

JISC DEVELOPMENT PROGRAMMES

Project Document Cover Sheet

Final Report

Project

Project Acronym	ReSET	Project ID	
Project Title	Rejuvenation of Science, Engineering and Technology related TLTP and other legacy material		
Start Date	1 February 2005	End Date	31 July 2006
Lead Institution	Glasgow Caledonian University		
Project Director	Dr Barry J Beggs		
Project Manager & contact details	Dr Barry J Beggs, ITRC, School of Engineering, Science & Design, Glasgow Caledonian University, 70 Cowcaddens Road, Glasgow G4 0BA. Tel - 0141 331 3826 Fax - 0141 331 3690 Email - bjbe@gcal.ac.uk		
Partner Institutions	Glasgow Caledonian University (GCU) ICBL, Heriot Watt University (HWU) Higher Education Academy - Engineering Subject Centre, Loughborough University (ESC) Higher Education Academy - UK Centre for Materials Education (including MATTER project), University of Liverpool (CME) Bell College, Hamilton (BC) Cardonald College, Glasgow (CA) Coatbridge College, Coatbridge (CO) James Watt College, Greenock (JW) East Down Institute of F&HE, Downpatrick (ED) Castlereagh College, Belfast (CC) EDEC project CALGroup project HELM project		
Project Web URL	http://reset.campuskelpie.co.uk		
Programme Name (and number)	Exchange for Learning (X4L), Phase 2		
Programme Manager	Lou McGill (previously Susan Eales)		

JISC

JISC X4L Programme – Phase 2



Final Report

Author

Barry J Beggs

Contact Person

Barry J Beggs

Date

15 December 2006

Table of Contents

Acknowledgements	4
Executive Summary	5
Background	6
Aims and Objectives.....	8
Methodology	10
Implementation.....	11
Outputs and Results.....	13
Outcomes	14
Conclusions.....	15
Recommendations	17
Appendix I Guidebook.....	19
Appendix II ReSET Learning Object Catalogue	28

Acknowledgements

The ReSET project was made possible due to funding provided by the JISC X4L Phase 2 Programme. The consortium is grateful for this support without which the work would not have been possible.

The work of the project was completed with significant contributions being made by all of the project partners:

- Glasgow Caledonian University (GCU)
- ICBL, Heriot Watt University (HWU)
- Higher Education Academy - Engineering Subject Centre, Loughborough University (ESC)
- Higher Education Academy - UK Centre for Materials Education (including MATTER project), University of Liverpool (CME)
- Bell College, Hamilton (BC)
- Cardonald College, Glasgow (CA)
- Coatbridge College, Coatbridge (CO)
- James Watt College, Greenock (JW)
- East Down Institute of F&HE, Downpatrick (ED)
- Castlereagh College, Belfast (CC)
- EDEC project
- CALGroup project
- HELM project

The general support provided by JISC to the project from its initiation until its conclusion was exemplary. In particular, the assistance of Susan Eales was of great value.

The JORUM team have consistently been highly supportive and responsive to the requirements of ReSET and their assistance has been very much appreciated.

Executive Summary

This project has taken CBL resources such as TLTP and other legacy material and used it as the basis for producing high quality, copyright-cleared, standards-compliant, reusable learning objects suitable for use by teachers on HNC, HND and Foundation Degree programmes. These learning objects are able to be used in the learning environments (VLEs) of the partner institutions and are made available through the JORUM repository for others to use. The project has produced guidelines for the workflow involved in the selection of suitable legacy resources through to the integration of the finished learning object into a learning content management system or learning environment. The partners teaching HNC and HND Programmes have gained experience in the selection and use of learning objects and in the processes required to create learning objects. All partners in the project have gained experience in the creation of reusable learning objects and the standards and infrastructure frameworks involved in such work. All FE, HE and other academic institutions in the UK now have access to the outputs of the project through the JORUM repository.

The project has rejuvenated TLTP and other legacy material by repurposing and adapting monolithic courseware as re-usable, accessible Learning Objects suitable for HNC/HND and Foundation Programmes in Engineering, Science and Technology. We believe that the use of tried-and-tested resources as a starting point has facilitated the identification and production of useful, high quality Learning Objects. The project worked in such a way as to maximise the involvement of teachers of these programmes whilst insulating them from the time-consuming and specialised requirements of copyright clearance and technical re-implementation.

The project has resulted in the production of 211 high quality, standards compliant Learning Objects, all of which are now available from JORUM. Other outputs include a guidebook on the rejuvenation of legacy CBL content, a project web site and a series of papers and presentations made during the dissemination of the project work to the academic community.

Background

Re-purposing and adapting computer-based learning resources promises many benefits over the alternative of creating new content: resources have already been quality assured and reviewed (through peer review or similar mechanisms); reuse is more cost effective than creation; alternative or additional resources can be provided to suit different student needs. Historically, however, such reuse has been difficult to realise, with resources being produced that are difficult to use in any context other than the one for which they were designed, and teachers being understandably unwilling to tailor their programmes to the resources available. One approach to enhancing reusability of computer-based learning resources is to provide such resources as Learning Objects. (For the purposes of this proposed project, ReSET defined a Learning Object as being a unit large enough to be pedagogically meaningful, for example one comprising enough material to address at least one learning objective). Learning Objects should be granular material which is well described and which conforms to reusability standards such as those produced by IMS Global Learning Consortium. Such resources can be aggregated into larger units, or disaggregated to facilitate repurposing for a different context. Because they are well-described, they can be stored in and retrieved from repository systems, which can also have a role in providing quality assurance and reviews of the material and, since they are standards-compliant, materials and software applications can be created which are widely interoperable.

