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Title: A flipped classroom approach to teaching oral pathology using virtual microscopy - the Glasgow experience.

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Title: A flipped classroom approach to teaching oral pathology using virtual microscopy - the Glasgow experience

Abstract: This paper describes a student-centred, integrated teaching model in which oral pathology and oral medicine staff members jointly deliver tutorials in a combined on-line and face-to-face format. Students are provided with clinical and histopathological information, which they must review and use to answer questions via a Virtual Learning Environment before the tutorial takes place. By reviewing the students' answers on-line before the teaching session, staff can focus the tutorial itself on resolving knowledge gaps and afterwards post a set of gold standard answers on-line for students to reflect upon.

Clinical relevance: This article illustrates a combination of teaching methods and modern technologies which integrate clinical with laboratory sciences and enhance the access of students to histopathological materials without the need for access to a traditional microscopy facility

Objective statement: To understand how a novel combination of flipped classroom and virtual microscopy can transform the teaching of oral pathology in a clinical context.

Introduction

Many of us will recall, as students, the horrors of undergraduate histology and histopathology practical classes. The frequent difficulties of identifying cell types and understanding tissue structures reflected, to a large extent, the lack of suitable educational tools for tutors faced with large classes of students who were supplied only with traditional microscopes and glass slides. Thankfully, technological advances have permitted dramatic improvements in the teaching of these subjects, particularly with the advent of virtual microscopy in which histological specimens are scanned to provide virtual slides that can be stored and shared over computer networks. These images can be viewed independently on any computer that has internet access and the user has the full functionality of a traditional microscope (movement around the slide and multiple magnifications) through the computer. Modern technologies ensure that virtual slides have a high resolution and they are resistant to damage or breakage. Other advantages include the removal of a need for access to a traditional microscopy suite, improving student access to histological materials and reducing maintenance costs for teaching institutions.

The first steps in the field of virtual microscopy took place in the 1980s and early 1990s.¹ Technological advances continued rapidly and commercialisation of virtual microscopy started in the late 1990s, when several companies developed a file format for storage of virtual slides that allowed images to be streamed over the internet.²

Integration of the virtual slides with an annotator applet in a database structure followed in 2001. This now made labelling of sections possible, in addition to linking the slides with gross images and textual material.³ By this stage the virtual

microscope was ready to be used to its full advantage in teaching and assessment, not only of undergraduate students but in continual professional training and development as well, for example distance-learning and clinico-pathological conferences. It is the combination of this new technology with a method of teaching delivery called the 'flipped classroom' that is the subject of this paper.

What is a 'flipped classroom'?

The pioneers of the flipped classroom concept (also known as the 'inverted classroom') were two American educators, Jonathan Bergmann and Aaron Sams.⁴ It is defined as: "*... a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter*".

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Whilst originally conceived for school teaching, the idea has quickly spread to higher education. The flipped classroom includes elements of both on-line and face-to-face teaching with the on-line component preceding the direct phase of teaching. The student has the responsibility of learning the topic (homework) whereas the facilitator engages in direct discussion and feedback in the classroom. In this way pre-class activities are used to help deepen students' knowledge.

Use of the flipped classroom in medical education has been documented in several subject areas, both undergraduate and postgraduate.⁶ These include radiology,⁷ primary care diagnostic skills,⁸ physiology,⁹ obstetrics¹⁰ and pathology.¹¹

In dental education, the flipped classroom model has been applied in a number of settings. One successful model has been the use of the flipped classroom method for pre-clinical skills teaching at Glasgow Dental School.¹² The flipped classroom method has also been used successfully for teaching paediatric dentistry,¹³ dental anatomy¹⁴ and prosthodontics.¹⁵

What is novel about the teaching described in this paper is that it employs virtual microscopy in a flipped classroom setting. Most of the published studies describing flipped classrooms in pathology have used videos as the online part of the classroom, after which students participated in learning activities designed to test knowledge acquisition. However, as discussed by Irma Sandercock of Arizona State University, unless it is combined with other strategies, watching videos as part of the learning process is considered to be passive learning, not dissimilar to a student sitting and listening to a traditional lecture.¹⁶

