The role of the Virtual Microscope in distance learning

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The role of the *Virtual Microscope* in distance learning

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Screen-based microscopes allow for a shared visualisation and task-directed conversations that offer significant pedagogic advantages for the science disciplines involving observation of natural samples such as the geosciences and biosciences, and particularly for distance education in these disciplines. The role and development of a *virtual microscope* used in the undergraduate teaching of geoscience at the Open University is discussed and then related to current developments in the collaborative web-based technologies and mobile computing.

Keywords: virtual microscope, geoscience, distance learning, collaborative learning, mobile learning

Introduction

The provision of virtual science teaching materials is going to become increasingly important in distance-education as both the increasing use of virtual residential schools (Robinson, 2009) and the global provision of open educational resources (Gourley, 2009) begin to require the collaborative engagement of students using web-based visualisation tools and also a range of forms of on-line tutorial provision. Trials of the use of virtual microscopes in the teaching of geoscience were first undertaken at Open University residential schools in the early 1990's (Whalley, 1995) and by 2000 a CD-based virtual microscope (called the Digital Microscope at the time) was being made available to students along with their conventional 'home-kit' microscope and thin-section slide set. In 2010 a web-based virtual microscope will replace a physical microscope on a second level Geology course allowing access to an effectively unlimited set of slides and providing educationally significant improvements for distance learners in that educators can now directly relate the detailed notes in their teaching materials to the dynamic visualisations being controlled by the students.

The role of visualisation in science education

The use of screen-based virtual microscopes is relevant to most fields of science education, and extensive use has been made of this medium for teaching and transfer of visualisation for histology (thin sections, commonly of human origin, stained in various ways). Detailed studies have been made in this field comparing the use of conventional optical microscopes with computer-based virtual microscopes. These have shown both high diagnostic concordance (Molnar, 2003) and also provided examples of the successful implementation of virtual microscopes in undergraduate teaching (Krippendorf, 2005). However our prime concern in this paper is the development of a virtual *petrological* microscope which would allow the user to gain skills relevant to Geoscience, in particular skills in recognising minerals, textures and features in rock thin sections.

Geosciences degree courses commonly involve students learning to use microscopes, and in particular to learn skills that can be applied to all rocks they may encounter during a later geoscience career. The learning objectives are thus focused on learning to recognise features they observe under the microscope, rather than the physical skills of microscopy, the later are merely enabling the students to learn to recognise rock and mineral features. A virtual microscope, capable of providing an equivalent experience allows students to learn to recognise geological relevant features in thin sections but not to acquire some of the physical less important skills associated with the microscope and without the need for extensive laboratory study time.

In a conventional laboratory students view rock thin sections under plane polarised light and learn to recognise mineral colour and relief (caused by variable refractive index), and view thin sections in cross-polarised light to observe differing birefringence colours (caused by light interacting with the mineral lattice). Importantly students also rotate the microscope stage with the thin section attached in order to view colour changes (pleochroism) in plane polarised light, and extinction (where birefringence colours reduce to black) in crossed polars. The use of the petrological microscope to recognise mineral and rock textures forms a crucially important part of a basic geoscience education and is the basis of many hours of laboratory based study and tutor-intensive training.

Figure 1. about here

As with most science based courses, these practical activities are not primarily related to learning facts but are actually concerned with learning how to discriminate and classify within the paradigms of the particular discipline. In this case, whilst undertaking the practical exercise of the recognition and naming of rock samples students are really being required to develop a deeper understanding of optics, and of the rock cycle as a model representing the relationship between rock categories and the process of their formation. The problems of teaching with complex visual materials, in effect of teaching learners 'how to see' from the scientific perspective of a particular discipline, are quite general. We could therefore reasonably expect that lessons learnt from the implementation of a petrological virtual microscope would generalise to many other topics in science education. Indeed many of the advances made at each each stage of the virtual microscopes described here have helped the parallel development at the Open University of screen-based microscopes for the biological sciences.

The main advantage of screen based microscopes for distance education is that they make possible a shared visualisation which allows students to pool knowledge and have detailed task-directed conversations that are not possible within the constraints imposed by conventional single-view instruments. This can help to overcome the problems MacKenzie (1982) describes in the early stages of mineral identification with the petrological microscope, "Much of the training is acquired by patient attention by the teacher to the student. The student needs his observations verified and this can result in the teacher being summoned every minute or so; with a class of ten or more, the student is for long periods left unattended, becomes frustrated and loses interest." The conventional remedy is to provide students with sheets of reference photographs but this is still a static, and significantly poorer, learning experience as it involves no element of exploration and discovery. Perhaps the most significant aspect of the virtual petrological microscope developed at the Open University is that students can explore the thin section in the same way as a conventional thin section under a microscope. But the new microscope also includes the capability to rotate thin section views in both the polarised and cross-polarised lighting conditions at the same time. The virtual microscope allows both plane-polarised and crossed polars to be viewed simultaneously, unlike conventional microscopes where this is achieved by the insertion and removal of a second polariser. This visualisation is truly virtual in that it is impossible to create other than on the computer screen, and it is important because it makes the conceptual issues being discussed much easier to grasp for students who are just beginning to study the geosciences.

