Under the Microscope: Co-operative Learning and Assessment in a Level One Biology Course

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Abstract

This paper discusses and evaluates a group task developed to enhance and assess level one Biology students' microscope skills. The task involved students developing and producing an instructional video on how to use a microscope accurately. In addition, students were asked to write a reflection on the process and its effectiveness for their learning of microscope skills. The initiative was underpinned by the principles of assessment for learning and co-operative learning. The task was designed to improve student outcomes and was also an action research project to enhance the teacher's own teaching skills. The expected outcome of a discernible increase in microscope skills was observed by teaching staff and reported by students. Unexpected outcomes included much greater peer teaching within the laboratory setting including microscope use as well as greater social cohesion within student groups.

Introduction

Science as a discipline requires the acquisition of conceptual knowledge as well as core competencies. These competences compose a skill set required by science graduates in order to participate in the workplace. However, teaching and learning approaches as well as assessment do not always enable the development of practical skills. With ever-increasing classroom sizes, reduced contact hours and greater research demands on academics, assessment is often relegated to the evenings and weekends. This results in assessment items being standard formats disconnected from the learning experience including traditional essays and reports that can be graded in the absence of the student. Practical skills are difficult to represent in writing and therefore are often not assessed, resulting in the production of graduates that may lack key skills. The limited focus on practical skills assessment may suggest to students that these competencies are less valued when compared to knowledge assessment of concepts and major theories (Knight, 2004, p. 13). Educators are thus faced with the challenge of developing assessment items that enable students to demonstrate both concepts and competencies.

Not only do the narrow assessment models make it difficult to develop and assess practical skills, but also, these traditional assessment methods do not align with the many changes in contemporary teaching and learning processes. Contemporary higher education is experiencing a revolution of sorts as pedagogical considerations become increasingly important and technology opens up multiple strategies for teaching and learning. Many of the traditional methods of teaching are being examined and questioned, for example emerging

research on flipped classrooms shows greater student performance over traditional transmission lectures (O'Flaherty & Phillips, 2015) while online learning is allowing greater flexibility and student-paced learning (Richardson & Swan, 2003). Translating these changing education paradigms into assessment practices has proved especially challenging. It is generally agreed that assessment practices have lagged behind in terms of change (Boud & Falchikov, 2006).

The benefits of employing a broader range of more creative assessments are well supported by the literature on assessment. Of particular relevance to this initiative are the concepts of assessment for learning, co-operative learning and self-evaluation. These concepts provide a strong theoretical framework for a move away from assessments that focus on the measurement of a final product. Such traditional assessments are often attractive to teachers of large classes because they seem easy to mark. However, summative assessment is fraught with problems including issues around the validity of assessment, the propensity to promote shallow over deep learning (Biggs, 2003) and increased stress for those involved in the assessment (Craddock & Mathias, 2009). By contrast, assessment for learning has been reported to have less stress and higher levels of engagement and to support authentic learning (Carless, 2007; Craddock & Mathias, 2009; Gibbs, 2006). Assessment for learning has the goal of improving the students' abilities in a given task and is designed to help students understand their own learning by showing them where they are at with a task and help them identify (through feedback) what they need to do to progress (Irons, 2008). Implementing assessment for learning is well-suited to the laboratory. Within the laboratory setting, students and teachers are uniquely placed to engage in dialogue and the associated learning around the assessment process. In this environment, students can become more active participants in assessment, and co-operation between students as well as between students and teacher can be fostered (Boud & Falchikov, 2006).

The laboratory context also fits well with the theory of co-operative learning and assessment. Co-operative learning and assessment where students work towards a common goal has been shown to increase the learning of all members of the group (Johnson & Johnson, 2009). Social interdependence theory suggests that the behaviour of one person will change when others are relying on them. This will be more prominent when students that have established a co-operative base group, that is a stable group that provides an environment in which students are happy to exchange and explore ideas (Johnson & Johnson, 2009). When these inter-dependencies result in positive results (goal or reward) there is evidence that co-operative learning results in greater understanding (higher achievement) and increased interpersonal skills (Johnson & Johnson, 2009; Johnson, Johnson & Smith, 1991). Student-student interactions allow students to learn more from the content because they hear how their peers have interpreted the information (Biggs, 2003). This increases not just knowledge gained, but also helps students to think differently as they explore how other people arrive at a given conclusion. Working as a team not only improves communication skills, but builds friendships that are valuable in any setting (Biggs, 2003). Integrating these co-operative processes into the assessment can thus have many wider benefits for student learning during the course of the assessment process.