Many of the benefits promised by the use of reusable computer based learning materials are dependent on two requirements. Firstly, there needs to be a reasonable number of such materials available, so that teachers and learners may choose suitable units. Without this choice, aggregating the units into a course is merely a less convenient way of obtaining larger units of courseware. Secondly, teachers need to be skilled at choosing and reusing this type of resource, so that they can select the most appropriate resource and tailor it to their specific needs where necessary. Currently, neither of these requirements is met.

There have been many content producing initiatives and programmes, such as the Teaching and Learning Technology Programme (TLTP), which funded the development of several large scale packages relevant to the teaching of science, engineering and technology. Many of the packages produced by these initiatives comprised materials that were aimed at first year university programmes, and would be of a suitable level for HND, HNC and Foundation programmes. The EASEIT-Eng project, which carried out evaluations of computer-based learning materials being used in UK HE Engineering programmes, found that many engineering TLTP packages (and similar resources of the same age) were still widely used in 2002. Teachers using these packages reported that the underlying pedagogy and subject coverage of these resources was sound, however their usefulness was inhibited by factors that include:

- The age of the software, which often required out of date hardware and supporting software in order to run;
- The material was often locked into monolithic packages that required the teacher to give the student complex instructions on which parts were relevant to the course;

- The material was difficult to integrate into VLEs;
- The teacher could not adapt the material.

By addressing the four points above, the re-purposed material produced by the project in the form of Learning Objects have increased value, improved accessibility and become widely available through JORUM for use by FE and HE institutions.

Aims and Objectives

All of the aims and objectives of the project have been met with no significant changes being made.

Aim 1: Creation of learning objects

Create standards-compliant reusable learning objects by repurposing or re-implementing parts of TLTP packages, and other legacy material which have proven to be useful stand-alone units of learning.

Associated objectives:

- Identification of sections from TLTP and other legacy materials that are suitable candidates for rejuvenation, i.e. sections that could form stand-alone units of learning that are pedagogically sound but use dated technology or are inappropriately embedded in large courseware packages;
- Clarification of who owns the rights over the work identified as useful, and whether they would allow disaggregation and repurposing of this work;
- Replacement of these with suitable learning objects from other sources or the repurposing or re-implementation of a substantial number of these legacy resources as learning objects;
- Quality assurance mechanism for the learning objects.

Aim 2: Description and evaluation of the learning objects

Provide information to help end users decide whether or not to shortlist a resource for use.

Associated objectives:

- Develop a means of ascertaining from potential users of learning objects the educational qualities of the resources created. This may be used in the creation of educational metadata;
- Creation of a (LOM) metadata record for each of the learning objects created;
- Create a schema for recording how computer based learning resources have been used along with comments on the success of this use. This objective is not equivalent to the functionality provided by JORUM. The ReSET team has experience in this area which allows investigation of an extended schema and share the results with the community. Any schema evolution will be fully standards compliant;
- Record how the learning objects created by the project have been used and to what effect. This could be provided as additional information to other potential users, or could be used to rank results returned from a query. This objective will not duplicate any of the functionality of JORUM.

Aim 3: promote the use of the learning objects.

Promote the use and integration into (current and future) learning environments of the learning objects that have been created.

Associated objectives

- Upload the learning objects to the JORUM repository;
- Demonstrate compatibility, where possible, with interoperability tools such as RELOAD and relevant products of the JISC eLearning Framework;

- Through exemplars, training materials and workshops aimed at teachers, the project will show how the learning objects can be tailored and integrated into VLEs. Teaching staff in colleges will become familiar with the concept of Learning Objects, and with their selection and use;
- Academic and technical staff at the partner institutions will become familiar with the interoperability standards necessary for reusable learning objects.

Methodology

The legacy resources used by ReSET contain assets (images, animations, video clips etc.) that could be suitable for *re-purposing* within the terms of the definition provided in JISC Circular 9/04. However, this would not release their full worth since these resources also contain a learning context (explanations, applications, assessments) that has proven to be suited to the topic addressed by the original package. ReSET has adapted the materials to produce learning objects that reproduce sections of the original package by using the best available standards-compliant tools for e-learning. For example a resource authored in ToolBook in the 1990's for delivery on CD-ROM acted as a prototype for the same content authored in Macromedia Flash and XHTML, which has been structured using the IMS Simple Sequencing specification, packaged using IMS Content Packaging, and described using the X4L/UK LOM Core profile of the IEEE Standard for Learning Object Metadata. As such, the rejuvenated resource has become suitable for *re-use*.

For learning objects to be reused it is not enough that the resource simply be "made available", rather it is necessary that they can be found by other teachers and learners looking for similar material and that these teachers and learners must be able to ascertain that the material is suitable for their need, and that they have the right to use it in the way that they wish. Therefore the project has paid particular attention to creating suitable resource discovery metadata, clarifying and expressing the digital rights claimed over the resource, and evaluating and describing the potential use to be made of the resource by teachers and learners. In this way the project has made a contribution to the development of knowledge and understanding of Learning Objects and their potential uses in the wider academic community.

Increased awareness of procedures for re-purposing Learning Objects, their suitability, quality and accessibility has contributed to their wider adoption, thereby increasing the number of people able to re-purpose and be involved in the development of JORUM.

Implementation

In addition to the legacy content re-engineering work and metadata construction activities which formed the backbone of the ReSET project there were other important aspects of development which were dealt with. Significant inputs were made during the early testing and use of the JORUM sandbox and the main JORUM system. A number of requests for modifications and additional feature requests were made to the JORUM team.

Evaluation

On a continuous basis the material being re-engineered was checked for accuracy and errors. This was relatively straightforward since all of the content had already been subject to the quality assurance procedures of the originating projects. This being said, a number of errors and clarifications were picked up. Academic members of the project team verified the final results.

Quality assurance

College partners were provided with draft versions of LOs and then submitted reports which were used to make revisions during the production of final versions of the LOs. The technical development team ensured that LO standards were being met at all stages of development. A version of the catalogue was maintained which included check boxes to track various aspects of compliance with LO standards, W3C compliance and operability in 2 VLEs.

