

JISC Final Report (*Public Report*)

| Project Information Project Information Project Information Project Information | | | |
|---|--|-----------------|-------------------|
| Project Acronym | | | |
| Project Title | Enlightening Science: Teaching and Learning Newtonianism in the Eighteenth and Twenty-first Centuries | | |
| Start Date | 1 October 2008 | End Date | 30 September 2009 |
| Lead Institution | University of Sussex | | |
| Project Director | Professor Robert Iliffe | | |
| Project Manager & contact details | Yvonne Martin-Portugues University of Sussex Arts A, A027 Falmer, Brighton BN1 9QN 01273 873188 / 12323 873220 y.santacreu@sussex.ac.uk | | |
| Partner Institutions | | | |
| Project Web URL | www.enlighteningscience.sussex.ac.uk | | |
| Programme Name (and number) | <i>Enhancing Digital Resources Enhancing Digital Resources Enhancing Digital Resources</i> | | |
| Programme Manager | Ben Shower | | |

| Document Name Document Name Document Name Document Name | | | |
|---|--|-----------------|-------------------|
| Document Title | <i>Project Final Report</i> | | |
| Reporting Period | | | |
| Author(s) & project role | Robert Iliffe, Project Director Peter Langman, Performance Coordinator Michael Hawkins, Technical Director Yvonne Martin-Portugues, Project Manager | | |
| Date | 26.08.2009 | Filename | ES_finalreport_v2 |
| URL | www.enlighteningscience.sussex.ac.uk | | |
| Access | | | |

| Document History Document History Document History | | |
|--|----------|------------------------|
| Version | Date | Comments |
| 1.0 | 25/09/09 | Draft final report 1.0 |
| 2.0 | 25/10/09 | Draft final report 2.0 |
| | | |

Table of Contents

| | |
|---|----|
| ACKNOWLEDGEMENTS | 3 |
| EXECUTIVE SUMMARY | 4 |
| BACKGROUND | 5 |
| AIMS AND OBJECTIVES | 5 |
| METHODOLOGY | 6 |
| XML Encoding Set-up | 6 |
| Podcasts/Vodcasts | 7 |
| IMPLEMENTATION | 8 |
| Establishing the team | 8 |
| Vodcast Reconstructions of Experimental Lectures | 8 |
| XML encoded texts | 9 |
| Learning Objects | 9 |
| The Project Website: www.enlighteningscience.sussex.ac.uk | 9 |
| The Learning Objects..... | 10 |
| The focus groups | 11 |
| OUTCOMES | 11 |
| CONCLUSIONS | 12 |
| IMPLICATIONS | 12 |
| APPENDICES | 14 |
| Focus Group Questionnaire..... | 14 |

ACKNOWLEDGEMENTS

This project was funded by JISC's Enhancing Digital Resources Programme.

We wish to thank the following institutions for their invaluable contribution to Enlightening Science:

- Boerhaave Museum, Leiden, Netherlands (http://www.museumboerhaave.nl/e_intro.html)
- The Royal Society, United Kingdom (<http://royalsociety.org/>)
- The Science Museum, United Kingdom (<http://www.sciencemuseum.org.uk/>)
- The Royal Observatory, Greenwich, United Kingdom (<http://www.nmm.ac.uk/places/royal-observatory/>)
- Museum of the History of Science, Oxford, United Kingdom (<http://www.mhs.ox.ac.uk/>)
- SEPNet (South-East Physics network) (<http://www.sepnet.ac.uk/>)
- Dr Jonathan Hare (<http://www.creative-science.org.uk/>)
- Lancing College, East Sussex, United Kingdom (<http://www.lancingcollege.co.uk/>)

EXECUTIVE SUMMARY

The Enlightening Science Project (ESP) is a multi-media resource designed to raise awareness, among students and teachers, of Newton's scientific achievements in an informative and entertaining way. The project aimed to deliver five learning objects, each dedicated to a Newtonian topic. The materials that comprise the learning objects include: a) XML-encoded texts of Isaac Newton's most important mathematical and optical writings, b) vodcasts of interviews with historians and scientists, and c) vodcasts of recreation of 18th century lecture courses and experiments. These materials have contributed to the existing richness of the Newton Project (www.newtonproject.sussex.ac.uk) while broadening its expertise.

