Interestingly, from the quiz (comprised of 10 MCQs & True/False questions), the average result from the 39 students who performed it was 92.7%

(with only one question averaging <90%, with 67% identifying the correct answer). From the author's point of view, it was then clear which question/area needed some attention in the pre-practical welcoming talk. 88.9% (24 responders) rated the usefulness of the video and quiz combination as being Excellent/Good.

Some students were more critical in their comments, for example, "*I would say it was useful but why do we need to know (the) inventor of (the) technique*" as well as "*good idea in theory, but since we were able to view the video as we did the quiz, it made the quiz feel redundant*". Students in the current education system are extremely familiar with technology to find information they need, when they need it. Knowing the discoverer of a process or technique, may no longer be considered important by some. However, in many walks of life, we are guided to cite and reference original sources. In scientific writing, this is especially critical. As students progress through their programmes, they quickly realise the importance of peer-reviewed sources and recognition of same, especially when assignments begin to assess this aspect of their work. It is still valuable to capture the student viewpoint on this at an early stage in their career and one for educators to be aware of discussing earlier in a degree programme. The latter comment focuses on, in their experience, a weakness of the quiz. Indeed, they make a valid point and this will be discussed further in the next section.

3.3 Strengths, weaknesses and possible improvements going forward

As with any process, it is crucial to obtain feedback to feedforward. Students were asked to identify the strengths, weaknesses and improvements in the innovation and these can be viewed in Table 3.

Strengths	Weaknesses	Improvements
"Clear"	*"the quiz was too short"*	*"the quality"*
"The short yet very informative video, and the socrative quiz that tested my knowledge of the video"	*"the length was a bit long"*	*"the quiz was maybe a bit too easy"*
"Good learning method"	*"there was still a lot of pre-lab talk when we began the lab"*	*"more questions could be added on socrative (quiz)"*
"increased understanding"	*"didn't convey the minute details, i.e. volumes, voltages, masses"*	*"quiz should have been timed"*
"animations in video"	*"the links for the video"*	*"talking in the video could be slowed down a bit"*
"can see the method in action"	*"the links for it on OneNote" (platform used in lab)*	*"separate links"*
"the content"	*"question content"*	
"introducing the topic and it not being over complicated"	*"good idea in theory but since we were able to view the video as we did the quiz, it made the quiz feel redundant"*	
"video very clear and well made"	*"speed of talking in the video reduced as I personally had to stop the video"*	
"the quiz - as your result was given straight away"	* there were comments of "*none*" with regard to weaknesses but these were removed as no specific detail provided	
"the explanation of the topic"		

Table 3: An overview of the student's views on the strengths, weaknesses and improvement areas of the innovation.

From the data, it is clear that the pre-practical quiz and video has been received well by the student group. Students realised the strength of the innovation on their learning and understanding of topics prior to practical sessions, with one describing it as not being "*over-complicated*". The video was described as being "*very clear and well made*" and that it helped by allowing viewers to "*see the method in action*". Feedback and the result being "*given straight away*" was seen as a positive, allowing students to self-assess and learn from the immediacy.

There are some weaknesses from the student viewpoint, for example whilst the majority identified the video as being the right length in duration, there was one comment about it being "*a bit long*". The speed of speech in any video content merits attention, particularity given the increasing number of students at the institution for whom English is not their first language. A stand out comment for the author was that "*there was still a lot of pre-lab talk*", as some time was spent clarifying some points and introducing the actual protocol and machine set-up. This may represent an area for improvement, i.e. create two sections of videos aimed at background theory/principle initially and lab manual protocol with volumes etc. mentioned. There are some comments around difficulties accessing the video (in this case OneNote virtual class notebook or QR code in the lab manual). Alternative methods of dissemination such as direct e mails, or via the primary virtual learning environment (e.g. moodle/blackboard) may be considered.

In the case for areas of improvement, there are comments on the quiz element of the innovation, that it was "*a bit too easy*" and "*should have been timed*". Yes, these are potential modifications that could easily be introduced, and that will depend on the learning goals set by the educator. In the case of this intervention, the questions were simple MCQs & True/False questions aimed at measuring understanding and knowledge gained from watching the video, also targeted building confidence (via the questions being quite easy). Perhaps initial quizzes could be used to build confidence, with subsequent practicals having a timed quiz, i.e. implementing a scaffolding type process.

3.4 The student viewpoint; is the traditional preparation approach finished?

From the results outlined above, each of the project's research questions were addressed (see section 1.4). It is clear the students engaged with the pre-practical technology and identified its learning benefits. They arrived at the practical more prepared and they had a clearer and improved understanding of the experimental concept being examined compared to previous years where the preparation relied on reading lab manual text. In addition, the accompanying quiz, which was performed by every student in the group, provided the lecturer with details on any areas, or gaps in understanding, which needed to be addressed before the practical commenced. This approach also minimised the need for a traditional, full pre-practical talk before the session began.