Dissemination

In addition to the regular and routine project partner meetings, a number of ReSET papers, presentations and contributions have been made at the following events:

- 22 March 2005 – X4L Programme Meeting, Birmingham
- 20 June 2005 – JORUM Contributor Launch, Manchester
- 1 July 2005 – Higher Education Academy Conference, Edinburgh
- 8 July 2005 – JISC Consultation Meeting, Cambridge
- 24 August 2005 – JORUM Evaluation Interview, Glasgow
- 28 September 2005 – X4L Advisory Board Meeting, London
- 30 September 2005 – JORUM team visit to Glasgow Caledonian University
- 6 December 2005 – X4L Programme Meeting, York
- 14 March 2006 – JISC Conference
- 23 March 2006 – X4L Programme Meeting, York.
- 13 June 2006 – JORUM Outreach Tour, Glasgow
- 25 July 2006 – Engineering Education 2006, Liverpool
- 6 September 2006 – Association for Learning and Teaching Conference (ALT-C), Edinburgh
- 13 December 2006 – HEA Engineering Subject Centre Workshop, Luton

Sustainability

The sustainability of the work of the ReSET project will be enhanced by a number of processes:

- Adherence to state of the art standards ensures that the LOs will be useful for a significant period of time;
- The depositing of LOs in JORUM ensures ongoing availability to the academic community beyond the project period;
- The active dissemination conducted during the project has spread knowledge of the outcomes to a wide audience;
- The aspect of the project work which involved the mapping of the new LOs to actual teaching and learning requirements has ensured that the LOs are relevant and up to date;
- Involvement of the entire group of partners has resulted in diffusion of many of the required skills involved in re-engineering legacy CBL content into LOs from a small specialist group in the consortium to a much larger group.

Outputs and Results

The major output of the ReSET project has been the creation of 211 standards compliant Learning Objects and the uploading of these Learning Objects to the JORUM repository. This was the single most important output that the project set out to achieve and this has been accomplished on time and within budget. The other supporting outputs detailed in the Project Plan have also been completed successfully. These are:

- The ReSET Project web site;
- A guidebook on the creation of LOs from legacy content;
- All JISC project documentation and reports.

The project team consider that this has been a highly successful project which met no significant difficulties during its lifetime.

Outcomes

The Project Plan identified 3 major outcomes. All of these outcomes have been achieved.

- **Outcome 1** – A significant range of learning objects for use in HNC/HND/Foundation programmes are now available from JORUM for use in VLEs. At the end of the project 211 individual Learning Objects had been re-engineered from the legacy content. IPR clearance agreements have been negotiated and completed for all of the relevant content and this allows use of the new Learning Objects by UK academic institutions. Appropriate sections and sub-sections of the legacy material were identified for conversion to Learning Objects with the assistance of the FE partners. This resulted in the ability to map the content of many of the new Learning Objects to actual course units and learning outcomes relevant to FE teaching. In many cases, where no hard copy 'workbook' to associate with the new LOs was available, the project team have written such workbooks. The main subject areas covered by the new Learning Objects are electronics, mathematics and materials science. All 211 Learning Objects have been uploaded to JORUM and are now available for general use.
- **Outcome 2** – The 211 Learning Objects created have been adequately described and evaluated to facilitate their selection for use by users of JORUM and VLEs. Rather than depend exclusively on the generic metadata creation support available at JORUM, the project team have created detailed and very specific metadata which includes aspects such as the mapping to the learning units and learning outcomes mentioned above. The complete process of identifying and recovering the Learning Objects from JORUM has been tested and verified. Testing of the operation of the Learning Objects has been performed in 2 VLEs (BlackBoard and MOODLE) and with 2 browsers (Internet Explorer and Firefox).
- **Outcome 3** - Teaching staff in colleges have become familiar with the concept of learning objects, and with their creation, selection and use. During the lifetime of the project the colleagues in the FE partner institutions have been fully involved in the development process and have become familiar with the concept and methods required to re-engineer legacy content into modern Learning Objects. In addition, the project team has experimented with the use of groups of Learning Objects in the context of creating Learning Design materials (using LAMS) and with the integration of Learning Objects into teaching resources such as electronic slide presentations and online student self learning materials. these activities have allowed the FE staff involved to gain insight into how Learning Object can be used in the real teaching and learning environment.

Conclusions

It is clear from the work of ReSET that re-engineering high quality legacy computer based learning resources to create modern Learning Objects is a very efficient method of producing large volumes of Learning Objects within reasonable time scales and with limited budgets. In some cases the legacy content can quite literally be extracted and, with minimal effort, be used to build a Learning Object. In the majority of cases, however, it is necessary to make some changes which can cause delays in the production schedule. From the prior experience of the project team it was known that any tendency to be drawn into complete re-design of the legacy content would result in significant delays and would obstruct the basic idea of running a 'production line' for Learning Object creation. The only aspects of design that were considered essential to spend significant time on were the establishment of a generic 'appearance' for all of the Learning Objects and a standard style of navigation which would suit all legacy resources. This design work was completed at an early stage and thereafter the production line was able to run unimpeded. There are some ancillary conclusions which can be drawn such as the very limited ability to do 'real' things with Learning Objects at the moment, but the major overriding conclusion is that it is very cost effective to use legacy content to produce large quantities of Learning Objects. Even although ReSET has produced 211 new Learning Objects from the available legacy content, approximately 90% of this material (with full IPR clearance in place) has not yet been re-engineered and remains available for rejuvenation.

Implications

It would be a great loss if there were no future opportunities to continue the work of the ReSET project to allow the extraction of significantly more of the available legacy content and the creation of Learning Objects from it. There are almost certain to be many other sources of high quality computer based learning materials in a wide range of disciplines which could benefit from a similar type of treatment that ReSET has provided. With the use of Learning Objects and techniques such as Learning Design being in their infancy, the ability to provide the academic community with relatively large scale libraries of Learning Objects would enhance the chances of uptake and accelerate the evolution of these important techniques and methods away from the research laboratories and into the classrooms.

