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THE *DoITPoMS* PROJECT – A WEB-BASED INITIATIVE FOR TEACHING AND LEARNING MATERIALS SCIENCE

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ABSTRACT

DoITPoMS (Dissemination of Information Technology for the Promotion of Materials Science) is a web-based teaching and learning resource based in Cambridge University: *www.msm.cam.ac.uk/doitpoms*. Over a 6 year period we have developed freely accessible web-based libraries of Micrographs, and Teaching and Learning packages (TLPs). The Micrograph Library is a searchable collection of approximately 800 micrographs covering metallic, ceramic, composite and polymer systems. There is accompanying descriptive information, with links to a web-based *Glossary of Materials Science* and to relevant phase diagrams. There are now 32 TLPs, grouped into 7 broad themes. In establishing these TLPs we have designed and maintained the same basic format, in order to give the site a recognizable look and feel, but with the flexibility to include differing amounts of text, images, video clips, animations and external links, as well as interactive questions and answers. Many of these resources are now used within the Cambridge curriculum and elsewhere. Students have been involved in their development, so that they have been tailored to student requirements and are delivered in an appropriate format. They are also used by those teaching Materials Science, e.g. to illustrate how to set up and use specific laboratory practicals and demonstrations. We have strong links with the *MATTER* (Materials Teaching Educational Resources) initiative and the UK Centre for Materials Education at Liverpool, now part of the UK Higher Education Academy.

Keywords: *web-based resource; teaching and learning; Materials Science*

INTRODUCTION

Materials Science, which is inherently interdisciplinary in nature, is taught as an independent degree course in some higher education establishments, and often in association with Engineering. It is also an essential part of many other courses, e.g., physics, chemistry, electronics, architecture, engineering, design and, increasingly, environmental science, medical, pharmaceutical and other bio-sciences. There is also a general trend in schools, colleges and universities towards broad, modular course structures.

These factors lead to the requirement for efficient communication with a broad spectrum of students taking a variety of different courses, and the need for effective support and supply of teaching resources to those who teach Materials Science.

The History

The *DoITPoMS* Project (Dissemination of Information Technology for the Promotion of Materials Science) is an educational initiative in Materials Science which began with three basic aims:

(i) to increase the support offered to both students and teachers,
(ii) to promote distributed learning, and
(iii) to supplement traditional teaching methods (i.e. lectures, laboratory classes and small group teaching).

The project built on recognised expertise in the Materials Science and Metallurgy Department at Cambridge University in the use of Information Technology to enhance the student learning experience, and set out to develop and disseminate such techniques within the UK Materials Education community. Broader benefits envisaged included the promotion of awareness of Materials Science in schools and the wider community through the creation of widely available resources and through dissemination activities. In addition, the resources developed may be seen as a contribution towards the drive for expansion of access to higher education. Strong departmental links with several European research and teaching institutions through a range of activities (including student exchanges), and involvement with the recent Cambridge-MIT Institute programme, also gave access to the European and US perspectives on materials education. Strong links have been maintained throughout with the UK Centre for Materials Education[1] (previously the Subject Centre in Materials), based at Liverpool University.

DoITPoMS was initiated (in 2000) in the Materials Science and Metallurgy Department, Cambridge University, in a 3 year programme funded by the Higher Education Funding Council for England (as part of a wider project: the Fund for the Development of Teaching and Learning). This funding enabled the employment of an IT Resources Co-ordinator and a Secretarial Administrator, as well as freeing the 4 academic investigators of a small proportion (notionally 5%) of their University duties. In addition, 5 partner institutes received funding for collaborative work, and there were funds for travel and interaction with these partners.

The partners were specifically chosen to represent a spectrum of institution and student intake characteristics, and to provide comprehensive coverage of the range of disciplines within the fields of Materials Science and Engineering. It was also imperative to call upon academics with personal interests in aspects of the proposed activities, and these included the development and application of educational software, process simulations, analytical and numerical tools for teaching purposes; enhancement of teaching methods; and the promotion of public awareness of Materials Science. The Partner Institutions were: University of Manchester / UMIST (Manchester Materials Science Centre); Oxford Brookes University (Department of Mechanical Engineering); University of Sheffield (Department of Engineering Materials); London Metropolitan University (London Metropolitan Polymer Centre); and University of Leeds (Institute for Materials Research).