The over-arching definition of active learning is any instructional method that engages students in the learning process, requiring the students to do meaningful learning activities and give thought to what they are doing.¹⁷ The major advantage associated with use of virtual microscopy is that this is an active process during which the student seeks the correct answer to the questions by studying the details of the slides in the context of clinical information and further reading. The advantages of active learning are well recognised¹⁷ and we believe the combination of the flipped classroom with virtual microscopy provides exciting opportunities for both undergraduate and postgraduate education.

The Glasgow model

In the currently used model, joint oral medicine / oral pathology tutorials are timetabled as part of the oral diseases course, predominantly during the Fourth Year of the BDS programme. They are delivered by staff members from both oral medicine and oral pathology, who teach together as a team in each session.

Design of the tutorials centres around a specific topic area, for example oral mucosal white patches. Digital scans of the teaching slides are hosted on the commercial website Slidepath® (<http://www.leica-microsystems.com>). This software provides the opportunity to incorporate narrative around each slide, so suitable clinical scenarios are created to accompany the histopathological material, and annotations can also be added onto each section. Hot links can be incorporated into the text, focusing on aspects of the histopathology, relevant journal articles, clinical images, websites and any other appropriate resources, thus providing the student with a comprehensive review of the topic (Figure 1).

The software used in this website also provides scope to design a questionnaire for each slide. These questions may either be in multiple choice question or short answer format (Figure 2). In preparation for the tutorial and as a key element of the flipped classroom approach, students must answer the questions. They are able to save their work as they proceed and can return to make changes as often as they wish, before submitting on or before the deadline. Once the answers have been uploaded, each student can view all the submitted answers, presented anonymously, from the entire class.

These materials are all accessed by the students via the Virtual Learning Environment (Moodle®) before the relevant tutorial.

One of the major advantages of the digital interface, which makes it excellent for teaching, is that all students are viewing exactly the same section. The fact that certain areas and structures can be outlined and annotated provides a superb teaching tool, enabling the students to all view the same cells/structures, hence saving time and effort for the teachers. Viewing can be customized further by use of a toolbar for brightness, contrast and even for viewing in black and white, which may be a preference for some users.

During the subsequent face-to-face session (Figure 3), each slide is viewed by the teacher and the class, with a discussion covering the clinical description, differential diagnoses, pathogenesis, management and treatment options. The main pathological details are observed and commented upon, after which the pre-session questions and group answers are reviewed. From the teacher's perspective this helps significantly to define areas of the topic that are causing confusion with students and to disclose knowledge gaps. Discussion in the session can then focus on these areas of difficulty and thereby reinforce learning. The teacher can also access each individual student's answers, which is useful for monitoring student participation in the sessions. A gold standard set of answers provided by the teaching staff is posted on-line after the face-to-face session, providing additional opportunities for feedback and student reflection.

One of the enjoyable aspects of this type of teaching is that no two sessions are the same because they are largely directed by answers the students have submitted, resulting in the opening of many different avenues of discussion. Furthermore, involvement of both oral medicine and oral pathology staff in the tutorials serves to

demonstrate the link between the two subjects when diagnosing oral diseases and formulating a treatment plan.

Advantages and disadvantages

Introduction of any new form of teaching requires careful consideration in relation to pedagogical suitability, together with assessment of the advantages and disadvantages for students and teaching staff. Student feedback has been very positive as exemplified by the following quote

“As a BDS4 student, I can compare the traditional microscopy experience from my first year at Glasgow Dental School to the digitised images we have been able to use this year. The difference is incredible, and I am sure my entire year would agree. The new software gives the ability for students to access the slides from home, at all times, and there are also annotations and descriptions on the slides which are beneficial for revision purposes.”