Recommendations

The project team recommends that the teaching, learning and research communities, along with their funding sources, give very serious consideration to viewing the results of the ReSET project as an indicator that re-engineering legacy computer based learning resources into state of the art Learning Objects is one of the most successful ways to promote the evolution and use of Learning Objects and associated technologies and techniques. As a consequence, it is recommended that appropriate funding bodies should significantly invest in work similar to that conducted by ReSET.

References

All 211 ReSET learning Objects can be accessed from the JORUM web site:

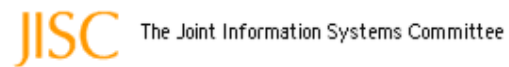
<http://www.jorum.ac.uk/>

The ReSET Project web site can be found at:

<http://reset.campuskelpie.co.uk/>

Appendix I

Guidebook on the Repurposing of Legacy Resources into Standards Compliant Learning Objects.



The ReSET Project

Guidebook on the Repurposing of Legacy CBL Resources into Standards Compliant Learning Objects.

INTRODUCTION

For the purpose of the ReSET project a 'Learning Object' (LO) is a piece of electronic media that facilitates learning and would be a component of a larger pedagogical framework. The majority of LOs produced by ReSET are Authorware pieces (interactive web based material requiring the Authorware web player) and were created from splitting up monolithic legacy Computer Based Learning material (CBL). A smaller number of LOs originally authored in ToolBook have been re-engineered in Flash. The largest piece the project produced was around 15 screens in length, the smallest a single screen illustrating a mathematical formula or circuit diagram – some of these single screens required the user to interact with them: dragging components on the screen or entering answers to a set number of questions.

To fit efficiently into current and future 'Virtual Learning Environments' and 'Learning Design' frameworks all ReSET LOs were designed to be like a page in a book; that's to say the LOs were not sandwiched between opening and end screens. These LOs are therefore learning elements which are able to fit into any structure decided by the user who is creating a learning environment with the LOs. A single LO can even become a discrete learning resource with the addition of a front and end screen. A number of the pedagogical experts in the project team felt that the provision of hard copy 'workbooks' to accompany the CBL resources was an invaluable supplement and, where such workbooks were not already available, the project team have written a number of such documents.

The basic steps involved the following:

1. Source the legacy material
2. Secure IPR rights
3. Redesign the user interface
4. Evaluate and rationalise material into discrete LOs
5. Re-engineer the original content
6. Publish and test the finished LOs

1. Source the legacy material

A group of partners who had previously developed CBL resources were involved in the ReSET project and they provided the legacy content which formed the basis of the new LOs. This approach made the process of obtaining content very straightforward and also ensured that the originators of the materials were able to contribute to the final products in terms of quality assurance, etc. In situations where this is not possible the process of sourcing content will obviously be more difficult.

2. Secure IPR rights

Due to the owners of the original IPR being partners in the ReSET project, IPR agreements and clearance were relatively straightforward to obtain. Full legal agreements were drawn up and signed by appropriate partners. As with the previous stage, when the legacy content owners are not formally involved in the repurposing activities this process will almost certainly be more difficult.

3. Redesign the user interface

The early stage of the ReSET project was devoted to re-designing the new user interface. The legacy content was taken from 4 separate sources, each with its own distinct user interface. It was decided to create a simple, standard user interface that would work well with material from all sources. With the legacy material being in some cases over 10 years old a number of standards that we take for granted today were not in place with this older material. Text links, words that when clicked brought up additional screens, were in a variety of colours. In the new ReSET work this text was coloured blue and underlined to mimic typical hyperlinks as seen on conventional web pages. Some of the legacy backgrounds were somewhat fussy making reading text a little difficult at times. Text was sometimes difficult to read because of a number of instances of bad colour choices, inappropriate drop shadows and font sizes being too small in places – all text that came under these conditions were modified in the updated ReSET work. All text (except for mathematical equations) were converted to a san serif font (Arial) as san serif fonts are widely accepted as being the better choice for screen based text (especially at a small point size). The monolithic legacy material also had a number of buttons and drop down menus that facilitated easy navigation from one section head to another and encompassed other features suited best to larger monolithic CBL pieces. These superfluous menus and buttons were purged from the ReSET LOs to give a clean streamline look which better suits a standalone Learning Object. The new ReSET navigation has been changed compared to the legacy material: before you could only navigate from one section head to another, now (with most ReSET LOs) you can move back and forward between screens. This makes it quick and easy to go back one screen if you didn't quite understand something when first viewed.

4. Evaluate/rationalise material into discrete LOs

To a large extent Learning Objects were derived from existing sections of the monolithic material. However in some cases sections could be granularised even further. Single screens that were part of a section sometimes became an LO in its own right. These single screen LOs were primarily interactive multiple-choice questions or a small interactive activity. Care was taken that all LOs made sense and could stand alone and work as a pedagogical chunk. Special care had to be taken in each LO to remove any references to other sections or modules in the monolithic material as the sections or modules referred to wouldn't exist in the standalone LO. Similarly phrases like '*As we a have already seen...*' and '*you have already learnt...*' had to be removed from the Learning Objects.

5. Re-engineer the original content

The majority of the legacy content was originally created in Authorware. Part of the upgrade at the early stages of the project was to try and utilise the accessibility features associated with the current version of Authorware (version 7.2). With this in mind the 'Accessibility Framework' was used instead of Authorware's standard 'Framework'. The 'Accessibility Framework' allows text content to be scanned internally and spoken aloud using a built in internal synthesised voice. With this accessibility feature being fairly new, and with us being unsure at this stage just how this feature could possibly be used, it was considered a good idea to use the 'Accessibility Framework' as we thought the feature could be used and didn't present any overheads if we didn't utilise the features in the end.

