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Designing online pre-laboratory activities for chemistry undergraduate laboratories

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Student preparation is essential for any successful learning. This is especially true within the laboratory, which can be seen as a complex learning environment. Students are very familiar with receiving information from online sources, with an increased amount of students using their mobile devices as their primary source for information. Therefore, providing the pre-laboratory material via this medium is a growing trend in tertiary institutions. In this chapter, we describe the processes in designing and evaluating online pre-laboratory activities. Moreover, we describe a very quick, free, and simple way to make any video interactive. We illustrate the reasons for the approaches taken with responses from student surveys. Students found the interactive pre-laboratory videos more beneficial to their preparation and stimulated their curiosity for the laboratory. The approach we used could be applied to any undergraduate chemistry laboratory program. The use of online pre-laboratory videos can be particularly useful for students doing different laboratories on a rotation.

**Introduction**

**Pre-laboratory Activities**

The chemistry laboratory is a key part of the majority of undergraduate chemistry programs around the world and this has been the case since its widespread adoption in the late 19th century (Reid and Shah, 2007). To maximise the value of laboratory sessions, students are often given information about the laboratory in advance (Agustian and Seery, 2017, Reid and Shah, 2007). There have been many different pre-laboratory activities and implemented strategies reported on in the literature with varying degrees of success. An excellent review of this literature describing strategies used to understand chemical concepts, laboratory skills and processes, or affective experiences can be found in the recent work of Agustian and Seery (Agustian and Seery, 2017). In this introductory section we will focus on the previous work,
advantages and limitations of online pre-laboratory videos, quizzes and interactive activities.

**Online Pre-Laboratory Videos and Quizzes**
The use of technology, such as online videos and quizzes, in student learning is very common in tertiary education. The majority of institutions use a Learning Management System (LMS) or Virtual Learning Environment (VLE) as the platform for students to access course material including lecture notes, laboratory notes, and test preparations, as well as messaging capabilities. University students are becoming increasingly accustomed to retrieving information on their courses from an online platform (Browne et al., 2006). Moreover, the majority of current university students have grown up with the internet and computers as a major part of their lives. As a result of this familiarity, university students have a natural aptitude for understanding and using new technologies (Camacho-Miñano and del Campo, 2016, Jones et al., 2010). Due to this change in the learner, educators in chemistry are adapting their teaching practices from a traditional lecture, tutorial and laboratory-based curriculum to an increasingly digital blended approach (Seery, 2015). Over recent years there has been an increased amount of work and evaluation of online videos as the primary source of pre-laboratory preparation in chemistry (Chaytor et al., 2017, Spagnoli et al., 2017, Teo et al., 2014) and other scientific disciplines (Elmer et al., 2016, Gregory and Di Trapani, 2012, Jones and Edwards, 2010, Lin et al., 2017).

Providing information to students beforehand about the laboratory has many advantages, such as reducing the likelihood of cognitive overload. This can impact students’ abilities to achieve the intended laboratory learning outcomes (Johnstone, 1997, Jones and Edwards, 2010, Winberg and Berg, 2007). Moreover, there is an increasing amount of literature, which evaluates the impact of online pre-laboratory videos on students learning (Stieff et al., 2018, Bortnik et al., 2017). In a 2015 study, Nadelson and co-workers, showed that students who have used a video based demonstration achieved greater post-laboratory quiz scores than a control group (Nadelson et al., 2015). However, a recent study on the use of online pre-laboratory videos and quizzes for a second year analytical chemistry unit showed no improvement in academic performance in the laboratory reports. Despite this, the authors did report a positive effect on students perceived learning, due to higher levels of preparation (Jolley et al., 2016). Rotation style laboratories at upper level undergraduate chemistry laboratory are very common. The use of carefully designed pre-laboratory videos can make students more autonomous and confident in conducting experiments (Schmidt-McCormack et al., 2017). There is a growing body of evidence to suggest that the use of online pre-laboratory videos and quizzes improves students’ perceived preparation for the laboratory (Nadelson et al., 2015, Whittle and Bickerdike, 2015). Students are able to watch the video at their own pace, replay parts of the video that are unclear to them and identify areas of deficiency (Bell, 2010, Slemmons et al., 2018). All of these factors contribute to students’ improved preparation for the laboratory.