Tables 1 and 2 summarise the advantages and disadvantages that we have identified during use of this technology-enhanced flipped classroom approach.

Conclusion

The flipped classroom, combined with virtual microscopy, has proved an effective and flexible model for the delivery of oral pathology teaching in a clinical context. The engagement of students as active learners has proved popular with them and the

flexibility of the process makes it attractive to tutors, who can provide more closely focused instruction in the face-to-face sessions.

Acknowledgements

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Advantages
All students acquire some knowledge of the subject before attending the face-to-face class
Feedback can be given during the face-to-face session when viewing the submitted answers
Flipped classroom approach reveals knowledge gaps which can be rectified during the focused face-to-face session
All students can visualize the same area/structures on the same section at the same time, providing a highly standardised experience
Display of each standardised section on a screen during class saves significant teaching time, allowing three cases to be comfortably completed in 90 minutes
The ability to provide links within each package to other resources for students to use for their self-directed learning in the pre-class phase
Disadvantages
There is a reliance on technology and software, which may on occasion cause issues in preparation and use of the teaching material for the flipped classroom
At higher magnification (x40), some small details and colours may not show up quite as clearly as under the light microscope
Programmes for viewing software may not be compatible with some devices
Investment of time is required to develop the on-line teaching materials

Table 1. Perceived advantages and disadvantages of the flipped classroom virtual microscopy model for teaching staff

Advantages
Excellent and easy access to the teaching material online from any place with an internet connection
Pre-class on-line learning facilitates participation in the class discussion with oral medicine and oral pathology staff, helping to deepen their knowledge further
Rapid and detailed feedback on their on-line answers
On-line availability of the slides together with the associated resources and gold standard answers is extremely useful for revision
Ease of use of the virtual microscopy compared with traditional microscopy
Disadvantages
Occasional issues involving technology and software
Having homework!

Table 1. Perceived advantages and disadvantages of the flipped classroom virtual microscopy model for students