With an increase in blended learning approaches, students are increasingly using videos to assist in their learning (Mitra, Lewin-Jones, Barrett & Williamson, 2010). Beyond passively watching videos, using interactive media where students engage with the video in some way further enhances their learning (Cherrett, Wills, Price, Maynard & Dror, 2009). The creation of videos can also be used to extend students' knowledge and have been used to improve skill

acquisition in chemistry (Erdmann & March, 2014) and student engagement with their own learning (Ryan, 2013).

Rationale and study aims
The limited assessment of core competencies meant that certain science skills were identified as not being adequately developed by biology students at the institution in this study. One such deficit was that students were not proficient in the use of microscopes. Post-graduate students who assisted in teaching laboratory classes were unable to demonstrate to novice students how to use a microscope accurately. This made it evident that this particular skill was not being well taught or learnt throughout the degree. A review of previous assessment items on microscope use indicated that the only assessment had been paper-based questions on the parts of the microscope. At that time, there was no evidence of assessment of procedural learning. Consequently some students came to the end of their degree who were still unsure of the correct microscope procedure. To combat this problem it was decided to trial an initiative in which year one students were required to create videos explaining to their peers how to use a microscope.

This paper therefore seeks to answer two research questions:
1. Is the use of this assessment strategy (making a video) an effective way of improving microscope skills?
2. Are there any other observable impacts on the students' learning as a result of the use of this strategy?

Methods

Student introduction to the video task and planning
Students enrolled in a level one Biology course (*n*=187) were asked in their first week of laboratory classes to rate the importance for a biologist of being able to use a microscope (1=little importance, 10=high importance). After the survey completion, students were asked to read through the assignment task.

In this task, students were instructed to work in small groups (2-4) to create a short (~5 min) instructional video on how to use a microscope. Their target audience was a naïve user starting a new job. Around 10 minutes were spent discussing expectations for the assignment as well as the rationale. Students were asked to seek help from teaching staff over the following four weeks while using microscopes and were encouraged to practice with their group members.

Microscopes were used every week for the first four weeks of semester; from week four onwards student groups were able to book the laboratory for filming. Student groups had 40 minutes access to the laboratory during which to produce their video and filming took place over a five week period. This included a two week teaching recess which allowed flexibility in timetabling for students to access the laboratory.

Filming and video submissions
Students were advised that cameras were available but were given the option to film on any device. The majority of student groups used their mobile phones to film. On arriving at the laboratory, students were given an opportunity to ask any questions, health and safety was discussed, and then access was granted to the first year teaching laboratory. The laboratory is equipped with Olympus CH-2 binocular microscopes and the students were also able to

request additional props such as slides, cover slips, and test tubes. No teaching staff were present in the room while filming occurred to allow for privacy; however, due to health and safety requirements the laboratory door was kept open and the course's senior tutor was within 5 metres of the laboratory.

Most student groups completed filming within the allotted 40 minutes time. However, some groups booked more than one session. After filming some student groups spent time editing their videos although editing was not a requirement and it had been made clear to the students that unedited videos were acceptable. On completion videos were uploaded to wevideo.com, youtube.com, or submitted directly on a USB. The different options allowed for student preference, because some students were not confident or comfortable putting their videos online. While some students had no concerns about privacy, other students wished for their videos to only be viewed by the assessor.

Student reflections and task grading
The video was graded as a group assessment. In addition, students were asked to submit an individual reflection online through the eLearning Moodle platform. This involved a series of guided questions that students were asked to respond to covering self-assessment, self-reflection, and overall critique of the task. The reflection was a place for students to identify mistakes made in their video. Such identification of errors was then treated as a correction when marking. They could also state what they would have liked to achieve, so that if they had wanted to edit in a specific way but did not have the technical ability they could express this. The reflection was also a place to address any issues encountered in working as a team, and to suggest improvements for future iterations of the task.