THE RESULT

A web-based resource has been developed, which consists of a Micrograph Library, and a Library of Teaching and Learning Packages (TLPs): *www.msm.cam.ac.uk/doitpoms*.

The Micrograph Library

This is a collection of micrographs (currently about 800), covering a wide range of specimen types and microscopy techniques. The value of the resource comes from the data which accompany all micrographs (*metadata*), effective methods for searching the site, and web links (both within the site, and elsewhere). The *metadata* fields are illustrated in the example shown in Figure 1: each field appears for every micrograph, although they may be filled to a greater or lesser extent (or not at all), depending upon the sample and its provenance. Thus the user knows what information to expect and where to look for it.

The library may be searched in many different ways: by entering a search word or term (there is both a *basic search* and *advanced search* facility), or by using links through the *metadata* fields. For example, a general *Browse* option leads to the micrographs listed according to materials *category* (e.g., ceramic, metal or alloy, device, composite, polymer, foam, etc.) and, from here, one may choose to list the micrographs of a particular category by *system*, *composition*, microscopical *technique*, or *keywords*. The list chosen may be ordered by micrograph number (simply the numeric sequence in which they were incorporated into the library), or by popularity. *Related micrographs* lists similar micrographs, including different magnifications of the same sample. Figure 1 shows the *Full record* page for one micrograph, including a thumbnail and the complete set of *metadata* fields.

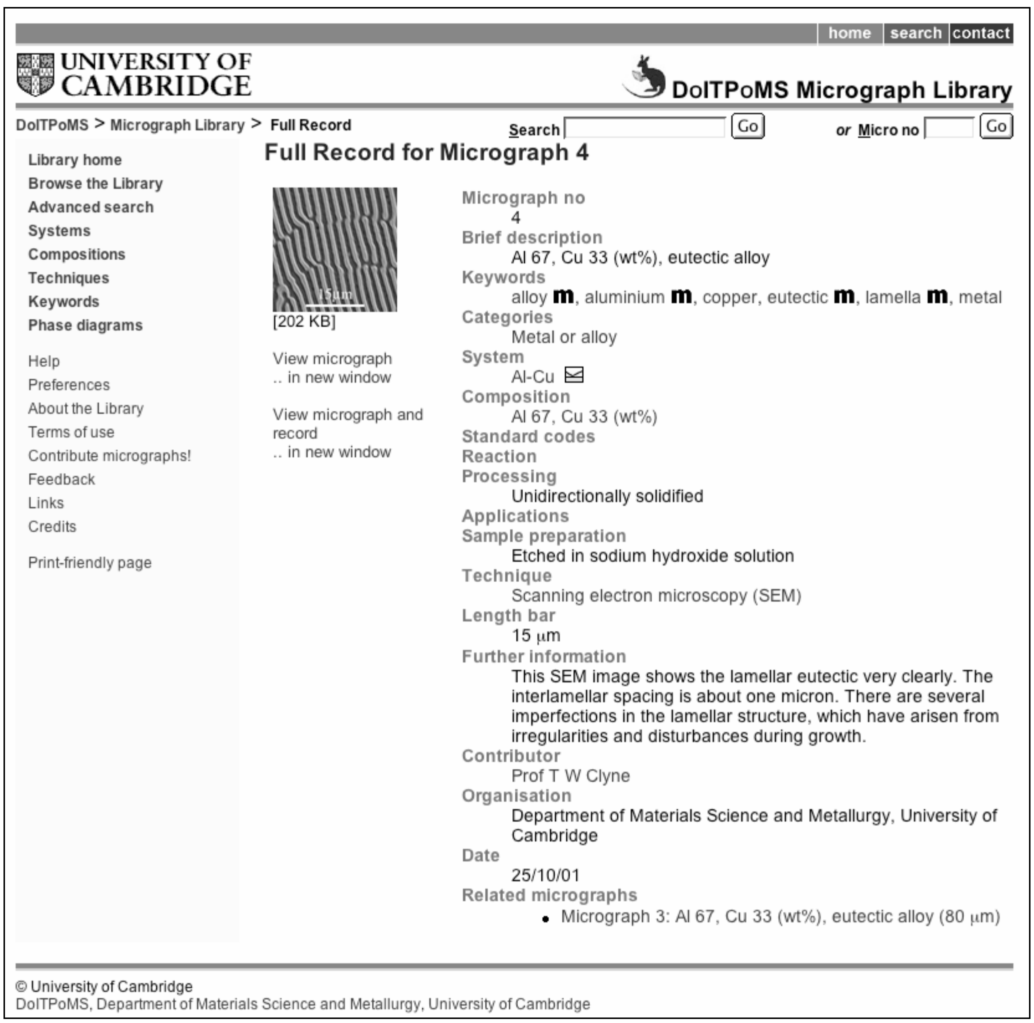

Figure 1. Web page showing the full record for one micrograph in the Micrograph Library, including a thumbnail of the micrograph itself, and all associated *metadata*.