The project has built on significant collaborative relationships with other institutions, such as the Boerhaave in Leiden, the Royal Society, the Science Museum, the Royal Observatory, Greenwich and SEPNet. Although building these collaborations took the better part of the project's life, they proved invaluable to overcome funding limitations and to access resources (instruments, premises, staff) among other benefits. For example, with no institution able to give access to their historical apparatus (essential for the recreation of historical experiments) it was not until August that - in association with SEPNet - funding was finally secured for the manufacture of replicas. Advice from teachers of science was especially helpful in customising these experiments to the educational aims of both teachers and students. To date, we have made seven recreations of 18th-century experiments, with each one accompanied by a video lecture demonstrating its use and what physical principles it proves.

To accompany these recreations we interviewed experts on various aspects of Newtonian philosophy and its dissemination through lecture courses. These interviews cover topics such as science and religion, Newtonian optics, the culture of experimental lectures in London, Newtonian biographies and the George III collection at the Science Museum. They are presented in various formats, simple video and audio files, and enhanced podcasts which allow for the inclusion of useful images to be included within them.

The issue of intellectual property rights was particularly complex, as these rights included those of the maker of the videos, the owners of any images used in the making of the videos, and the words of any individuals interviewed. And yet the resources were to be made freely available to all of the users. We eventually decided that the rights of all concerned would be best protected through the adoption of a Creative Commons Attribution – Non-commercial – No Derivative Works 3.0 License.

The encoding of mathematical texts also brought its own challenges. For example, recording fine grain differences in mathematical formula raised the problem of extending MathML to support the full TEI element; although, the most significant drawback would be breaking browsers' ability to render MathML natively (an important facility for the delivery of our materials). The compromise position was to put the TEI's elements for coding variant readings (`<app><rdg/></rdg/></app>`) around the entire mathML code chunk and accept the necessary loss in coding granularity.

Academically the general premise of the project has not only been vindicated, but the idea of using interviews and films to shed light on textual materials provides a template showing how different media can be mixed to the best effect, and how they can be used to support one another. The unique and innovative mixture of history and science, and of text and vodcast, has captivated a number of people concerned with presenting similar textual materials online. In terms of practical conclusions, this project has illustrated just how important personal networking is when trying to expedite such projects. The best results were always reached through personal relationships, and through recognising when the interests of two independent projects coincided.

BACKGROUND

The scientific and mathematical achievements of Isaac Newton laid the foundations for the classical physics that was developed in the eighteenth and nineteenth centuries. To this day, Newtonian physics underpins the core of the scientific curricula taught in schools and universities across the globe.

The Newton Project (www.newtonproject.sussex.ac.uk), which has been funded since 1999 by the AHRB and the AHRC to make freely available transcriptions of Newton's non-scientific manuscripts, was created with the express goal of 'bringing Newton's works to life.' The project ultimately seeks to make all of Newton's writings available to general, student, and scholarly audiences. The Enlightening Science Project aims to build on the unique experience of the Newton Project, and to promote it to even larger audiences than it currently enjoys, informing these audiences of both the historical contexts and the core doctrines of his scientific works.

Using Newton's canonical printed works and eighteenth century lectures on Newtonian physics as a key resource, the Enlightening Science Project aims to engage audiences further and to promote a deeper understanding of Newton's works and their legacy. It also seeks to create materials that are both scholarly resources for professionals and sources of information and entertainment for a broader, non-specialist audience.

At the core of the Enlightening Science Project are a series of tools and functionalities that allow both expert and general users to understand more clearly the central concepts behind Newton's scientific achievements. These tools include: textual and podcasted introductions to Newton's texts; vodcasted recreations of the eighteenth century lecture courses in which Newton's doctrines were explained to both genteel and academic audiences – including re-creations of the experiments these lectures often included, and vodcasted interviews with eminent scientists and historians.

AIMS AND OBJECTIVES

The project primarily seeks to raise awareness among students and teachers of Newton's scientific achievements in an informative and entertaining way, using the history of science to elucidate Newton's doctrines for both science and humanities students. The general aims and objectives have not changed.

Our first goal was to make freely available online all versions of the most important scientific texts composed by Isaac Newton that were published in his lifetime. These writings, which revolutionised the fields of optics, physics, and theoretical astronomy, are *Opticks* (1704, 1706, 1717), and *Principia Mathematica* (1687, 1713, 1726). In addition, we will add the drafts of *De motu corporum* which were composed in the three years prior to the first edition of *Principia* of 1687, alongside Newton's early research on optics, his optical lectures, relevant optical correspondence, and the manuscript drafts of the 'Queries' which were appended to the three editions of *Opticks*. These texts are accompanied by a written introduction as well as podcasts and vodcasts introducing students and the general public to their historical and intellectual contexts as well as to the core scientific doctrines contained within them.