With this new Framework in place the layout of the Authorware's flow line was different so it wasn't just a case of copying icons from the old legacy material and pasting it into the new structure. Care had to be taken that the icons were being placed correctly and that variable names weren't being modified.

The structure of the flow line reflects the new navigation that was put in place. The old legacy material only allowed you to navigate from one section to any other but the new navigation allows page to page access.

6. Publish and test the finished LOs

After publishing, all LOs were tested in Internet Explorer and Firefox to see that they functioned correctly and you could exit from them. The LOs were then taken into the Reload Editor where a simple organisation structure was made to ensure that the appropriate HTML document was being opened to launch the Authorware piece. Basic metadata was attached at this stage: title, description and some keywords (these keywords were mostly words highlighted within a lesson's text). Other work was done to augment this metadata in full. The pieces again were tested at this point using the Reload preview mode as this was meant to simulate how it would look when viewed in a VLE.

The LOs were then tested in both Moodle and BlackBoard. One problem that was identified was that an LO with an apostrophe in its metadata (in the title/description field) would refuse to run in Moodle (e.g. Ohm's Law was a problem).

To facilitate the tracking of the entire process of creation, quality assurance and tracking of each LO a project catalogue was designed and updated as the work progressed. The ReSET LO Catalogue is available as a separate document.

Appendix II

ReSET Learning Object Catalogue

ReSET Project - Learning Object Catalogue

1	C0001	Inverting Amplifier (01) - Negative Gain	Derivation of gain.
2	C0002	Inverting Amplifier (02) - Gain Question	Question on gain.
3	C0003	Inverting Amplifier (03) - Voltage Question	Question on voltage
4	C0004	Non-Inverting Amplifier (01) - Positive Gain	Non-Inverting Amplifier Derivation of gain.
5	C0005	Non-Inverting Amplifier (02) - Gain Question	Non-Inverting Amplifier question on gain.
6	C0006	Non-Inverting Amplifier (03) - Voltage Question	Non-Inverting Amplifier question on voltage.
7	C0007	Integrator (01) - Voltage Ramp	Operational Amplifier Integrator circuit Demonstration.
8	C0008	Integrator (02) - Circuit Diagram	Operational Amplifier Integrator circuit including derivation of time constant .
9	C0009	Integrator (03) - Example	Operational Amplifier Integrator circuit numerical example.
10	C0010	Integrator (04) - Output Voltage Question	Operational Amplifier Integrator circuit output voltage question.
11	C0011	Integrator (05) - Input Voltage Question	Operational Amplifier Integrator circuit input voltage question.
12	C0012	Synchronous protocols (01) - Transmission	Synchronous clock signals, timing, synch characters.
13	C0013	Synchronous protocols (02) - Control Characters	Synchronous protocol control characters.
14	C0014	Synchronous protocols (03) - Protocol Analyser	Protocol Analyser, including demonstrations and communication flow.
15	C0015	Synchronous protocols (04) - Data Link Escape	DLE stuffing prevents premature loss of data in synchronous communication.
16	C0016	Synchronous protocols (05) - High Level Data-Link Control	Synchronous Protocols, HDLC protocol, HDLC frames and flag sequence.
17	C0017	Synchronous protocols (06) - HDLC Demonstration	HDLC protocol demonstration between primary and secondary devices.
18	C0018	Synchronous protocols (07) - Flag Sequence	Flag sequence used transmitting data in synchronous communication.
19	C0019	Asynchronous Protocols (01) - Transmission	Asynchronous Transmission, including interactive demonstrations.
20	C0020	Asynchronous Protocols (02) -	Asynchronous waveform format,

		Waveform	including ASCII character example.
21	C0021	Asynchronous Protocols (03) - Echoplexing	Echoplexing allows error detection and correction in asynchronous communication, including demonstration.
22	C0022	Open Systems Interconnection	Open Systems Interconnection model, including example of application layers.
23	C0023	Elements of Protocols (01) - Introduction	Introduction to protocols, contention, addressing, parity and error detection.
24	C0024	Elements of Protocols (02) - Transmission Control	Covers protocols, addressing.
25	C0025	Elements of Protocols (03) - Contention	Covers protocols, contention.
26	C0026	Elements of Protocols (04) - Communication	Covers protocols, addressing.
27	C0027	Elements of Protocols (05) - Parity Error Detection	Covers protocols, parity and error detection
28	C0028	Elements of Protocols (06) - Checksum	Parity, checksum and error detection
29	C0029	Elements of Protocols (07) - LRC & VRC	Covers protocols, parity, checksum, LRC & VRC and error detection
30	C0030	Elements of Protocols (08) - Cyclic Redundancy Check	Covers checksum and error detection
31	C0031	Elements of Protocols (09) - Automatic Repeat on reQuest	Covers error detection method.
32	C0032	Elements of Protocols (10) - Line Utilisation	Covers protocols, parity, line utilisation
33	C0033	Diode Construction (01) - Materials	Covers diode construction and materials
34	C0034	Diode Construction (02) - Packaging	Covers diode packages
35	C0035	Diode Performance (01) - Symbol	Covers diode symbols
36	C0036	Diode Performance (02) - Resistor Characteristics	Covers diode voltage, current and resistance characteristics
37	C0037	Diode Performance (03) - Resistance Demonstration	Covers diode resistance characteristics
38	C0038	Diode Performance (04) - Resistor Question	Covers diode resistance characteristics
39	C0039	Diode Performance (05) - Biasing	Covers diode characteristics, biasing of diodes
40	C0040	Diode Applications (01) - Rectifier Applications	Covers diodes in a rectifier configuration
41	C0041	Diode Applications (02) - Rectifier Circuit	Covers diodes in a rectifier circuit
42	C0042	Diode Applications (03) - Biasing Question	Covers diode question in a rectifier circuit
43	C0043	Diode Applications (04) - Resistance	Covers diode question in a rectifier