Many systems include a phase diagram (there are currently 12 binary phase diagrams available, all linked to the relevant micrographs), and these may also be used as the basis for searching the library. Each phase diagram is interactive, in that the mouse may be scanned across it to give temperature and composition at any point. *Key words* are, where appropriate, linked directly to the *MATTER*[2] *Glossary of Materials Science*, which gives definitions.

The micrograph itself may be viewed enlarged, and may be very simply downloaded, for example using 'copy and paste', or 'drag and drop' into another document or presentation. In all cases the scale bar is shown clearly superimposed on the micrograph, which means that there are no issues with re-sizing, since the scale bar is re-sized as well.

A web page gives detailed instructions for anyone to contribute micrographs to the library, asking for all necessary *metadata*. Contributors are credited within the *metadata* (and, for example, *contributor* may be used as a search term). There is also a page on *Terms of use*, which states that images may be freely downloaded and used for non-profit making activities within educational institutions, where full acknowledgement of the source must be given. Acceptable use may be in lectures and presentations, computer aided learning materials, online tutorials, tests, homework, and educational web pages.

Teaching and Learning Packages

There are currently 32 TLPs, which are listed in 7 different groupings: *Techniques for Studying Materials*, *Structure and Properties of Materials*, *Mechanical Behaviour of Materials*, *Plasticity and Deformation Processing*, *Biomaterials*, *Materials Conservation and Recycling*, and *Energy Storage*. There is also a TLP on the *Teaching of Foreign Languages*, which deals specifically with issues related to language teaching for scientists.

The format for each TLP follows the same, recognisable pattern, so that the user knows what to expect and where to look for information. A front page includes a relevant illustration, and a list of available pages (see Figure 2a). These always begin with *Aims*, which are the learning outcomes to be expected from working through the TLP. *Before you start* gives information about any prior knowledge which may be required in advance of using the TLP. This may be linked to the *MATTER Glossary* for further explanation and, where specific knowledge is a prerequisite, there is often a link to a site to supply this information (e.g. another TLP). There then follows a set of pages containing the teaching and learning resources in the form of text and illustrations, which may include equations, animations, video clips, models, simulations etc. Full use has been made of the web as a delivery mechanism, and hence text is kept to a minimum and much information is relayed in the form of animations, simulations and video clips. Often these include an interactive element (e.g. pushing a button to begin a simulation, or manipulating a 3-dimensional representation with a mouse). Video clips are clearly labelled with their size, so that a user can estimate how long they may take to download (for example, see Figure 2b).

All TLPs end with questions which are interactive. A choice of answers may be given, and clicking on one brings up a text box: *correct* or *incorrect*, generally with some explanation. In some cases there may be a *hint* text box to click on, or a full worked answer. In addition, there are longer descriptive questions which are not accompanied by answers and hence may be used for student assignments. A *Going Further* page gives references in the form of books, articles and links to other sites.

Many TLPs are based upon laboratory practical experiments used for undergraduate teaching in the Cambridge Materials Science courses. These include details of the experimental equipment required, with instructions