Our second goal was to use insights from the way eighteenth century natural philosophers had disseminated Newton's ideas to the general public in order to make the central doctrines in Newton's abstruse texts accessible to modern audiences. The eighteenth century saw a proliferation of lecture courses which used both experiments and instruments to inform their audiences about Newton's most significant ideas. Newtonian natural philosophy could not have been as successful as it was without the ability to portray the central tenets of his scientific discoveries through exciting displays of prismatic lights, electric shocks, and representations of the solar system in planetaria. We took a selection of these courses, both published and manuscript, and re-created them, making the re-creations freely available as vodcasts.

The aim of making Newton's physical theories more comprehensible reflects the lectures of the eighteenth century inasmuch as the project seeks to inform both scholars *and* the general public, and is intended to be both informative and entertaining. Each vodcast will be presented as part of a coherent, mutually supportive collection of resources – the Learning Objects which will include texts, interviews with scientists and historians, podcast introductions, and so forth, which educators will be able to edit in order to integrate them into their own digital learning environments. It is this flexibility, alongside the vodcast reconstructions themselves, which makes Enlightening Science such an exciting and forward-looking project.

Enlightening Science also aims to train a new generation of transcribers, coders and interviewers at the cutting edge of e-learning. The Newton Project has for a decade been committed to hiring individuals who combine a number of skills and talents, individuals able to work not only on the technical difficulties inherent within Newton's work, nor simply on the TEI encoding that is the basis of our approach, but who are capable of realising the potential of the project to reach many more users than is possible with printed works. Project members will both learn from the existing Newton Project team and forge new paths in e-learning.

At its heart, the Enlightening Science Project seeks to promote awareness of the extraordinary textual and conceptual riches which exist on the Newton project site, resources covering the fields of theology, physics, and optics. While we are, naturally, hopeful of attracting as large an audience as possible to the Newton Project website, our primary aim is to educate and engage individuals interested in Newton and his doctrines. We wish both to raise awareness amongst the general public regarding his works and the legacy they have passed down to the modern world as well as promote greater discussion of their significance.

METHODOLOGY

The production of the project deliverables was suited for an Agile-based approach. This approach gave us the flexibility to implement new courses of action as opportunities for partnerships and external collaborations emerged, a strategy that has been crucial to the implementation of the project. Equally, it allowed us to regularly re-assess the work against the aims and the resources available.

XML Encoding Set-up

Sourcing document images

The production process began with the sourcing of document images. Newton's manuscripts were available on the Chadwick-Healey microfilm edition. The reels were scanned by the transcribers using the microfilm scanner in the University of Sussex as 400-600dpi grey-scale jpeg images. These files were then archived in the project data store and a more compressed PDF version was made by the technical director. The PDFs were then posted to the development server so they could be downloaded by team members. Images of pre-1700 printed materials were acquired from *Early English Books Online (EEBO)*¹ and post-1700 materials from *Eighteenth Century Collections Online (ECCO)*². Printed materials unavailable in EEBO or ECCO were downloaded from Internet Archive³ or Google Books⁴.

Technical set up

oXygen academic licenses were acquired for each transcriber. <oXygen/>⁵ version 10 is a cross platform XML editor with an integrated subversion client that allows the project to employ the SVN system to back up materials to the Newton Project development server and ensure data integrity. This system guarantees that everybody has the latest version of any given material on their computers.

The transcribers follow the transcription and tagging guidelines that are also used in the Newton Project. These guidelines are based on the Text Encoding Initiative's P5 Guidelines⁶ and can be found at: <http://www.newtonproject.sussex.ac.uk/prism.php?id=52>

1 <http://eebo.chadwyck.com/home>

2 <http://www.gale.engage.com/DigitalCollections/products/ecco/index.htm>

3 <http://www.archive.org/index.php>

4 <http://books.google.com/>

5 <http://www.oxygenxml.com/>

6 <http://www.tei-c.org/index.xml>

Delivery

All the texts are dynamically transformed by Apache Cocoon⁷ into (X)HTML using the custom written Newton Project XSLT stylesheets. Two different versions of the MathML code are generated to accommodate browsers' varying support of MathML:

- If a user has a MathML capable browser (e.g. Firefox, Opera) the XSLT produces an XHTML+MathML file that allows the browser to render the MathML.
- For browsers that do not natively support MathML (e.g. Safari and Internet Explorer), the XSLT creates an HTML that links to dynamically generate images of the MathML. The images are created using JEUCLOUD⁸ and an automated build script. While these images are not searchable, they faithfully reproduce the format of the original material.