The videos themselves were marked along with the students' self-reflection. All grading was undertaken by one person for consistency. The grading criteria included clarity of communication as well as the actual microscope usage explanation; see Appendix 1 for the marking criteria. The marker was looking for an explanation of the different parts of the microscope, as well as the basic procedure on how to mount a slide, adjust focus and light, as well as trouble shooting. The overall allotted grade was the individual grade added to the adjusted group grade based on mistakes identified within the reflection, and was worth 5% of the first year course mark. The reflections were used to evaluate the success of the task based on the students' own perception of improvement in microscope skill development, as well as reflections on soft skills such as working in a group. The average time required to mark the assessment item was 10-15 minutes per video, which included reading the reflections of all students within the group (3-4 students).

Task evaluation
From week one, observations were made on students' use of the microscope. Interactions between students were noted, for example when students helped each other using the microscope. Questions and requests for help from teaching staff were also recorded during the students' first and third encounter with the microscope. Prior to the students arriving in the laboratory, all teaching staff were briefed on the requirement to record questions asked during the laboratory session. The type of questions asked in relation to the microscope were recorded and categorised as technical or clarification (see results table 1 for example questions). Technical questions were questions that were more focused on the set up of the microscope, while clarification referred to questions about what the students were actually seeing under the microscope. The type of question asked of teaching staff after completion of the task was also recorded to give a post-video comparison.

Results

Research question 1: Is making an explanatory video on using the microscope an effective way to improve students' microscope skills?

The results of the initial question posed on the importance of microscope use demonstrated a very strong belief by the students that microscope skills are fundamental for biologists. Every student rated the importance at over 8.5 out of the possible 10 ($\bar{x}$=9.4), and 43% of surveyed students rated the importance as 10.

An indication of the effectiveness of the initiative in improving students' microscope skills was the noticeable shift in the types of questions that students asked when seeking help in the laboratory. Table 1 shows some of the questions asked during the laboratory sessions and how they were categorised. In general, the main problems were being unable to focus and not knowing how to use the microscope lighting. Both of these issues related to students being unfamiliar with how to use the microscope and were therefore technical questions. Only two examples of clarify questions are provided in the table because all the clarify questions related to the same concerns as the two recorded here.

Table 1. Examples of student questions when asking for help in the laboratory and how they were categorised.

Help sought	Category
There is nothing on this slide	Technical – student was unable to focus
When I look down all I see is black	Technical – student does not have microscope on
I can't use two eyes, is this ok	Technical – student needs to adjust body or scope
Can you help me focus	Technical – student was unable to focus
I can't focus on 40x lens but 10 was ok	Technical – student has slide face side down
Is this what I'm supposed to be looking at	Clarify – seeking clarification for correct cell
Which cell is prophase	Clarify – student unsure of cell

When comparing student questions between the three observations (first microscope use, third use, and post-video task) it was clear that students had developed the ability to use the microscope (Figure 1). Most noticeable is the absence of technical questions being asked after completion of the video task. The frequency of clarifying questions did not change, which was expected because students were encountering new material under the microscope in each session and therefore were unfamiliar with what they were observing.

The videos that the student groups produced and the student reflections also provided indications of an improvement in the students' microscope skills. Overall the videos produced were excellent; the average grade was 90% (group mark plus individual reflection mark). Students were able to demonstrate their ability in microscope use as well as have fun in their assignment. Around 90% of students reflected that they felt their own skill level was higher now than prior to the video creation. Additionally, those students agreed that the task had been enjoyable for them and assisted their overall learning. The remaining students felt their own skills had not improved; some reported that the task was "*a waste of time and not worth the effort required*". Some of these students were repeating the course and therefore might have felt that they were already proficient in microscope use.
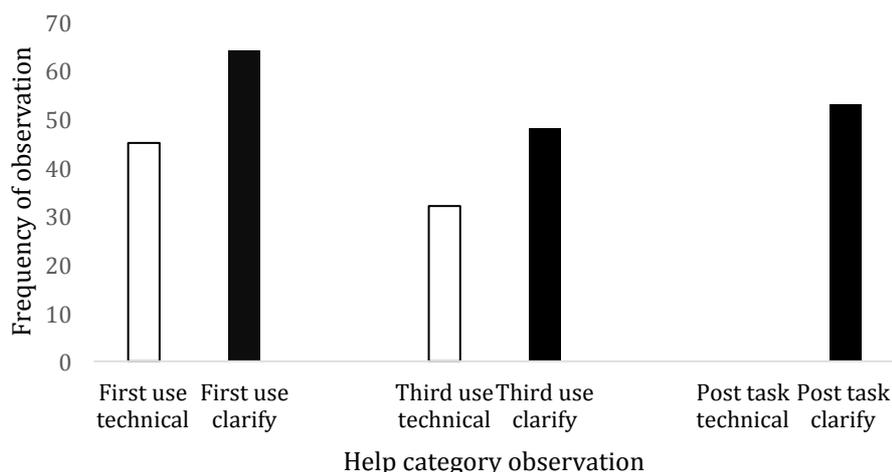
Figure 1. Frequencies of categories of student questions before and after the video task was completed. Frequencies are total number of questions asked.