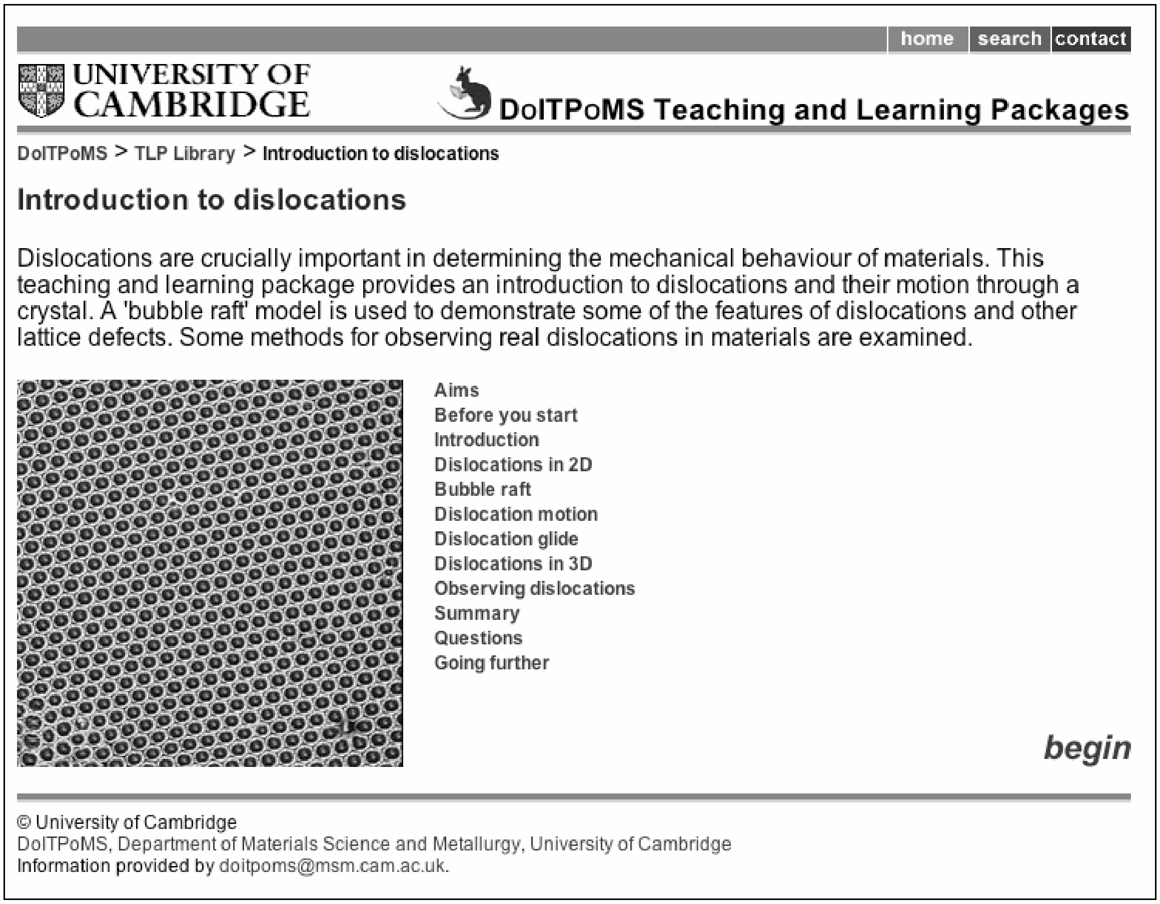

Figure 2 (a). The front page of a TLP, 'Introduction to Dislocations'.

for setting up the practical, the expected results and, where appropriate, a description of the analysis and interpretation of the results. Photographs of the equipment are often supplemented with a video clip of the practical set-up in operation and/or the experiment actually running in a practical class, illustrating the students' interaction with it. Hence, teachers may choose to use such a practical by setting it up for themselves, or may use the TLP to demonstrate the practical to a class. Students may use it to prepare for a laboratory class, or to run through a missed class, or to see what should have happened if their own experiment goes wrong.

Use of the Resources

All these resources can be used in very flexible ways. For example, the smallest unit may be extracted: a micrograph, a still from a video clip, or a diagram, to be incorporated into a teacher's own material. Alternatively, larger sections may be taken, and information from descriptions and links may be added as required. We believe that this flexibility offers the best chance of uptake by others – we do not prescribe the way a topic should be taught (although we may suggest it!), but leave this to the user.

However, the TLPs are available to be taken up in full, e.g., for a teacher to learn about a subject or topic themselves; to get ideas for practical classes or demonstrations, or to set as study tasks for students. Resources may be used by students to access at home, perhaps when a laboratory or library is not available, for set assignments, project work, or just for general revision and broadening of knowledge.