Once transcription is complete, the text is proofread by a second researcher and the XML syntax audited by the Technical Director and validated against a custom schematron schema that detects common coding mistakes. The text is then deemed fit for initial online release. Subsequent online checks are carried out against the manuscript and printed materials.

Podcasts/Vodcasts

The fundamental approach taken by Enlightening Science was to follow the 18th-century lecturers and to show rather than tell. It was also considered vital that in order to fully contextualise Newton's thought, some attempt must be made to re-create the experience of the lecturers' audiences. The decision to make discrete video recordings of costume reconstructions, supported by video interviews and presentations by historians and scientists was simple enough, but created a whole new set of questions. These questions included what resolution to shoot the videos, how best to allow access to them, how best to encode them, how visitors to the ES portal might be allowed to utilise these particular resources, and how the intellectual property of the makers might best be protected.

When deciding on resolution rates for encoding the video segments, we initially opted for three separate resolutions, low, medium, and high, in order to allow for different uses. The low resolution version, for example, was designed for small file sizes, so that it could be easily downloaded through low-bandwidth internet connections. We encoded the videos in H.264 video, using the industry standard Mpeg-4 compression. The two files sizes we decided upon combined image size and k/bits per second. The smaller size was 680 x 360, at 220 m/bits per second, and the larger 1280 x 720, at 672 k/bits per second – the relative file sizes being 7.4 meg and 19.8 meg for a sample video of 3 minutes 26 seconds.

The files will be available on the site in three different ways:

- As streaming flash videos dynamically generated from the MP-4 files by the open source JW PLAYER⁹
- As downloadable MP-4 and WMV files
- Via both the project's main podcast and through the separate learning object podcasts

The file size was also dependent upon the length of the video segment. Both for logistical reasons with regards file size and also bearing in mind the issues of concentration, it was also decided to aim, wherever possible, for each video to be no more than ten minutes, and preferably between 5 and 7 minutes long. This led, for example, to the introductory video of Desaguliers, which was in total around 17 minutes long, to be split into four smaller sections. This makes them easier to download, easier to understand, easier to assimilate, and more likely to be watched in full.

The issue of intellectual property rights was particularly complex, as these rights included those of the maker of the videos, the owners of any images used in the making of the videos, and the words of any individuals interviewed. And yet the resources were to be made freely available to all of the users. We eventually decided that the rights of all concerned would be best protected through the adoption of a Creative Commons Attribution – Non-commercial – No Derivative Works 3.0 License.

⁷ <http://cocoon.apache.org/>

⁸ <http://jeuclid.sourceforge.net/>

⁹ <http://www.longtailvideo.com/players/jw-flv-player/>

Research involved comparing different lecture texts and making decisions with regards to which ones to reconstruct – decisions which involved considerations such as ease of audience comprehension, effect and significance of the experiment itself, relevance of the experiment to the modern curriculum, and ease of reproduction.

Having made decisions based on these particular considerations, the next step was the search for appropriate instruments. As with most projects of this type, a general lack of funds necessitated a particularly creative approach to acquiring the tools with which to carry out the project. As a result we worked on building collaborative relationships with projects in other institutions, such as the Boerhaave in Leiden, the Royal Society, local schools, the Science Museum and, latterly, the Royal Observatory, Greenwich and SEPNet. The final breakthrough was made when it was discovered that SEPNet and Enlightening Science had similar goals with regards outreach, only that the former wished to perform outreach in real time rather than virtually. Therefore through an investment of ability, machines which seemed beyond the reach of the project suddenly burst into being, allowing the video reconstructions of key Newtonian experiments to take place.

IMPLEMENTATION

Establishing the team

During the first month of the project two project teams were assembled: two transcribers and a performance coordinator. Each of these teams had different methods for developing the work. All technical development was undertaken by the Technical Director (Mike Hawkins) who also serves in the Newton Project.

- The **transcription team** (Abdul Sami and Margarita Fernandez Chas) was responsible for the tagging and transcription of Newtonian Optical, Mathematical and Physics texts. Both transcribers were trained mathematicians and knowledgeable in MathML. This combination of skills was a requirement for their recruitment because the core Newtonian texts contain a significant amount of mathematical content. It was consequently essential that our transcribers were able to engage with the mathematics intellectually in order to code it effectively.
- The **performance coordinator** (Pete Langman) was responsible for the transcription of eighteenth-century lecture courses in experimental philosophy, interviews with scientists and historians of science as well as the recreation of famous historical experiments and lectures.