**Online Interactive Pre-Laboratory Videos**
Although instructional videos have a great deal of merit, a substantial amount of research has evaluated using of multimedia and interactive computer-based instructions as better modes of learning. The rationale for this type of online variation on instruction is known as the multimedia principle (Butcher, 2014, Mayer, 2009). The multimedia principle states that people learn better from words and pictures than from words alone. Mayer provides an excellent review article on other principles to consider when designing multimedia for e-learning (Mayer, 2017). The addition of an interactive component to an online video provides another functionality, which is becoming more accessible to academics as technology improves. There has been a great deal of literature about the use of interactive online learning in other environments. For example, the use of interactive features on e-textbook are said to improve the feeling of participation, which can lead to increased motivation to learn (Ghaem Sigarchian et al., 2018). For specific pre-laboratory activities, students completed the tasks in the lab in a shorter timeframe and laboratory
skills improved through the use of interactive computer-based instructions (Burewicz and Miranowicz, 2006). The study of Burewicz and Miranowicz also found that the use of interactive instructions, as opposed to paper instructions, lowered the number of errors or uncertain responses in the laboratory work. The trends in the literature are clearly showing that the use of interactive online videos or animations is more favourable to students than conventional paper instructions (D’Ambruoso et al., 2018, Fung, 2015).

This chapter aims to provide evidence on our experiences in developing and evaluating pre-laboratory videos, quizzes and interactive online videos. In the following methods and results sections, we provide details on how to develop pre-laboratory activities and evaluation over a three-year period of action-initiated research. In the implications and adaptability section we provide issues that could be resolved in your context, should you wish to adopt this approach. This chapter finishes with some concluding statements, which includes our planned future endeavours in this area.

**Methods**

**Our Context**
The pre-laboratory videos and quizzes have been designed for the laboratory component of a first year synthetic chemistry unit at the University of Western Australia. Students wishing to pursue a bachelor of science with a major in chemistry or engineering science (chemical specialisation) are required to take this unit. Each year this unit attracts around 400 students in its cohort. The unit covers essential basic knowledge on atomic structure, chemical bonding, molecular geometry, stereochemistry and elementary reactions of the major classes of organic molecules. There are six laboratories in this unit. Each laboratory session is 3 hours in duration and a laboratory demonstrator (teaching assistant) provides all instruction and assistance to the students in the laboratory. The titles of the laboratory experiments are:

- Acid/Base separation and recrystallisation techniques
- Molecular Models
- Electrophilic Aromatic Substitution Reactions
- The Reduction of Benzophenone to Diphenylmethanol
- Synthesis of Carboxylic acids and Esters
- Purification of Carboxylic acids and Esters

**Development**
The development of the pre-laboratory activities occurred in two distinct phases over a 3-year period. The first phase was to create 5-10 minute pre-laboratory videos, which were filmed, edited and uploaded to the VLE. To accompany the pre-laboratory video, an information sheet was uploaded onto the VLE. The information sheet contained all the experimental procedures that the students would need to complete the laboratory. This information was also given in the laboratory manual and worksheets. A set of online, mainly multiple choice, quizzes were created as the assessments for the pre-laboratory activities, and accompanied the pre-laboratory video. In the second phase, we created an interactive video. We will describe the approaches that we took to implement pre-laboratory activities into the unit.

**Getting Started: Recording, Editing and Uploading Videos**
The videos were recorded using a simple camcorder, however, with the advancement in technology capabilities over recent years, the camera and microphone of a mobile phone would suffice. The length of the video was an important consideration. The video needed to be long enough to present enough of the information needed to prepare the student for the laboratory. However, we hypothesised that if the video was too long then it could be difficult to maintain the interest of the student. A 2017 study on
creating videos for an introductory physics undergraduate course suggests that the length is an important consideration. Students accessing these videos only watched the video to its entirety half of the time. This study also makes the observation that as the video length increased the fraction of students watching all of the video decreased (Lin et al., 2017). This was also found in our results, where the total average watching time was lower than the whole length of the video (Table 1).

All of the videos were initially created with a very similar format. The videos were scripted and a storyboard developed. Making a storyboard and a script is a very good approach to take, which will save a great deal of time and cut down on the amount of reshooting and editing. The storyboard and prior planning enables you to visualise each component of the video and make sure that it follows a logical flow. The script will save you time by reducing the amount of mistakes that you make while filming and also ensures that key concepts are addressed without the need for rambling or long segues.