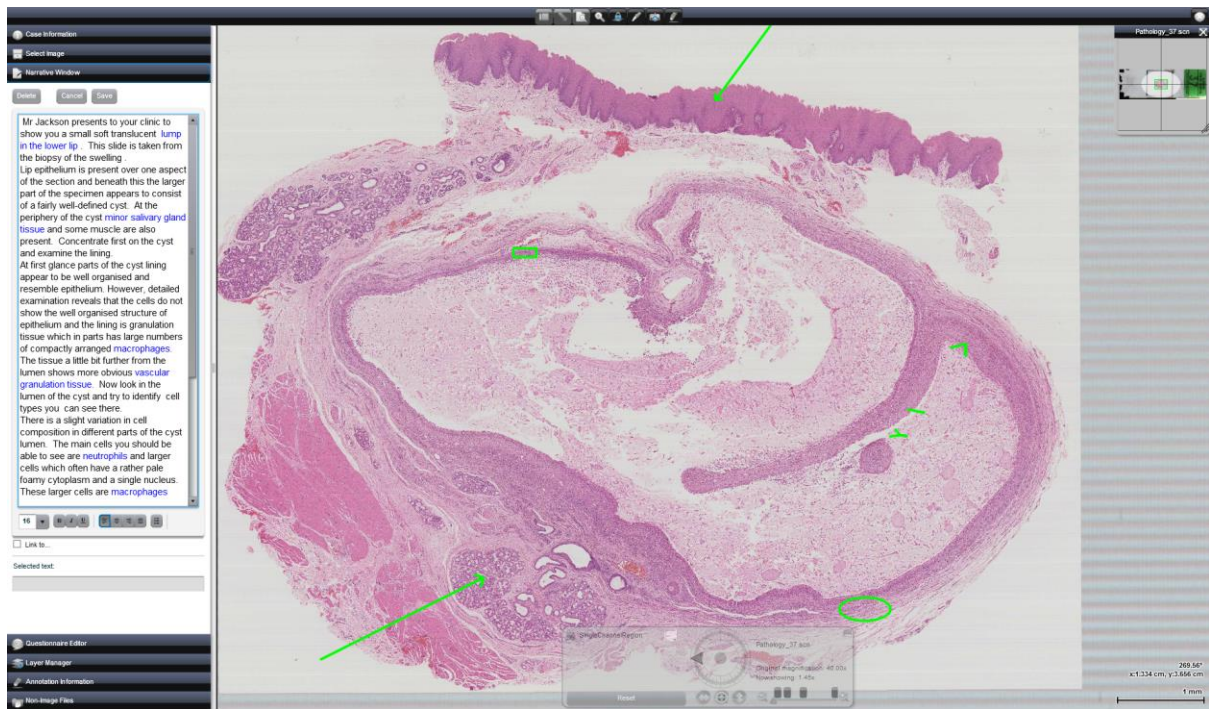


Figure 1. The use of annotations and the narrative with hot links in blue text.

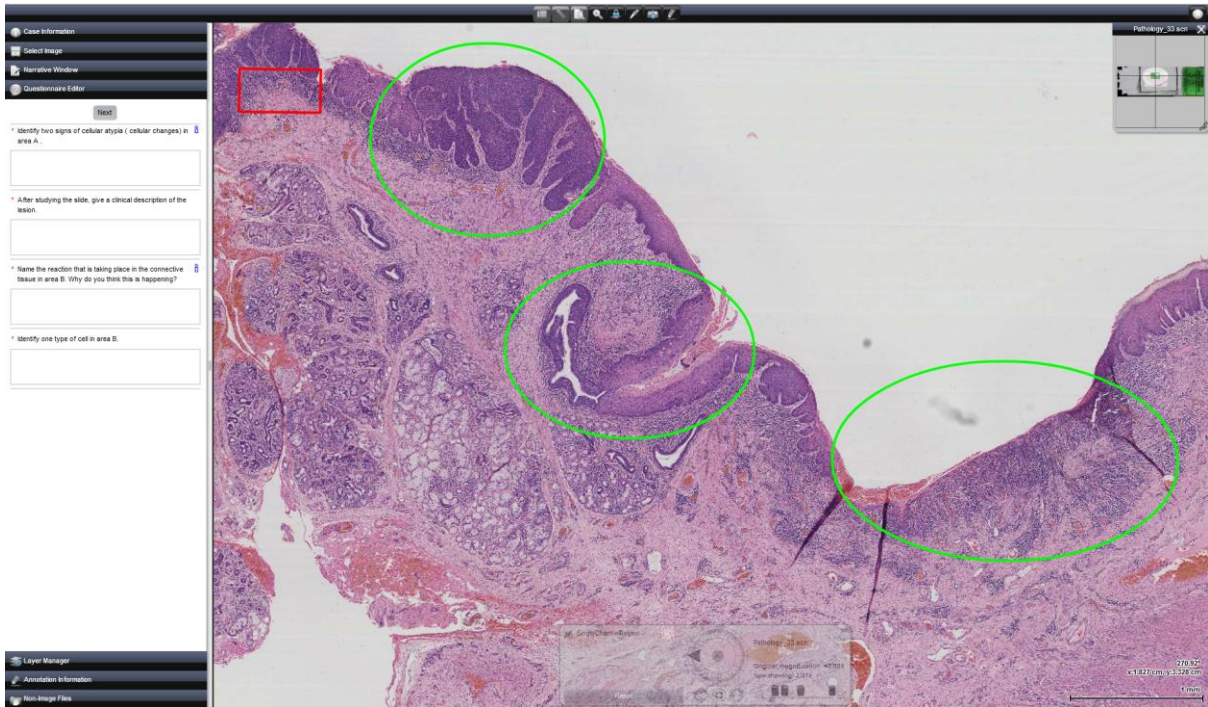


Figure 2. An example of questions posed for the students ahead of the tutorial.