Research question 2: Is there any other observable impact on students' learning as a result of using this strategy?

While we do not have extensive evidence, observations made indicated a potential for rich co-operative learning in this initiative. For example, a group of four students were working around one microscope and had called teaching staff over because they were having trouble finding their specimen. When the teacher instructed the students to start the process of focusing again, one student took control and proceeded to start focusing but another student quickly spoke up suggesting a better method. The second student then instructed the first student how to use the microscope leaving the teacher to merely observe. Similar instances of students teaching students were observed on multiple occasions.

As the semester progressed it became apparent that student collaboration had extended beyond the teaching of microscope use. For example, a student came in to a different laboratory class time and asked if he could practice using the microscope. Instead he ended up helping other students in the laboratory. After explaining to a group a better way to adjust the light and therefore see the specimen in greater detail he went further and was able to help them answer one of their laboratory questions. Afterwards he commented that he understood one of the experiments "*so much more now*" because of being asked questions by the students that made him "*really think about what it meant and how best to explain it*".

Another broader observable impact was the positive impact on the social dimension of students' learning. This was apparent in student reflections. In this section students were encouraged to be honest because this was a space for their voice. Some of the themes that came through were the camaraderie of the exercise and the notion of having fun; selected quotes include:

It felt kind of wrong that we had fun but got marks for it.

Working with my partner we became friends, I didn't expect that to happen but I discovered she had a really cool sense of humour.

Not only did I learn things but I had fun doing it, I liked that there was less pressure because [the tutor was] close by for help and we were able to get instant help to clarify the magnification problem. I actually finally get how magnification works!

Other students spoke about finding their place within the group, or stepping out of their comfort zone and finding they enjoyed being in front of the camera. The reflection from one student sums up the social component well:

> *To begin with I found the idea of a video extremely daunting. Right from the outset I was adamant that I did not wish to appear in the video itself and that I would be most happy behind the scenes…. My group are an extremely mixed bunch and I don't think you could picture a more unlikely grouping. Yet we came together and overcame - sometimes in the funniest ways - culture barriers, language difficulties and creative differences to find a mode of working together that managed to gel. We have all contributed to the video and so this was a team effort….Whats more, I am the 'star', something that I did not want at first and yet was so much more easier than I had imagined it to be.*

Discussion

The expectation of the initiative was that the creation of an instructional video and the associated processes would improve students' use of the microscope. In particular, these processes involved more student-student discussion and more teacher-student interaction than in traditional assessment of learning. This increase in interactions is in line with the assessment for learning paradigm, which emphasises process and dialogue around process. The success of the initiative was shown in the shift in the kind of question that students asked. After the initiative, questions were related to what the student was seeing under the microscope rather than on focusing or other set-up issues. The improved technical understanding reflected what the students also felt, with most students reporting that their own ability to use the microscope had increased. This outcome is not surprising. The requirement to clarify something to an inexperienced person compelled students to think systematically and deliberately about the process. Such deliberation, and the ensuing practice, developed the necessary skills to use the microscope correctly.

While it was not possible to determine the average length of time spent on this assessment, it is likely that the time investment was greater than 30 minutes for most students. When considering this time investment, it could be argued that the same results could have been achieved through rote practice. However, the advantages of this assessment item were that students came into the laboratory in their own time so no class time was sacrificed, as well as the reported fun students had learning. While the students were extrinsically motivated to learn through the allocation of a grade, self-reports of having fun suggest an underlying intrinsic reinforcement of the task (Malone & Lepper, 1987).