A member of staff was filmed presenting the information (Figure 1). There are several advantages of filming yourself in a pre-laboratory video. This is especially important if you are teaching in the laboratory. Students appreciate seeing the person from the video in the laboratory. This is important in units that have very large cohort size, where students can feel very isolated as they make that difficult high school to university transition. The use of a ‘talking-head’ has practical advantages as well. A ‘talking-head’ is a shot of a person’s head as they talk to the camera. This approach encourages less movement in your video. Videos being streamed over the internet will have a much higher quality if the amount of movement in the video is kept to a minimum. (Hartsell and Yuen, 2006)

Laboratory equipment was filmed and edited to be in screen shots in the final video. Where possible, narration in the laboratory was avoided. This is due to the poor sound quality as a result of the fume hoods. Initially the videos focused less on the experimental procedure and more on the theory behind the experiments. Reaction mechanisms or calculations were presented by filming a white board as the information was written out for the students to follow (Figure 2).

The editing of the video can be performed with any of the free software that is available in Apple (iMovie) or Windows (Windows Photos paired with Audacity works well for simple editing) operating systems. In the production of our videos, however, we used two different pieces of software that were not free; Adobe Premier Elements and Camtasia. Each software package allows the editing and exporting of videos with essentially the same features. However, we personally felt that Camtasia was the easier of the two to use for a novice. All additional materials, such as annotations and screen shots of lab equipment, were included to aid the students through the pre-laboratory video (Figure 1).

Once the video has been filmed and edited, you are now ready to upload it to the VLE. We strongly recommend that you upload the video to a YouTube channel that you administer. There are several advantages to uploading a video to YouTube:
- It is a reliable platform.
- It is accessible on desktop and mobile devices.
- It has freely available analytics tools, which provides a quick and easy way to evaluate its use.
- The video can be embedded in the VLE systems for easy student access.

The final point is an important aspect to consider. A video which is embedded in the unit means that students do not have to leave the VLE and go to an external website to view the video (Figure 3). The two main VLE providers, Blackboard and Moodle, have this capability built-in to its system.
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Figure 1: A screen shot from one of the annotated YouTube videos depicting the use of a talking head approach as well as providing additional information of chemical symbols and technical information.

Figure 2: A screen shot from one of the YouTube videos depicting the use of the white board to detail a reaction mechanism. This allows students to follow the reaction as it is written out.

Figure 3: Example of the pre laboratory video embedded in the blackboard VLE used for this study.
Using YouTube Analytics

The visibility of the videos on YouTube was set to unlisted. There are three visibility settings available on YouTube; public, private, and unlisted. The public setting means that it is visible to everyone and will appear on search engines. The private setting means that the video is only visible to the creator of the video and viewers that the creator selects. The video will not appear on the creator’s YouTube channel or search results. The practicality of setting the visibility to private is non-sustainable, especially with large undergraduate classes, because each viewer would have to be assigned access to the video. The unlisted setting offers the same privacy as the private setting, however, and more importantly, only viewers with the link will have access. Therefore, embedding the video in the VLE ensured that only students enrolled in the unit had access to the video. This allowed us to make use of the YouTube analytics to collect quantitative feedback on the number of views and the specific sections of videos that were of interest to our students. We cannot categorically say that the number of views each semester (Table 1) were only from students enrolled in the unit, however, by setting the visibility to unlisted we can be sure that the overwhelming majority of views were from our students. The number of views were far greater than the number of students enrolled in the unit, which implies that students were watching, at least in part, the video more than once.

YouTube analytics also provides insight into the times in each semester that the video was viewed. The number of views across Semester Two, 2015, indicated, unsurprisingly, that the majority of views took place the day before the laboratory (Figure 4). This trend was consistent throughout every pre-laboratory video in any semester. There is encouragement that there are not two lone peaks in Figure 4 (the laboratory

<table>
<thead>
<tr>
<th>Video</th>
<th>Sem 1, 2014 (370 students enrolled)</th>
<th>Sem 2, 2014 (328 students enrolled)</th>
<th>Sem 1, 2015 (250 students enrolled)</th>
<th>Sem 2, 2015 (231 students enrolled)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid-Base Separation</td>
<td>679</td>
<td>554</td>
<td>440</td>
<td>404</td>
</tr>
<tr>
<td>Molecular Models</td>
<td>N/A</td>
<td>N/A</td>
<td>260</td>
<td>393</td>
</tr>
<tr>
<td>Aromatic Chemistry</td>
<td>652</td>
<td>517</td>
<td>439</td>
<td>472</td>
</tr>
<tr>
<td>Reduction of a Carbonyl</td>
<td>558</td>
<td>485</td>
<td>346</td>
<td>361</td>
</tr>
<tr>
<td>Acids and Esters</td>
<td>N/A</td>
<td>N/A</td>
<td>446</td>
<td>497</td>
</tr>
</tbody>
</table>

Table 1: YouTube analytics of the number of views of each pre-laboratory video across the first two years of the study.