The great value of a web-based resource is the

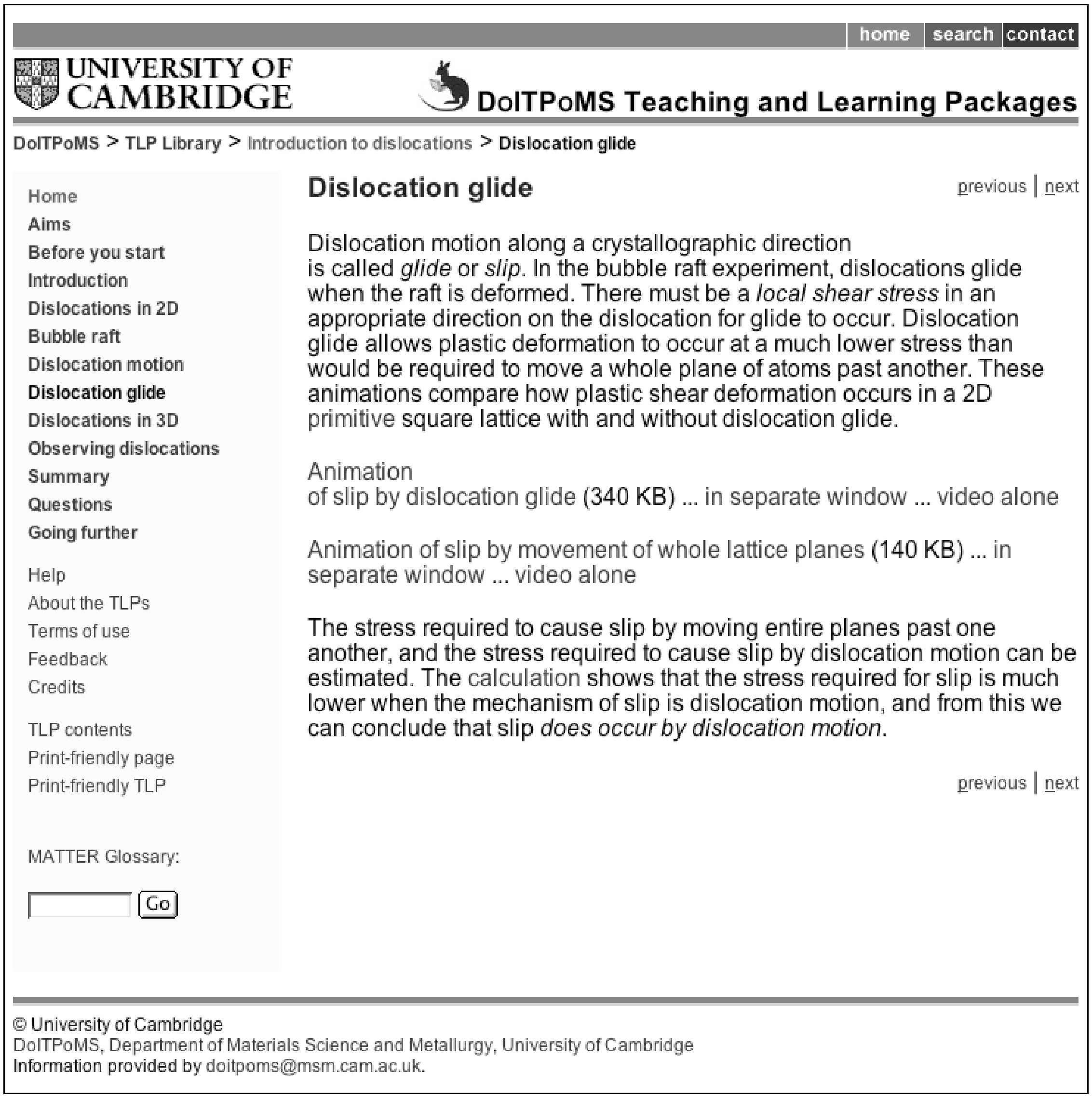

Figure 2 (b). A page from the same TLP.

ability to make links with other resources. Here we have made good use of such linking, but always aware that it is only of value if it can be assured, i.e. there is no point in linking to a web site that subsequently disappears! Hence, links through established sites are of the greatest value, and in this we have benefited from our own links with other educational initiatives, such as the *MATTER* project.

Resources include a *Feedback* page, in which users are encouraged to comment (either anonymously, or including their contact details). Many users are happy to give contact details and this can lead to valuable correspondence. It is obviously essential that any error or ambiguity is rapidly corrected and that suggested improvements are incorporated, if appropriate.