Figure 2. about here

The use of the virtual microscope provides several opportunities for students to develop skills in new and innovative ways, although there are also some disadvantages in that students do not learn some of the practical skills associated with focussing and microscope set-up which require physical feedback. Such skills are often an important part of learning science but can also be over emphasised since many students in conventional laboratory settings remain weak in this area. The main benefit of the virtual microscope is for students in less advantaged settings where there are fewer microscopes than students or indeed no microscopes at all. Students with significant disabilities or who need more time to acquire visualisation skills also gain from having access to the microscope slides outside a conventional laboratory setting. It has to be admitted that the advantages provided by the virtual microscope are counter balanced for some aspects of the learning experience by the loss of physical contact and the physical feedback associated with focussing and manipulating the rock and thin section. However, as set out in Table 1, the advantages would seem to clearly outweigh the disadvantages for distance learners and those without easy access to laboratory microscopes and significant tutorial provision. However, the overwhelming advantage of the virtual microscope for distance learners is the capability to record and recover locations in the thin section so that students and tutors can discuss features and mineral identifications.

Table 1. about here

The development of the *Virtual Microscope* at the Open University

While the Open University has provided a CD based microscope for several years it was only as an adjunct to the petrological microscope sent out to most students and was primarily used as a teaching support that allowed students to view labelled specimens. This earlier version was based on Macromedia™ software and required students to install and QuickTime™ on their hard drive in order to view the rotating views while the static views known as 'hand lens view', presented only static images of the thin section at low magnification in normal transmitted light conditions.

Figure 3. about here

The web-based microscope to be used with a second level Geology course in 2010 represents both a significant technical and educational advance over previous versions. Instead of fixed views of the thin sections available in earlier versions and via thin section photomicrographs, students can now zoom in and then pan around large areas in order to explore the slide, with a degree of magnification that would be very difficult to control on the type of microscope conventionally available to undergraduate students. This is achieved via a browser window using Adobe Flash™ and Zoomify™ software to handle images by splitting each large (commonly over 500MB) image into over 1000 files each of which is called into the browser as the user moves to view a new area. Adobe Flash™ software is used very commonly in animations on websites and thus almost all students currently have this installed on their computer enabling full engagement without the need to download any new software even on machines where they have low level privileges such as a shared computer or an internet cafe. The slides can now also be graphically annotated to aid weaker students as shown in Figure 2, and the view manipulated by hypertext links. This allows the educator to draw the students' attention to significant features or provide the answer to a particular question, or alternatively to direct questions in order to test the students' understanding. Versions of the virtual microscope that are currently under development have made use of recent advances in mobile computing (Sharples, 2002), with prototypes virtual microscopes now available for devices like the *Apple iPhone* and *iPad* there is the potential for location sensitive microscope 'apps' which allow the student to see specimens relevant to their location in the field, for example in a quarry where sample collection is not allowed for environmental reasons. The use of the virtual microscope in collaborative web-based environments such as *Google Wave* also has great potential for distance education. It will allow students to develop work groups for study outside the laboratory and to jointly interact with a 'shared vision', whilst also communicating with text or voice.

Conclusion

The only certainty with the use of computing technology in distance education is that the rate of change in developments will continue to increase, and as has already happened to some extent with the new second level Geology course at the Open University, that this is likely to lead to some aspects of a course presentation being out of date even before they are introduced. This does not have to be a problem, distance educators just have to design in sufficient flexibility to allow for the reuse of valuable teaching resources as technologies evolve that have significant educational value. This is exemplified by our move towards new HTML5 web-based and mobile versions of the Open University's virtual microscope where the valuable resource of microscope images and their related teaching materials have simply been mapped to the requirements of the different delivery mechanisms.

The *shared* prototypes of the virtual microscope that are under development have the potential to become an important new tool for science education, allowing learners to use the same software tools to collaborate with each other or to take part in interactive tutorials. These versions of the microscope will allow us to support the changing conversational styles of tutorial groups and investigate the effect of facilitating learning conversations that are extended over the period of a whole course. Enabling the transition between tutor led discussion to student led small-group collaboration on the course assignment exercises would complement the Open University's current programme to build a comprehensive online student learning environment where students genuinely become part of a community of learners.

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