Figure 4: Representative YouTube analytics plot of the views of the Acid-Base Separation pre-lab video, Sem 2, 2015.
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is run over two days due to the size of the class). There is a general increase in views in the week leading up to the laboratory. This implies that some students are taking the time in the week leading up to the practical class to view the pre-laboratory video.

**Designing an Assessment: The Online Quiz**

Given that this unit has a large cohort size, there are many practical advantages to creating an online multiple-choice quiz to accompany the online video. The main advantages are that this type of quiz provides an incentive for students to watch the online video, and it can be automatically graded, which saves time for unit administrators. Most VLEs allow online quizzes to be easily created, maintained and allow the opportunity for students to receive automatic feedback on their answers. The inclusion of automatic feedback to any online quiz provides many good outcomes for students, including increased learning opportunity (Chittleborough et al., 2007). The number of options in a multiple-choice question is still a contentious issue in the literature, however, research suggests that two to three distractors and the correct option is enough (Haladyna et al., 2002). The literature in this area has also recommended avoiding the “all of the above” option (Harasym et al., 1998) and implausible options (Cheesman, 2009) in this style of quiz.

There is a variety of different subjects that could be used as the content of pre-laboratory multiple-choice question. In our experience a range of questions that focus on the practical part of the laboratory as well as the theoretical background works well. Moreover, the quiz questions should be directly related to the either the laboratory procedure or the content of the online video. We will provide an example of a practical and theoretical question and the type of instant feedback we provide to students after they have answered a question, which includes either feedback for the correct answer or why the incorrect answer is wrong. Providing this level of feedback is valuable for students, especially those who do not know what they do not know, which is common amongst first year students.

The short online quiz to accompany the online pre-laboratory video provides an incentive for students to watch the video. This is particularly effective if the online quiz has a small weighting towards the final grade. The following points should be considered when compiling an online quiz:

- Do not make the online quiz too long.
- Do not make the online quiz too hard.
- Align the questions with one of the learning outcomes of the laboratory.
- Align the questions to the content of the online video.

The points above will ensure that the video is watched and that students will complete the online quiz, without overloading them with information and any undue stress.

**Getting Creative-Building Interactivity**

An interactive component to the videos provides an active learning element, which is highly desirable. A similar process preparing and designing the video was used, however, at distinct parts of the video we wanted to give students a choice to make. The interactive video was edited using the Camtasia software. We used the annotation tool within the YouTube website, which was free and easy to use, to create the interactive video. The annotation tool allows the user to layer text and links to the already uploaded video. We took two approaches; the first was to record individual videos and upload them all to the YouTube website and the second was to upload one long video, which had each option placed one after the other. In principle, both approaches are the same, where the annotation in the YouTube video was a link to either a different video in the first case or a different position on the video timeline in the second.
Practical Question from Acid/Base separation and recrystallisation techniques lab:
After a crude product has been dissolved in a hot solvent, what is the purpose of filtering the solution for the first time?

a) Any insoluble impurities are removed (correct answer)
b) The pure product is obtained in solid form from the filter funnel
c) To separate out the two liquids
d) To separate quinine from benzoic acid

Correct Answer Student Feedback: In recrystallisation, the crude product is dissolved in hot solvent, and the hot solution is filtered. Any insoluble impurities are removed by this filtration step.

Incorrect Answer Feedback
• for answer b: This answer is not correct. Think about the step you will be taking and where you think the impurities will be. Read on in the procedure. Do you keep the solid phase or liquid phase?
• for answer c: This answer is not correct. A separation funnel is used to separate out two liquids.
• for answer d: This answer is not correct. The aim of the experiment is to separate out these two compounds. However, you can do this from the solubility of the two in different solvents. The step in this question is concerned with purification of one of the compounds.