		Question	configuration
44	C0044	Diode Applications (05) - Adding a Capacitor	Covers adding a capacitor to a rectifier circuit
45	C0045	Diode Applications (06) - Capacitive Effect	Covers adding a capacitor to a rectifier circuit
46	C0046	Diode Applications (07) - Ripple Voltage Example	Example calculating the ripple voltage in a half wave rectifier circuit with a smoothing capacitor
47	C0047	Diode Applications (08) - Ripple Voltage Question	Example calculating the ripple voltage in a half wave rectifier circuit with a smoothing capacitor
48	C0048	Diode Applications (09) - Common Applications	Covers diode applications in a Limiter and an RF Detector
49	C0049	Introduction to Transistors (01) - Transistor Devices	Illustrations and information on transistor package types and manufacturing materials used
50	C0050	Introduction to Transistors (02) - Bipolar Junction Transistor	Illustrations and information on the npn and pnp Bipolar Junction Transistor physical make-up, circuit symbols and behavioural differences
51	C0051	Introduction to Transistors (03) - NPN Transistor Behaviour	Illustrations and information of electron flow and biasing of an NPN Bipolar Junction Transistor in circuit
52	C0052	Introduction to Transistors (04) - Common Emitter Amplifier	Illustrations and information on the current flow and gain of the Common Emitter Amplifier
53	C0053	Introduction to Transistors (05) - Amplifier Gain Question	Question on the gain of a common emitter amplifier circuit
54	C0054	Introduction to Transistors (06) - Amplifier Gain Example	Illustrations and information on transistor package types and manufacturing materials used
55	C0055	Introduction to Transistors (07) - Characteristic Curves	Graphically shows the behaviour of a Common Emitter Amplifier through characteristic curves. Demonstrates how changes in collector current, base current and collector/emitter voltage influence each other
56	C0056	Introduction to Transistors (08) - The Load Line	Description of the load line superimposed on the characteristic curve of the Common Emitter Amplifier circuit. Graphical representation of operation in both cut-off and saturated regions
57	C0057	Introduction to Transistors (09) - Load Line Questions	Questions on collector current and collector/emitter voltage from the characteristic curves. Information on the behaviour of the Common Emitter Amplifier and graphs of the characteristic curves
58	C0058	Introduction to Transistors (10) - The Operating Point	Graphically illustrates the behaviour of signals passing through a Common Emitter Amplifier circuit.

			Demonstrates the use of this circuit as a small signal amplifier
59	C0059	Describing Amplifier Performance (01) - Amplifier Gain	Conceptual description of an amplifier and gain as a ratio of input and output
60	C0060	Describing Amplifier Performance (02) - Gain Questions	Four questions on gain as a ratio of input and output
61	C0061	Describing Amplifier Performance (03) - Equivalent Circuit	Simple equivalent circuit of an amplifier illustrating the relationship of input voltage, output voltage and gain
62	C0062	Describing Amplifier Performance (04) - Voltage Question	Amplifier input voltage question with several selectable answers to response
63	C0063	Describing Amplifier Performance (05) - Amplifier Example	Complete amplifier example illustrating the effect of input resistance on the amplifier output voltage
64	C0064	Describing Amplifier Performance (06) - Simplified Amplifier Circuit	A simplified circuit of an amplifier introducing the output voltage being limited by the d.c. supply
65	C0065	Describing Amplifier Performance (07) - Power Supply	Worked example of gain as a ratio of output power to input power. In addition, introducing the amplifier power supply
66	C0066	Describing Amplifier Performance (08) - Voltage Gain Question	Single amplifier voltage gain question
67	C0067	Describing Amplifier Performance (09) - Output Voltage Questions	Four short questions to calculate amplifier output voltage
68	C0068	Describing Amplifier Performance (10) - Power Gain Question	Single question on amplifier power gain
69	C0069	Describing Amplifier Performance (11) - Maximum Amplifier Current	Circuit illustrating maximum amplifier current and how this is dependent on the load resistance
70	C0070	Describing Amplifier Performance (12) - Maximum Current Question	Single question on the maximum amplifier input voltage which can be safely applied with a rated maximum output current
71	C0071	Binary Codes (01) - Binary Digits	Interactive switching example demonstrating binary digits
72	C0072	Binary Codes (02) - Binary Example	Interactive switching example demonstrating binary digits to represent numbers
73	C0073	Binary Codes (03) - Binary Representation	Binary bits used to build a diagram and the introduction of bytes
74	C0074	Binary Codes (04) - ASCII Code	Example of bytes being used in ASCII coding
75	C0075	Binary Codes (05) - Parity	Explanation of odd and even parity used in ASCII coding, plus additional question on parity used in an ASCII character

76	C0076	Transmission Methods - Parallel and Serial Transmission	Explains and demonstrates the benefits of serial and parallel transmission methods
77	C0077	Communication Channels (01) - The Telephone	Description of common channels used in communication, with the emphasis placed on the telephone
78	C0078	Communication Channels (02) - Data Communication	Description and illustrations of the communication process, with emphasis placed on the conversion of digital-to-analogue, and the equipment needed to achieve this. Ending with a digital error detection question
79	C0079	Channel media (01) - Twisted Pair	Properties of twisted pair telephone wire
80	C0080	Channel media (02) - Coaxial Cable & Optical Fibre	Properties of coaxial cable and optical fibre
81	C0081	Channel media (03) - Microwave Links	Explanation and demonstration of microwave communication methods using high frequency radio signals
82	C0082	Networks - LAN and WAN	Brief overview of communication networks and Local Area and Wide Area networks
83	C0083	Long Distance Communication (01) - Serial transmission	Example of serial transmission, including descriptions of unipolar and bipolar signals
84	C0084	Long Distance Communication (02) - RZ Line Code	Description of bipolar signal line codes carrying serial data, including interactive RZ line code example
85	C0085	Long Distance Communication (03) - NRZ Line Code	Description of Non-Return to Zero line code, including an interactive example
86	C0086	Long Distance Communication (04) - NRZI Line Code	Description of Non-Return to Zero Inverted line code, including an interactive example
87	C0087	Long Distance Communication (05) - Line Code Degradation	Description of line code degradation during long distance transmission, with emphasis placed on bandwidth. In addition, a narrow band example of a Public Switched Telephone Network is utilised to provide clarity to the prior description
88	C0088	Long Distance Communication (06) - Data Transmission Question	Review question on long-distance external data transmission and short-distance internal data transmission, with simple drag and drop interaction
89	C0089	Long Distance Communication (07) - Line Code Questions	Review questions on line codes with regards to voltage level changes, functionality, degradation and bandwidth