Vodcast Reconstructions of Experimental Lectures

The vodcast reconstructions of experimental lectures necessitated expertise from research to final output, if it was to be produced in-house on an extremely limited budget. From the standard academic research undertaken to identify the lectures, experiment apparatus/machines, and audiences most appropriate for reproduction, to the technical issues of producing vodcasts which were accessible on any machine, each step was undertaken in a slow and methodical fashion.

As with most projects, the actual production of the vodcast reconstructions, the filming itself, occupied a small percentage of the total time invested. Finding suitable sets, costumes, wigs and props to organising scripts, filming, editing and mastering the end-product took much longer than was anticipated. A five-minute film took roughly two weeks of solid work to complete, excluding quite apart from the hundreds of minor, peripheral issues which needed continual attention.

The main problem encountered during this part of the project was the question of experimental machines. As the lectures themselves were predicated on demonstration, and the demonstrations were achieved by the use of machines, they were vital to the project's success. Unfortunately, no institution felt able to allow its historical machines to be taken out of their cabinets – and with institutional wheels grinding exceedingly slow, it took months of detailed negotiation before this was forthcoming. With budgets already stretched this meant attempting to win funding from an external body, itself somewhat difficult in the present financial climate. It was not until August that funding was finally secured for the manufacture of replicas of certain experimental machines – in association with SEPNet. It is for this reason that the prime output of the project, experimental reconstructions, came relatively late in the life of the project.

XML encoded texts

Our ambitious goal to encode the variant readings of all three key editions of the *Principia* in one file using TEI's <app> proved more complicated than initially estimated. The key challenges were:

1. The inability to record fine grain differences in mathematical formula in an adequate manner. For although extending TEI to support MathML is relatively straightforward, it is problematic to extend MathML to support the full TEI element. Aside from breaking the W3C recommendation, the most significant drawback would be breaking browsers' ability to render MathML natively (an important facility for the delivery of our materials). The compromise position was to put the TEI's elements for coding variant readings (<app><rdg/><rdg/></app>) around the entire mathML code chunk and accept the necessary loss in coding granularity.
2. Problems based on block structure. <app> can only occur with blocks of text (i.e. paragraphs, lines of verse, etc.). It consequently is difficult to cope with situations where variant readings cross block boundaries or include the addition/deletion of entire blocks. Although the situations can be resolved by breaking multiple block readings into smaller chunks and by the insertion of additional blocks, this does have an adverse affect on transcription speed since transcribers must simultaneously consider both the nature of the variant readings in the texts and how it is to be mapped on the structure of the XML document. The **solutions** applied were:
 - to produce full variant version of book 3 of the *Principia* using TEI's <app> for testing and evaluation purposes;
 - to code the remaining books as separate files; therefore, they are available for reading and studying;
 - to investigate the use of a fuzzy-text comparison tool, such as the TEI Comparator (<http://sourceforge.net/projects/tei-comparator/>) developed by James Cummings, Arno Mittelbach, Sebastian Rahtz.

Learning Objects

Discussions on the number of learning objects took place during the first two months of the project. Initially, six were considered manageable. However, in the last two months of the project, a number of issues made it clear that we could only focus on five. Scheduling was the uppermost amongst the problems encountered. Academics, while keen to contribute to projects such as this, are also extremely busy, and it proved difficult to co-ordinate schedules between various academics and the Enlightening Science crew. Budgetary considerations meant that the crew used to film both reconstructions and interviews was comprised of students, which added to scheduling difficulties.

OUTPUTS AND RESULTS

The Project Website: www.enlighteningscience.sussex.ac.uk

The Enlightening Science website is the central vehicle for publishing our main deliverables (the learning objects) and for disseminating information about our endeavours. The website has three levels: high school, undergraduate and teacher. The landing page defaults to the student level. Each level has access to all the learning objects and the functionality and navigation is the same for both. However, each level is customised in terms of content:

- The teacher level has access to all the materials available in the website. The introductory page provides a explanation of the main theme and a description and links to the resources. This gives the teacher the freedom to select what materials s/he wants to download and re-use for teaching or research purposes.
- At a student level (either high-school or undergraduate) the access to the materials is more focused. Links are provided to specific sections of the core reading. A 'Further Reading' section is provided for those students interested in pursuing a specific theme further.

All core project deliverables are available via a collection of RESTful web services in order to encourage the portability and reuse of our core materials by our users.