Theoretical Question from Electrophilic Aromatic Substitution Reactions lab:
Which of the mechanisms below is the correct mechanism pathway for an electrophilic aromatic substitution reaction?

a) Correct Answer Feedback: This is correct. The pi bond in the benzene ring is acting as the nucleophile, electron source, donating a pair of electrons to the electron deficient electrophile (E). A base (B) provides the source of electrons that abstracts hydrogen from the carbon attached to the electrophile. Electrons from the hydrogen bond move into the ring to reform the aromatic ring.

Incorrect Answer Feedback
• for answer b: This is not correct. The electron deficient species is trying to donate electrons. The arrow indicates movement of electrons.
• for answer c: This is not correct. A hydrogen only has the electron that is used in a bond. It cannot push an electron toward the base (B) as it does not have any electrons free.
• for answer d: This is not correct. A positive charge indicates a position of electron deficiency. There are no electrons free to move toward the hydrogen for abstraction to occur.
An example of a choice was the type of funnel to use in a vacuum filtration, a Büchner or a Hirsh (Figure 5). The students could make a choice and receive feedback on the outcome of their choice. This type of freedom is seldom used in a first year undergraduate chemistry laboratory due to the recipe style laboratory manual. Moreover, students are reluctant to make a choice in a laboratory, due to anxiety over making a mistake, which could have an impact on their grades.

**Questionnaires**

A series of online questionnaires were developed to evaluate the impact of the online pre-laboratory activities. The purpose of the questionnaire was to decide if the pre-laboratory activities could, in principle, be used as part of students’ preparation for laboratories. At the end of the questionnaire, students were provided with an opportunity to comment further on any aspect of the pre-laboratory activities by submitting a response to a free text section of the questionnaire. We received 63 responses to this questionnaire from a cohort size of 370 (17% response rate).

The second questionnaire, which was administered in Semester Two, 2016, was developed with the aim of comparing the new, interactive videos with the old, passive videos. The Acid-Base Separation (Lab 1) and Molecular Models Laboratory (Lab 2) were passive, online pre-laboratory videos developed in 2014. The Aromatic Chemistry Laboratory (Lab 3) had an online interactive video. In the comparison, we wanted to delve deeper into the impact of an interactive video on not just preparation, but also confidence to solve problems, stimulation of curiosity, and encouragement to learn. Similarly to the questionnaire in 2014, students were also given an opportunity to provide additional comments on their preference for interactive or passive pre-laboratory videos in the form of a free-text section at the end of the 2016 questionnaire. We received 62 responses to this questionnaire from a cohort size of 232 (27% response rate). Participation by students was voluntary and students were provided with approved participant information and consent forms, which outlined the potential risks and benefits of being involved in the studies. The studies were conducted in accordance with UWA Human Ethics Approvals RA/4/1/5939 and RA/4/8993.
Presentation and Discussion

This section of the chapter is to provide results of student’s responses to the survey questions, which allows reflection on the approach we have taken. Based on our experiences we have highlighted recommendations that educators wishing to adopt this approach should consider.

Students’ Evaluation of the Pre-Laboratory Activities
The aim of the surveys was to provide evidence that the students were using the pre-laboratory videos to prepare for the laboratories. Students were first asked to evaluate how well the pre-laboratory video and information sheet prepared them for the laboratory. Students indicated, with over 83% agree or strongly agree responses, that both of these items prepared them for the laboratory practical. It is interesting to note that the students still appreciated the information given in the laboratory manual, which is essentially the laboratory procedure in a recipe format. Moreover, we are not advocating a completely online format of the laboratory manual because students still find it useful to annotate the traditional printed laboratory manual with their own notes to help them through the procedure.

Recommendation 1: A multi-media approach of online video, online pre-reading and printed instructions is an effective way of providing students with both the theoretical background and the practical procedure.

The pre-laboratory quiz was never designed to be a long and arduous assessment item. There were two main purposes when we designed the pre-laboratory quiz. The first was to provide a small incentive for students to watch the pre-laboratory video and to read the pre-laboratory information sheet. Therefore, the pre-laboratory quiz was incentivised with 10% of the final mark for the laboratory assigned to this quiz. The second purpose was to provide an opportunity to get automatic feedback on the answers that the students submitted. Therefore, for every question, students were told immediately if their answer was correct or incorrect. After the due date of the online quiz, students were provided with the correct answer, if necessary, and feedback on their answer. Students were then asked to evaluate the pre-laboratory quiz; was it too short or too easy? (Figure 6).