When asked if the students agreed/disagreed with the introduction of pre-practical video resources to assist preparing for practical sessions, 96.3% (26 responders) strongly agreed/agreed with 3.7% (1 responder) neither agreeing or disagreeing. Interestingly, 0% (no responders) wish to move forward with just a practical manual containing text to read before commencing a practical while just 11.1% (3 responders) wish to solely use pre-practical videos with quizzes. Interestingly, 88.9% (24 responders) have a preference for a combination of both approaches (lab manual text and pre-practical video & quiz).

3.5 The staff viewpoint & recommendations

My overall aim was to improve the preparation for practical sessions amongst my students, as compared to the traditional approach to diagram/text focused lab manuals. I focused on the generation of pre-practical videos as the mode of assisting preparation. My goal was to generate a helpful, informative and engaging short video, and produce it in sufficient quality so it would be relatively 'future-proofed'. Reflecting on the approach, a real benefit for me with this approach was the complementary app-based quiz. This improved student engagement with the video and importantly, highlighted to me any areas that needed revision, i.e. the question in the quiz that scored 67% on average showed me that before I entered the practical session, I needed to go through the topic of this question with the group. Setting up the socrative quiz takes just minutes, and was extremely straight-forward. My goal included keeping the questions fairly simple as I wanted to build confidence in the students, and this was mentioned by one student in their feedback whilst another felt that the questions were too easy, or that the quiz should be timed. I understand these comments. Initially I targeted building confidence with the quiz. Going forward, subsequent quizzes in later stages of the module using this approach, will increase in complexity gradually (with regard to content/timing). It is worth noting the students' views mentioned in the end of section 3.4; 88.9% (24 responders) would prefer a combination of preparation resources both with videos/quizzes and lab manual introductory text.

In hindsight, I would consider making two short videos; or having two short, distinct sections in one video. One element would focus on the theory and concepts, whilst the other could focus on the protocol from the manual/reagents/volumes, to improve familiarity with the process (as mentioned in one student comment). This essentially requires determining the rationale for the pre-practical video; i.e. to introduce components, laboratory techniques to address affective dimensions such as confidence or motivation (Agustian & Seery, 2017). The video I recorded was 6 minutes in length, and for me this is in an acceptable range, however I now believe shorter is better. 74.1% (20 responders) stated the video was of the right length. One aspect I learned a significant amount about since, and would take forward to future projects is the importance of crisp, consistent audio – especially if you are recording on multiple devices. This is important for everyone to consider when purchasing equipment with a budget, or planning their video. Practice with the recording equipment you have and self-assess the quality, then show it to an independent person to obtain some feedback.

Finally, one aspect I would like to consider is students making videos for students. I run a similar project in another setting and the student generated videos work very well as a teaching tool in other class settings.

In summary, I would highly recommend this pre-practical approach. 92.6% (25 responders) rated their overall experience of the practical after viewing the particular pre-practical video as excellent/good. As a lecturer, I found it very beneficial for the student groups in their learning, understanding of, and engagement with, a practical topic. International students also benefited as they could replay the video multiple times. Repeat viewing of the videos was also shown to assist subsequent lab report generation according to 51.9% (14 responders). In my experience, from engaging with the video and quiz, students arrived better prepared, confident, with a strong grasp of what was about to take place – something I personally have not identified when relying on a text-only laboratory manual. A previous report by Burewicz and Miranowicz (2006) identified a similar finding in that students with written instructions prepared for the shortest time as compared to other groups who were assigned video, or interactive computer programmes to prepare with. Hence, the selection of the mode of pre-practical preparation does warrant focus, with video appearing a very worthwhile concept to introduce.

4. Conclusions and future directions

Preparation is important, and with regard to practicals, deserves as much attention as the design format of a session and the accompanying assessment strategies. In fact, Agustian and Seery (2017) state "*a pre-laboratory activity should be part of the overall laboratory experience",* so there is a need to make this a mainstream component of the practical design in curricula. It holds the potential to enhance learning overall and facilitate reducing cognitive load for students. The use of short, concise pre-practical videos can engage the learner with the theory behind a session or the protocol to be performed. Combining this with an online, or app-based, quiz can allow formative self-assessment to take place whilst immediate feedback is provided. In addition, the lecturer can quickly identify gaps in understanding that warrant further attention before the practical commences. In essence, we are really beginning to advance pre-, in- and post-practical activities that can enrich learning, understanding and build confidence in these "powerful learning environments" referred to by Elen *et al.,* (2007).

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Appendix I Online Questionnaire (performed anonymously using surveymonkey.com)

Q1 Did you watch the pre-practical video before the relevant practical session?