Figure 3 shows statistics from the web site: successful requests, distinct hosts served, and data transferred. There are clearly fluctuations which accompany the academic calendar cycle, and may also be linked to the appearance of new resources on the site.

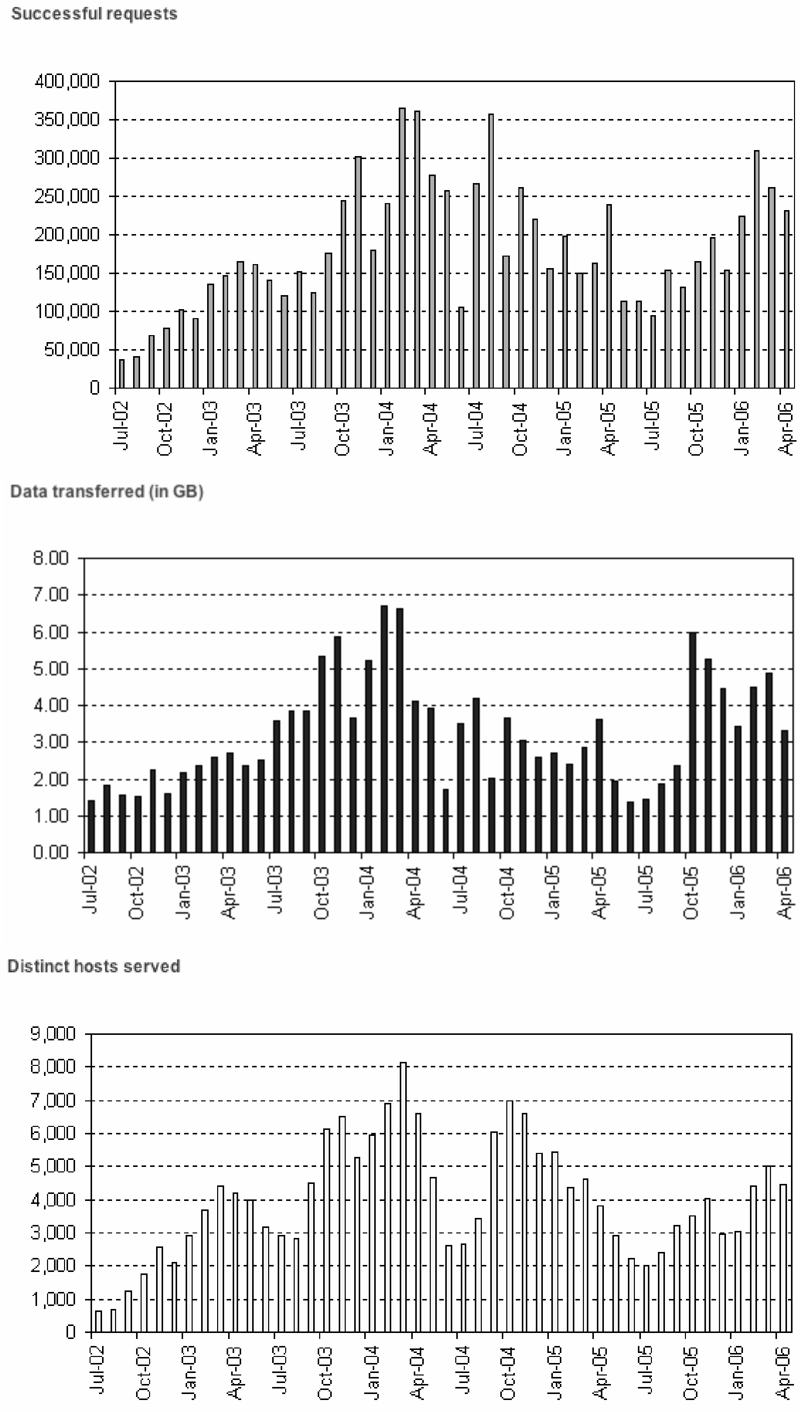

Figure 3. Web statistics of site usage.

What We Have Learned

Our experience has shown the importance of format and style. If a web-based facility is recognisable, accurate and easy to navigate around, then others will rapidly learn to trust it and use it. The ability to demonstrate an existing, 'working' product is often sufficient to persuade even the most sceptical of academic colleagues!

We learned that a considerable critical mass of micrographs was required before others picked up on the site and began to contribute further examples. The recognisable format and style, demonstrating a valuable and easily searchable resource, then assisted in encouraging contributions from elsewhere.