1. Texts: /view/texts/[diplomatic|normalized]/document_id
2. Dynamically generated extracts: /view/extract/[diplomatic|normalized]/document_id/start={startOffset}&end={endOffset}
At present, the start and end offsets can only refer to block level items (e.g. paragraphs, headers) and page breaks (e.g. page breaks and addSpan/anchors)
3. Dynamically constructed podcasts and playlists

The Learning Objects

Although the web site is the point of entry to the project the main deliverables are the Learning Objects, each one dedicated to a specific area of Newtonian philosophy:

1. Science and Religion
2. Newton's Optics
3. Newton the Man
4. Newton's Physics
5. Newtonian Audiences

Each learning object contains an introductory section (written and podcasted) and a number of sections dedicated to an aspect of the main theme. In addition, each learning object comprises textual and audiovisual materials. The following subsections explain these materials in more detail.

The Texts

The manuscripts will be available for display in two formats: diplomatic and normalised. A diplomatic transcription offers a detailed representation of the document with minimal editorial intervention. All additions and deletions are rendered in the text and shorthand abbreviations have not been expanded. Normalised transcriptions provide a tidied-up view of the original text. Editorial interventions are applied to expand abbreviations and correct textual mistakes. Additions are silently included within the body text and deletions are not displayed. The reader has the ultimate freedom to select which format s/he prefers. For further discussion of what an electronic edition means, please go to: <http://www.newtonproject.sussex.ac.uk/prism.php?id=29> Our aim is to provide introductions to each text with a brief explanation of the historical and intellectual contexts and the core scientific doctrines contained within it. Whenever the resources allow it, a vodcast is also available.

Recreations

We have made seven recreations of 18th-century experiments, with each one accompanied by a video lecture demonstrating its use and what physical principles it proves. The video lectures come in two varieties, modern and historical. The modern lectures are given by Dr Jonathan Hare, and show the machines at work as well as explaining the rationale of their construction. The historical lectures take the form of period recreations, in which an actor demonstrates the machines – the construction of which is based directly on original drawings from lecturers such as Desaguliers's Gravesande, and Francis Hauksbee – using the lecture texts as originally published by their designers. At present, the historical recreations will not be possible until October due to availability of actors.

Interviews

To accompany these recreations we have interviewed experts on various aspects of Newtonian philosophy and its dissemination through lecture courses. These interviews cover topics such as science and religion, Newtonian optics, the culture of experimental lectures in London, Newtonian biographies and the George III collection at the Science Museum. They are presented in various formats, simple video and audio files, and enhanced podcasts which allow for the inclusion of useful images to be included within them.

The focus groups

Enlightening Science visited Lancing College, East Sussex. The group consisted of eleven schoolchildren, aged 15 through 17 (GCSE to A level), ten boys and one girl. The questionnaire used in this particular focus group is appended [See Appendix 1]. The main objective was to understand how the material produced by Enlightening Science will be used by the key target markets: students and teachers. In general, the students liked the videos (both reconstructions and interviews) that were shown to them over the texts, which reinforces the site ethos, namely that visual images and historical contextualisations are effective ways of drawing students in.

OUTCOMES

Aim: *To raise awareness among students and teachers of Newton's scientific achievements in an informative and entertaining way*

The multi-media aspect of the Enlightening Science Project (ESP) was designed to make the resources on the site truly accessible to a number of different target audiences, in particular undergraduate courses, school physics curricula (especially Key Stages 3 and 4) and the general public. The project has built on significant contacts with the Royal Society Education Section, SSAT (The Specialist Schools and Academies Trust) and SEPnet (The South of England Physics Network) in order to tailor our materials, especially the filmed recreations of experiments, to schools and colleges. Advice from teachers of science at Key Stages 3 and 4 has been especially helpful in customising these demonstrations, as well as the commentaries on them. Nevertheless, by embedding these materials in a historical context we intend to interest students specialising in humanities subjects just as much as students working on science GCSEs.

During *Newton Day*, an event organised with the Royal Society on 6 October, the experimental machines made in collaboration with SEPnet, were demonstrated for the first time. These machines will be re-used by SEPnet in schools demonstrations after we have used them for our videos. This ensures not only the continuous publicisation of our resources, but also that our resources play an active role in physics outreach. The Science Museum, the Royal Observatory in Greenwich and the History of Science Museum in Oxford have also provided access to instruments, premises and staff, and links have been formed with the Vega Trust and the Brighton Science Festival.