- Yes / No

Q2 Please Detail The Device You Used To View The PCR Pre-practical Video:

- Smartphone
- Laptop
- Desktop

Q3 How Often Did You Access The Pre-practical Video

- 0, 1, 2, 3, 4, 5 Or More

Q4 On the below scale (Excellent, Good, Average, Fair, Poor), how would you rate the following aspects of the use of pre-practical videos implemented in the laboratory sessions? Please tick the box that applies to you for each topic:

- My level of preparation for the practical session after viewing the PCR pre-practical video
- The ability of a pre-practical online video to assist understanding of the PCR practical topic
- How easy it was to find the PCR video
- How easy it was to play the PCR video
- Lead up time to view the PCR video
- My understanding of the PCR topic after viewing the video
- The usefulness of the PCR video
- The usefulness of pre-practical videos in combination with online quizzes
- My overall experience of the PCR practical session after viewing the pre-practical video.

Q5 From a student point of view, the introduction of pre-practical video resources for practical sessions is something that I ____________ with. Please fill in the blank by ticking one of the following options:

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q6 Do any of the following apply to your experience of using the pre-practical video approach? Please tick all of the boxes that apply to you. You may tick more than one box:

- I felt more prepared for practical sessions (in comparison to sessions without pre-practical videos)
- I enjoyed watching the PCR video before the session
- I do not feel the pre-practical videos are needed
- The PCR video content was pitched at the right level
- The PCR video helped me with my practical lab report as I could still view it after the session
- Combining quizzes with the pre-practical PCR video was beneficial
- I enjoyed the practical session more due to feeling prepared
- The PCR video was the right length

Q7 Can You Please Comment On The Implementation Of The Online Socrative PCR Quiz In Combination With The Pre-practical Videos?

- Open Ended Response Text Boxes

Q8 Which Of The Following Would You Prefer With Regard To Improving The Preparation For Your Practical Sessions? Please Tick The Box That Applies To Your Answer.

- Practical Manual With Typed Introductory Text For You To Read (as Normal)
- Use Of Pre-practical Videos And Quizzes To Introduce A Practical Session
- A combination of both of the above approaches

Q9 Please Comment On The Strengths/weaknesses And Areas Of Improvement With The Pre-practical PCR Video And Socrative Quiz Approach Implemented. Please Enter Your Responses In The Text Box Below.

- Open Ended Response Text Boxes

Appendix ii Socrative Quiz Questions

#1 What does PCR stand for?

ANSWER CHOICE

A Polymerase Caspase Reflux

B Poly-A-polymerase complex reflex

C Polymerase chain reaction

D PAP Clamping Residue

E Polymerase Complex Reaction

Explanation: PCR stands for Polymerase Chain Reaction

#2 The first step in the polymerase chain reaction (PCR) is

ANSWER CHOICE

A Denaturation

B Primer Extension

C Annealing

D Cooling

E none of the above

Explanation: You must denature the strands using heat before the primers can anneal (and subsequently be extended)

#3 The average number of cycles in a PCR reaction is 10

Correct Answer: True/False

Explanation: The average number of cycles for most PCRs is between 30-35 cycles

#4 The role of a primer in PCR is to hybridise with it's complementary sequence and ultimately specify the region to be amplified

Correct Answer: True/False

Explanation: primers are designed by the user against the sequence to be amplified - they are complementary to the target sequence

#5 How many steps/stages are there in one cycle of a PCR reaction?

ANSWER CHOICE

A 2 steps

B 3 steps

C 4 steps

D 5 steps

E 6 steps

Explanation: 3 steps: Denaturation, Annealing, Extension.

#6 The thermo-stable enzyme used in PCR is called

ANSWER CHOICE

A RNA polymerase

B DNA polymerase

C Primase

D Taq DNA polymerase

E Ligase

Explanation: Taq DNA polymerase is the enzyme used. It is a thermostable enzyme isolated from the bacertia Thermus Aquaticus.

#7 The PCR technique was developed by

ANSWER CHOICE

A Kary Mullis

B Kohler

C Milstein

D Altman

E Mr. PCR

Explanation: Kary Mullis developed the PCR technique

#8 Five primers are used in a general PCR reaction.

Correct Answer: True/False

Explanation: Two primers are used in a general PCR reaction. You need a forward and reverse primer for any PCR reaction to take place. Both are designed against the same target sequence, one will bind to one strand, while the other will bind to the complementary strand.

#9 The base pairing rule plays a role in PCR

Correct Answer: True/False

Explanation: True - base pairing is used to help the primer anneal to the correct target sequence. In addition the Taq DNA Polymerase uses base pairing with the parent strand to know which base (G,A,T or C) to add to the growing new strand.

#10 Why do we include a negative no-template control for every PCR reaction?

ANSWER CHOICE

A To ensure the machine is working

B To ensure there is no contamination in any of the reagents being used

C To ensure we didn't forget a reagent

Explanation: B; we need to ensure there is no contamination in any of the reagents being used.