It is necessary to have a pool of workers in order to produce high quality material for addition to the site. To this end we have employed undergraduate students over summer vacations. Students are all volunteers who show a genuine interest in Materials Science and in the project. They are paid a market rate to stay in Cambridge, typically for between 4 and 8 weeks, based in the Materials Science Department. Each student is assigned to a specific, new TLP, with a member of the academic staff acting as advisor. The students generally work individually on their 'own' TLP, but a team spirit is engendered by having a group of students (typically between 4 and 8) working at the same time. Weekly meetings with all students and staff involved include updates on progress and discussion of ideas and plans for the following week's work. It is essential that support facilities are available during this period: bench space, laboratory equipment and technical support for setting up and running experiments; support from the photographic department for handling pictures and videos; and computing support in order to transfer the outcome onto the main *DoITPoMS* site.

One of the most significant extra benefits to have come from the development of the *DoITPoMS* site has been the result of this summer student activity. The students enjoy it, and can get a feeling of empowerment from their direct input into the site. They generally decide on the specific content and the way that it is put together, i.e. the final 'look' of the pages, with some guidance from the academic in charge. They learn a great deal, and gain experience with a particular aspect of Materials Science, as well as the building of such a resource. They invariably become enthused about the subject, and they have some great ideas – being well placed, with respect to the market, on how to present the material.

A bonus has also been the use of the site to advertise possible course content, as well as general information about the subject. In the Cambridge undergraduate degree programme students are enrolled as 'Natural Scientists' and can choose Materials Science as just one of their course options prior to specialisation in their 3rd year. It is therefore essential for the department to be able to advertise the subject, particularly for those coming straight from school, where they may never have heard of it. Students in later years can also gain an insight into the subject, and how it is taught, before making their course choices. Our experience has been that the more information we can offer, then the more likely it is that the course is taken up. Negative attitudes tend to spring from a lack of knowledge and a reluctance for the unknown.

We benefited greatly from the involvement of our UK partners, particularly in dissemination. It was extremely important for other establishments to use the site and give us feedback on the general applicability of what we were producing. This was often performed through organised student classes using a particular resource, evaluating its effectiveness, and returning feedback and critical appraisal. The resources themselves were generally put together in Cambridge, since we were concerned to produce a 'badged' product, with immediately recognisable content, appearance and attributes, leading to an implied assurance of quality. This is, of course, not to say that only we were able to produce high quality resources, but we believe that very tight control of content and appearance led to the recognisable product that has been widely taken up. Our experience was that such tight control meant that resources were constructed at one site, though they may incorporate content from others.

Dissemination workshops were also held, to advertise *DoITPoMS*, describe its application and illustrate how it might be used. Attendees (including lecturers and teachers of Materials Science, and those interested in education and teaching) used the resources during the workshop and offered valuable feedback.

The Future

The TLP library is expanding, through employment of summer students, and additions are continually being made to the micrograph library as contributions are received. Web site maintenance is always necessary, as is correspondence with contributors and those offering feedback on the site.

SUMMARY

DoITPoMS represents a freely accessible, comprehensive set of teaching resources, including a Micrograph Library, with associated *metadata*, and a library of Teaching and Learning Packages (TLPs), which are stand alone packages, each based on a specific Materials topic. These resources can be used by both students and teachers to enhance the learning experience. They are designed to be used flexibly – taking as much or as little as is required, and we believe that this aspect will continue to lead to widespread uptake across a broad, and varied market. We have made every effort to produce a recognisable, high quality product, which is very easy to access, with a range of search methods available, and benefiting from direct links with other, similar initiatives.

DoITPoMS can assist all teachers of Materials Science, both those who are already experts in the subject, and those from other sciences who, for example, may find that they are required to teach a Materials Science course. It offers examples of good methods for the teaching of specific areas, supplies resources for the enhancement of existing courses, and has encouraged academics to become involved with their own creation of resources.

The resources have been taken up within much of the Materials Science teaching in Cambridge and elsewhere. The *DoITPoMS* site has also proved to be of great value for dissemination of information about Materials Science and Materials Science courses to high school students, potential undergraduates, parents etc., who might otherwise be unaware of what the subject has to offer.

ACKNOWLEDGEMENTS

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REFERENCES

1. *www.materials.ac.uk/*
2. *www.matter.org.uk/*

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