In the development of our resources, links with schools such as Lancing college have proved invaluable, providing us with students to test our resources on, teachers to discuss the viability of our experiments with, and insights into the needs and desires of both staff and student body alike. Similarly, we have explored the possibilities of virtual experiments and dramatic renditions through InQbate at Sussex University, liaised with the AIMhigher outreach programme, and worked with the Adult Learning Group in Brighton and Hove.

Aim: *To make the most important scientific texts of Sir Isaac Newton published in his lifetime are freely available. Promote awareness of the extraordinary textual and conceptual riches which exist on the Newton Project site, resources covering the fields of theology, physics, and optics.*

The printed editions of *Principia* (1687, 1713, 1726) and *Opticks* (1704, 1706, 1717) are available. The manuscript *De Motu corporum* is forthcoming. Currently, over 2.75 million words have been transcribed.

The core textual materials composed both by Newton and by eighteenth century authors of lecture courses and popularisations are available to scholars via a sophisticated interface. The manuscript and printed materials, containing the most significant of Newton's scientific writings (excluding his purely mathematical texts), will be of immense interest to the large community of scholars and the general public interested in various facets of Newton's work. Links to pre-existing materials available via the umbrella Newton Project will also enhance the resource discovery features of the project site.

Aim: *To make recreations of experiments and lectures accessible as vodcasts*

The recreations of experiments and lectures provide a useful resource for science teachers to engage with students, especially those who are generally less interested in science. Focus group work demonstrated the value of presenting information both in video form and especially in costume, while the 'modern' explanations by Dr Jonathan Hare provide simple explanations of concepts that can be difficult to comprehend. The fact that these reconstructions make use of machines identical to those used in the eighteenth century not only shows students

how the principles of classical physics have not changed over the past three hundred years, but also that the dissemination of Newton's theories was central to the triumph of Newtonian science.

The interviews provide different benefits to the target audiences. Students appreciate the more informal nature of the video talk as opposed to the traditional textual explanation. The videos also serve as a perfect introduction to the more complex pieces accessible through the Enlightening Science and Newton Project portals.

The most important lesson to be learned is that projects such as this are dependent almost entirely on the forming of relationships with individuals, as it is only through this that some of the bureaucratic problems encountered when dealing with institutions can be overcome – projects such as this run to a large degree on goodwill.

Aim: *Training of new transcribers.*

The two part-time transcribers combined their expertise in mathematics with their knowledge of MathML. Thus, they were able to work on the technical difficulties inherent to the mathematical representation of Newton's equations, etc. This knowledge was expanded through training to include XML.

The acquisition of XML coding skills was straightforward since both transcribers had considerable experience using markup languages. The acquisition of critical editorial skills took longer but it contributed to the project's spirit of building bridges between scientist and historians. Thus, this training showed the transcribers that there are other ways of looking at texts and also how their experience in MathML transferred to us. In the same spirit we brought some students in from physics and social sciences background to collaborate.

With regards to lessons learned, the primary lesson to be drawn from the project is the need to combine clear goals, timescales and targets with the flexibility to grab exciting opportunities when they arise, and change plans when they need to be changed. Over-rigid and over-flexible modes of operation are both insufficient to allow for the realisation of such a project. Innovative projects such as this are potentially inefficient, as new ground is constantly being broken, and the flexibility needs to be built in from the outset as this project has demonstrated.

CONCLUSIONS

A number of conclusions can be drawn from this project. Academically the general premise of the project has not only been vindicated, but the idea of using interviews and films to shed light on textual materials seems to be worthy of being used much more widely. As is (arguably) the case with most projects, Enlightening Science would have benefited from an extra period of time to achieve its goals. Coordinating the three main elements of the project – texts, experimental recreations and website interface – was a difficult but rewarding exercise. As stated earlier, a key problem surrounded the acquisition of instruments for the films and the hiring of people who could do a professional job filming interviews and experimental reconstructions. Unavoidable delays in producing these films has made it difficult to coordinate the project as a whole until right at the end of the project.

In terms of practical conclusions, this project has illustrated just how important personal networking is when trying to expedite such projects. The best results were always reached through personal relationships, and through recognising when the interests of two independent projects coincided. In the case of the Royal Society our work dovetails well with their educational outreach programme, while our work provided SEPnet with an innovative way of producing accessible and scientifically appropriate materials. In each case, these groups could provide a small but useful budget that allowed us to make the instruments necessary for the reconstructions, and a forum in which a large number of teachers could come and assess and give advice on what we have done so far.