For both of these statements, there was a mix of responses from students. A slight majority of student responses indicated a neutral response, and more students disagreed than agreed with the statement. Student responses to the statements, especially in regards to the ease and length of the pre-laboratory

Figure 6: Students indicated their level of agreement with whether they felt the pre-lab quiz was A) too short and B) too easy (n=63).
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The students provided an overwhelming positive response for the final question of the questionnaire, which asked students if the pre-laboratory material helped them in their understanding of the laboratory. From the 63 students that took part in the questionnaire, 87% responded with agree or strongly agree to this statement. At the end of the questionnaire we provided students with an opportunity to elaborate on any aspect of the pre-laboratory material with any additional comments. There were some very positive responses:

"The pre lab did emphasize on the particular reaction mechanisms and the pre lab video highlighted the various equipment being used in order to prepare us for the lab. Thank you and please continue having the prelab material. I loved it :)"

A student, without any prompt, even commented on the difference between the online deliveries of the pre-laboratory material compared with the traditional method of using the laboratory manual:

"I was a big fan of being able to do all of the pre lab online. It is a more efficient way than was previously done where students had to do it in their book."

A student made reference to preparation being explicitly linked to confidence in the laboratory. This is encouraging, as it has been shown in the literature that students show more confidence in the laboratory when pre-laboratory activities were introduced (Teo et al., 2014).

"I thought the prelab concept was very effective, it helped me effectively prepare and organise myself before labs and thus I was able to get in the lab, feel confident with the procedure and the background of the lab (i.e. the mechanisms)."

The first implementation of the pre-laboratory activities were filmed and edited with very little technical support. It is important to note that all of the filming took place in the office of the laboratory coordinator with a video recorder and use of a white board. There was no state of the art studio, sound or lighting involved. The students’ responses were very positive, even with this unsophisticated approach.

Recommendation 3: Do not wait to get the technical support to make a professional looking video. Just do it! Talking to the students, via an online video is a very effective way of preparing the students for the laboratory.

**Students’ Evaluation of the Interactive Pre-Laboratory Video**

The evaluation of pre-laboratory activities in Semester two, 2016, was to compare the impact of an interactive pre-laboratory video with passive pre-laboratory videos. The questionnaire was administered to students through an online link on the VLE at the end of the third laboratory. Students had a week to complete the questionnaire and it was closed before the start of the fourth pre-laboratory video, which was also a passive video. There were two main areas where students felt that the interactive pre-laboratory video was superior to the passive pre-laboratory video; preparation and stimulation of curiosity.

Students’ responses to the statement ‘The video prepared me for the laboratory’ was in much higher agreement for the interactive pre-laboratory video (Lab 3) than the two passive videos (Lab 1 and Lab 2) (Figure 7A).

One of the motivations for designing an interactive pre-laboratory video was to stimulate the curiosity of students for the practical session. For Lab 3, 46% of students thought that the video stimulated their curiosity a great deal or a lot, compared with only 26% for Lab 2 and 22% for Lab 1 at the same levels of
agreement (Figure 7B). This result indicates that providing a choice or a decision in the pre-laboratory video makes students think about the consequences of their actions.

Students also responded more favourably to the interactive pre-laboratory video compared with the passive videos when we asked students the statement ‘Preparing for the assessment activities helped my learning of the topic’ (Figure 7C). In this statement the assessment activity was the online quiz, which accompanied the online video. There is a clear difference in students’ perceptions of their learning when an interactive online video was used with the online quiz as opposed to a passive video.

Students felt that they had the same access to learning resources from passive or interactive videos. The responses of students to the statement “I had access to adequate learning resources for the practical session” (Figure 8A) were very similar between Lab 1 and Lab 3. Moreover, Lab 2 had the most positive feedback with 65% of students responding with “mostly” or “always” for this statement. However, even though access to the resource was similar between types of pre-laboratory video, there was a difference
Figure 8: Student responses to the statement: A) “I had access to adequate learning resources relevant for the practical session” and B) “I felt encouraged to learn by the learning activities provided.” (n=62)

Student responses to "I was given adequate feedback about how well I was doing in the pre-lab"

Figure 9: Student responses to the statement, “I was given adequate feedback about how well I was doing in the pre-lab”. (n=62)
between the encouragements to learn from the video (Figure 8B). Lab 3 had 48% of students respond with “mostly” or “always” to the statement ‘I felt encouraged to learn by the learning activities’ compared to 36% for Lab 1 and 38% for Lab 2.