The outcome of greater co-operative learning was unintended. In witnessing the spontaneity of peers teaching each other it became apparent that there was an underutilised resource that could be cultivated. The premise for the video was that teaching is an excellent mode of learning; it is often through teaching that areas of weakness are exposed and deeper understanding arises (Marbach-Ad & Sokolove, 2000; Skinner & Welch, 1996). It was rewarding to see students embrace co-operative learning. From this development, future laboratory exercises will aim to capitalise on this co-operative learning further.

The assessment item was also revealing in terms of some of the prevailing thinking about assessment that it exposed. For example, when in the laboratory filming, some groups approached the course tutor to ask for help. More than one group asked if it was ok to seek assistance because they felt like it was cheating. This was an interesting observation;

assessment is so often a private affair and there is a tendency for students and teachers to experience power dynamics where the teacher holds the power (Higgins, Hartley, & Skelton, 2001; Jamieson & Thomas, 1974). Indeed for assessment to function properly it needs to be clear to the students what is expected of them, making dialogue vital. We cannot assume students will have the level of assessment literacy that allows them to interpret a given assignment even if the teacher is sure it is written clearly (Smith, Worsfold, Davies, Fisher & McPhail, 2013). This idea of opening up a dialogue around assessment with the students and working with them still encounters resistance, particularly in science which has a tendency to favour traditional assessment modes. However, interactions such as the ones described should not be ignored and should signal the need to have communication with students around assessment, not just an expectation that they will understand the criteria (Smith et al., 2013).

The students' reflections of their feelings indicated they were not stressed because of the amount of help given prior to producing the videos. This reinforces the importance of providing formative feedback as a way of fostering learning through reduction in anxiety. Assessment is often a fraught experience for students and conversations around expectations can support students to develop skills to a level of competency. Consequently in our design anxiety around assessment is reduced and genuine learning has taken place. Correspondingly providing support during the learning process can facilitate deeper and longer-term learning (Chin & Brown, 2000). With deeper learning students should be able to solve problems and make links between new and existing knowledge (Biggs, 2003). Shifting students towards a deeper learning approach increases the quality of their learning and promotes long-term learning (Prosser & Trigwell, 1999).

The student reflection part of the initiative proved to be a very significant component. With the video there was no draft copy; on completion of the video and re-watching, any mistakes identified could not be easily fixed. Allowing students to discuss their mistakes and then marking them as correct allowed for this. Furthermore reflection allowed students to engage in self-assessment, a skill that requires some practice. Reflection results in the learner 're-processing' information, which solidifies the learning (Moon, 2001). From this point of view, reflection therefore is similar to revision that students would do prior to a test. Too often the structure of assessment items (such as multiple summative pieces) means students do not revisit concepts after completing an assessment item.

The value of the project transcended the increased proficiency in microscope use. The initiative also demonstrated a useful technique for assessing practical skills. With students reporting having fun while learning and increased confidence in microscope use, it is clear that the assessment met its goals. The unintended outcome of greater co-operative learning filtering through the classroom opens opportunities to explore this as another avenue of teaching and learning for students. An increase in co-operative learning will complement greater transparency and dialogue in the assessment process. Both approaches will seek to lessen traditional power dynamics of teacher versus student within the class.

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Appendix 1. Marking criteria for microscope video group task

Group _____   Lab stream _____

Creativity (5 marks)		
Could include things such as: • Students were in the video • Company name or similar • Students introduce themselves • Use of editing (credits, transitions, music) • Other creative aspects		
Comments		
Accuracy (25 marks)		
Should include things such as • Explains different parts of the microscope • Magnification vs objective • How to put on slide • How to move slide around the stage • How to focus starting with 4x lens • Moving to higher powers • Ways to adjust light (voltage control and iris) • Use of condenser • Troubleshooting		
Comments		
Communication (10 marks)		
• Purpose of task was explained • Instructions were clear		
Comments		
Total Video Group Score (/40)		

Name _____

Reflection (10 marks)	
It is expected that any mistake made during filming will be addressed in the reflection, as well as questions on Moodle answered. *Comments*	
Total score assignment score (/50)	

NB: Your group score is added to your individual reflection score. In addition, any mistakes identified in your reflection will be added to you INDIVIDUAL REFLECTION mark.