IMPLICATIONS

The Enlightening Science Project provides a template showing how different media can be mixed to the best effect, and how they can be used to support one another. As for Enlightening Science itself, everyone with whom we came into contact was unconditionally enthusiastic, not least those physics teachers with whom we worked. We believe that the project can easily be extended in the future, with more recreations of eighteenth century experiments, or through even more ambitious programmes concentrating on later science, possibly in conjunction with the Royal Institution (which after all perfected the public lecture).

The unique and innovative mixture of history and science, and of text and vodcast has captivated a number of people concerned with presenting similar textual materials online. Interestingly enough, we think that the methods conceived for and developed in this project are applicable to the more general Newton Project, where short vodcasts, or longer interviews can provide much better introductions to the materials than conventional textual forms. An obvious implication of this is that websites that merely make resources *available* are no longer enough, and the increasing availability of resources must be matched by an increase in their accessibility. Another implication is perhaps building on the recent increase of use of academics on tv and the radio, as resources such as enlightening science will increase the necessity for academics to be media-trained.

Even this is not by itself sufficient, and the success of educational websites such as this and the First World War poets site rest in part on active face to face engagement with various user-groups both during and after the project. The lessons to be drawn here clearly concern the close connections between impact and sustainability. Impact can be measured and managed in various ways, and will clearly be of great concern to research-active academics over the next decade. Although it remains a somewhat nebulous concept for traditional forms of research, by their very nature digital resources have the potential to have a far greater impact in terms of the size of audience reached. However, only continuous engagement with specialist user-groups (e.g. schools/ UGs) can really guarantee a sustained impact outside academia. With this in mind, it is worth considering whether a loose and self-moderating community of users could 'own' and develop a more organic version of the site in the future.

With regards building on this work, it would perhaps be useful to create a dedicated media team who could be consulted upon by different projects to produce uniformly high-quality video and audio resources, so that other projects like Enlightening Science can build on existing expertise without having to re-invent the wheel.

APPENDICES

Focus Group Questionnaire

I. INTRODUCTIONS (5 MINS)

1. Moderator explains purpose of the group & general expectations (there are no right or wrong answers – we are really just trying to understand your thoughts and opinions; it is very likely that there are some very different opinions in the room. This is good. Please offer your thoughts even though the person before you may have a very different idea.....)
2. Respondent shares basic information (name age – experience with physics)

II. BASIC DISCUSSION OF PHYSICS CLASSES (20 MINS)

What do you like and dislike about physics classes?

Probes:

1. Exactly what do you mean when you say.....?
2. Share with me your thoughts and feelings about a time when you remember particularly enjoying a physics class? What were the things that you did in class? What made it more interesting than usual?
3. How often do you have to complete projects and other in depth learning assignments for your physics classes?
4. Tell me about the resources you would typically use when you have a project or other type of learning assignment for physics?
5. Probe specifically for:
 - Library books
 - Internet
 - Podcasts
6. What are the advantages and disadvantages of each type?

III. ISAAC NEWTON (15 MINS)

1. What sort of information have you covered in your classes?
2. How clear a picture of Newton do you have?
3. What do you think Newton's contribution to the sciences was?
4. What was Newton's most famous idea?
5. What was his most important idea?
6. How relevant is Newton to the modern world?
7. How important is Newton to the state of modern science?
8. How is Newton approached in your classes?

IV. REVIEW OF PODCASTS/VODCASTS (15 MINS)

Show PODCASTS/VODCASTS..... (explain what you are going to show them and what sort of questions you are going to ask)

1. What are your initial reactions to this? What is the main idea? How interested are you in the main idea? What were you thinking as you were watching this? How did you feel as you were seeing these images? Give me some words that describe your emotions and feelings as you are watching this.
2. Which words, phrases, or meanings used in the podcast either confuse, appeal or don't appeal to you?
 - Probe around the various messages included in the video;
 - How appealing is this idea to you?
3. Which are the images that are the most memorable? List each image on a chart pad as it is mentioned – and ask what sort of emotions the respondent associates with the image. What does this image make you think of? What is good about that? What is not so good about that?
4. Use the chart pad to sort through the images mentioned and identify in order of priority which are the most memorable images of all and why?

- Imagine you are creating a podcast using some of the images we have shown here? Which are the ones you would ABSOLUTELY INCLUDE? Why?
 - Which are the images you would ABSOLUTELY leave out? What is it about the images that makes you say that?
5. Are there any negatives or issues that you think may upset or concern people watching this?
 6. Any other questions or comments?