A somewhat unsurprising result is that students felt that they had more adequate feedback with the interactive pre-laboratory video compared with the passive pre-laboratory videos (Figure 9). Nearly half of the responses (47%) were for the “mostly” or “always” responses to the statement ‘I was given adequate feedback about how well I was doing in the pre-laboratory’. This is compared to 35% for Labs 1 and 2.

These results indicate that there is a preference towards an interactive component in videos, especially when it comes to preparation and stimulation of curiosity for the laboratory. However, it is also relevant to point out that any form of online pre-laboratory video and quiz is beneficial to the student.

Recommendation 4: The annotation function in YouTube provides a quick and free method of making a passive video into an interactive video, which stimulates students’ curiosity and helps them prepare.

The creation of pre-laboratory videos and quizzes for students to view and complete before attending an undergraduate laboratory has many strengths and benefits. The research study provides evidence that the students used the online pre-laboratory video and quizzes to aid in their preparation for the laboratory.

Conclusions

The aim of this chapter is to provide insight, based on our experiences, on the design of online pre-
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laboratory activities. This approach has some very obvious practical strengths for both educator and student. The videos and online quizzes only need to be made once and can be used many times over. The students are given a platform to prepare for their laboratories in a timely manner. However, there is a time issue for both educator and student. The educator needs to put in the time to develop the resources in the initial stages. The student also needs to afford the time in their schedule to watch the video and complete the quiz. However, if the online resources are mobile compatible, then students have even more flexibility in their schedule. Future work in this field will be to research the types of interactive pre-laboratory activities. The approach we used was very simple, however, gamification theory can be used to engage the students in the pre-laboratory activity.

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Tristan Clemons
Tristan is a National Health and Medical Research Council research fellow at the University of Western Australia (UWA) interested in the teaching and learning of chemistry at the undergraduate level, especially in the roles of laboratories and laboratory preparation of students. Through his work, Tristan has been recognised for a number of awards including a WA Young Tall Poppy Award in 2014 a UWA Award for Exceptional Contribution to Education Futures in 2016 and recently in 2018 recognised as a 40 under 40 winner as an influencer in the WA Business Community under 40 years of age.

Nikki Y Man
Nikki completed a PhD in organic chemistry and microbiology at the University of Western Australia (UWA). Having taught instrumental music since 2007, she added chemistry laboratories to her belt from 2013; in the same year, she became part of the UWA Travelling Scientist program, delivering science talks in the remote Kimberley region. She was a finalist in the Royal Society of Chemistry’s Chemistry World Science Communication Competition in 2016. In 2017, she was a visiting lecturer in organic chemistry and academic skills at Southwest University China for the Australian Education Management Group. Nikki is currently a postdoctoral researcher at the Max Planck Institute of Colloids and Interfaces, working in the outreach-specialised research group, “Kitchen Lab”.

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Cara is currently a masters student at the University of Western Australia. Her research project is focused on developing pre-laboratory activities for a first year chemistry unit. She is the recipient of the Raoul Robellaz Kahan Scholarship and a Government Research Training Stipend.

Dino Spagnoli
Dino Spagnoli is the coordinator of first year studies in chemistry and biochemistry at the University of Western Australia, which involves coordinating all activities related to online quizzes and laboratories for first year chemistry units. He lectures and coordinates large first year units with cohort sizes between 100 and 450 students. Along with Tristan Clemons and Shannan Maisey, he won the UWA Award for Exceptional Contributions to Education Futures for his work on developing online pre-laboratory videos in 2016. He also was nominated and the recipient of the 2016 UWA Faculty of Science Excellence in Coursework Teaching (Level 1) award.

Siobhán S Wills
Siobhán completed a PhD in carbohydrate chemistry at the University of Western Australia (UWA). During her PhD, she volunteered in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) STEM Professionals in Schools program, delivering science outreach education in primary schools, as well as demonstrating undergraduate chemistry laboratories. It was through demonstrating that Siobhán had the opportunity to delve into chemical education research, helping to design pre-laboratory exercises and videos to mitigate stress and anxiety associated with labs for first year students. Siobhán currently works as a postdoctoral researcher for Bayer AG CropScience in Germany.
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