90	C0090	Digital Speech Coding (01) - Pulse Code Modulation	Description of the various stages of digital speech coding using pulse code modulation techniques. Topics covered are filtering, sampling, quantization and digitization
91	C0091	Digital Speech Coding (02) - Quantization Noise	Description and example of quantization noise
92	C0092	Digital Speech Coding (03) - Quantization Question	on quantization levels with regards to the size of a digital to analogue converter
93	C0093	Digital Speech Coding (04) - Data Rate	Example of data rate or bit rate with reference to sampling
94	E0094	Amplifier Fundamentals (01) - Voltage Model	Introduction to a simple amplifier model used for analysis purposes. Initially focusing on the ideal properties of a voltage amplifier model, including an interactive demonstration
95	E0095	Amplifier Fundamentals (02) - Current Amplifier	Focusing on the ideal properties of the simplified current amplifier model, this LO illustrates the gain equation using circuit values
96	E0096	Amplifier Fundamentals (03) - Transconductance Amplifier	Focusing on the ideal properties of a simple transconductance amplifier mode
97	E0097	Amplifier Fundamentals (04) - Transresistance Amplifier	Focusing on the ideal properties of the simplified transresistance amplifier model
98	E0098	Amplifier Fundamentals (05) - Amplifier Input and Output	Focusing on the ideal amplifier model input and output source and the effects of impedance
99	E0099	Bipolar Junction Transistor Amplifiers (01) - Small Signal BJT Model	Description of the small signal Bipolar Junction Transistor model with DC and AC operating characteristics. Including animated Quiescent point demonstration and derivation of the small signal transconductance parameter
100	E0100	Bipolar Junction Transistor ... (02) - Common Emitter Amplifier	DC analysis of the common emitter amplifier circuit operated as a small signal amplifier
101	E0101	Bipolar Junction Transistor ... (03) - Common Emitter Design	Detailed interactive design of the common emitter amplifier. Comparison can be made between ideal and designed load line
102	E0102	Bipolar Junction Transistor ... (04) - Common Collector Amplifier	DC and AC analysis of the common collector amplifier. Including derivation of current gain
103	E0103	Bipolar Junction Transistor ... (05) - Common Collector Example	Limited common collector design example. Highlighting the effective design and application of the buffer amplifier
104	E0104	Bipolar Junction Transistor Amplifiers	Interactive common collector

		(06) - Common Collector Desi	amplifier design and simulated analysis. Passive component selection guided by hint and help buttons
105	E0105	Bipolar Junction Transistor Amplifiers (07) - Common Base Amplifier	Brief description of the common base amplifier, including circuit parameters and operating characteristics
106	E0106	Bipolar Junction Transistor Amplifiers (08) - BJT Circuit Characteristi	Characteristic gain and impedance parameters of common emitter, common collector and common base amplifier designs
107	E0107	Field Effect Transistor Amplifiers (01) - FET Transistor Model	Brief overview and description of the field effect transistor model operated as a small signal amplifier. Including operating characteristics and circuit parameters
108	E0108	Field Effect Transistor Amplifiers (02) - FET Small Signal Model	Comparison of the FET small signal amplifier adn the BJT small signal amplifier
109	E0109	Field Effect Transistor Amplifiers (03) - Common Source Amplifier	An analysis of the common source amplifier parameters. Examines the AC and DC equivalent circuits
110	E0110	Field Effect Transistor Amplifiers (04) - Common Drain Amplifier	An analysis of the common drain amplifier parameters. Examines the AC and DC equivalent circuits
111	E0111	Semiconductors & PN Junctions (01) - Intrinsic Semiconductors	The Bond Theory looks at the behaviour of valence electrons in solids to help explain their structure
112	E0112	Semiconductors & PN ... (02) - Metals, Insulators and Semic	The electrical properties of metals, insulators and Semiconductors
113	E0113	Semiconductors & PN Junctions (03) - Conductor (metal)	The Conduction Band and Valence Band in a metal conductor
114	E0114	Semiconductors & PN Junctions (04) - Insulators	Properties of an Insulator
115	E0115	Semiconductors & PN Junctions (05) - Semiconductors	Properties of an Semiconductor
116	E0116	Semiconductors & PN Junctions (06) - Hole Motion	The mechanism by which electron holes contribute to the conduction process
117	E0117	Semiconductors & PN Junctions (07) - Extrinsic Semiconductors	Doping of Silicon to make P an N type Semiconductor material - interactive
118	E0118	Semiconductors & PN Junctions (08) - Current flow	The mechanisms of current flow - drift & diffusion
119	E0119	Semiconductors & PN Junctions (09) - Drift Current	Description of drift current in conductors
120	E0120	Semiconductors & PN Junctions (10) - Ohm's law	A Derivation of Ohm's law
121	E0121	Semiconductors & PN Junctions (11) - Diffusion Current	Diffusion Current - the description of its movement

122	E0122	Semiconductors & PN Junctions (12) - Total Current	Equations on Total Current
123	E0123	Semiconductors & PN Junctions (13) - Semiconductor Physics	Some fundamental points of Semiconductors
124	E0124	Semiconductors & PN Junctions (14) - The Depletion Region	The structure and properties of a p-n junction
125	E0125	Semiconductors & PN Junctions (15) - Biasing	Applying a biasing voltage on a p-n junction
126	E0126	Semiconductors & PN Junctions (16) - Forward Biasing	A p-n junction under forward bias conditions
127	E0127	Semiconductors & PN Junctions (17) - Reverse Biasing	The structure and properties of a p-n junction
128	E0128	Semiconductors & PN Junctions (18) - Breakdown Region	An explanation of the breakdown region within a p-n junction
129	E0129	Semiconductors & PN Junctions (19) - Capacitance	The sources of capacitance in a p-n junction
130	E0130	Semiconductors & PN Junctions (20) - Diodes	The technical details of the diode
131	E0131	Semiconductors & PN Junctions (21) - Forward region	Analysis of how the change in temperature affects the characteristics of the diode
132	E0132	Semiconductors & PN Junctions (22) - Zener Diodes	The characteristic of the zener diode
133	E0133	Semiconductors & PN Junctions (23) - Diode Models	A description of the Ideal and Semi Ideal diode
134	E0134	Semiconductors & PN Junctions (24) - Diode load lines	Diode load lines - the current voltage relationship
135	E0135	Semiconductors & PN Junctions (25) - Rectifier Circuits	A description of the use of diodes in the design of rectifier circuits
136	E0136	Semiconductors & PN Junctions (26) - Half-wave	A description of a half-wave rectifier
137	E0137	Semiconductors & PN Junctions (27) - Full-wave	A description of a full-wave rectifier
138	E0138	Semiconductors & PN Junctions (28) - Ripple filtering	Description and example of the effect that a reservoir capacitor has on reducing ripple voltage
139	E0139	Semiconductors & PN Junctions (29) - Zener shunt regulator	Description of a voltage or shunt regulator implemented with a Zener diode
140	E0140	Non-Ideal Operational Amplifiers (01) - Review of Ideal Op Amp	Brief review of an ideal op-amp characteristics and performance
141	E0141	Non-Ideal Operational Amplifiers (02) - Transistor Model of Op Amp	Transistor level view of the internal structure of an operational amplifier and simple model view of the op-amp characteristics
142	E0142	Non-Ideal Operational Amplifiers (03) - Frequency Response	This Learning Object examines the frequency response of a non-ideal op-amp through the use of bode plots. Including overview of open loop gain and phase shift

143	E0143	Non-Ideal Operational Amplifiers (04) - Simplified Op Amp Model	Simplified model of an op-amp with interactive areas used to highlight three characteristic stages i.e. input, output and frequency response
144	E0144	Non-Ideal Operational Amplifiers (05) - Simplified Op Amp Equation	Description of terms used in the simple op-amp gain equation
145	E0145	Non-Ideal Operational Amplifiers (06) - Gain Derivation	Complete derivation of the op-amp gain equation extracted visually from the simple op-amp model
146	E0146	Non-Ideal Operational Amplifiers (07) - Gain Magnitude & Phase	Op-amp gain and phase shift questions
147	E0147	Non-Ideal Operational Amplifiers (08) - Gain Bandwidth Product	Description of the Gain Bandwidth Product, illustrated by means of an animated bode plot
148	E0148	Non-Ideal Operational Amplifiers (09) - Differential Input Impedance	Brief description of the differential input impedance of an operational amplifier
149	E0149	Non-Ideal Operational Amplifiers (10) - Output Impedance	Brief description of the output impedance of an operational amplifier, with the aid of a simple model diagram
150	E0150	Non-Ideal Operational Amplifiers (11) - Frequency Response	In depth description of the frequency response of an operational amplifier used in a non-inverting closed loop configuration. This learning object incorporates derivation of gain and bode plot analysis
151	E0151	Non-Ideal Operational Amplifiers (12) - Frequency Response Question	Frequency response question of an operational amplifier used in a closed loop non-inverting configuration
152	E0152	Non-Ideal Operational Amplifiers (13) - Input Impedance	Analysis of the input impedance of an operational amplifier used in a non-inverting closed loop configuration
153	E0153	Non-Ideal Operational Amplifiers (14) - Input Impedance Question	Question on the DC input impedance of an operational amplifier used in a non-inverting closed loop configuration
154	E0154	Non-Ideal Operational Amplifiers (15) - Output Impedance	Analysis of the output impedance of an operational amplifier used in a non-inverting closed loop configuration
155	E0155	Non-Ideal Operational Amplifiers (16) - Output Impedance Question	Question on the DC input impedance of an operational amplifier used in a non-inverting closed loop configuration
156	E0156	Non-Ideal Operational Amplifiers (17) - Frequency Response	In depth description of the frequency response of an operational amplifier used in an inverting closed loop configuration. This learning object incorporates derivation of gain and bode plot analysis

157	E0157	Non-Ideal Operational Amplifiers (18) - Input Impedance	Brief description of the input impedance of an operational amplifier used in an inverting closed loop configuration and an introduction to the use of miller components
158	E0158	Non-Ideal Operational Amplifiers (19) - Output Impedance	Brief description of the output impedance of an operational amplifier used in an inverting closed loop configuration
159	E0159	Non-Ideal Operational Amplifiers (20) - Op Amp Gain	This learning object examines the deviation in op amp gain due to loading
160	E0160	Transistor Operation and Character... 01) -Introduction to Transis	An Introduction to Transistor Amplifiers
161	E0161	Transistor Operation and Characteristics (02) -BJT - Physical Struct	The physical structure of a bipolar junction transistor
162	E0162	Transistor Operation and Characteristics (03) - BJT Operation	The operation of a bipolar junction - studying the operation of the npn BJT in the active mode
163	E0163	Transistor Operation and Characteristics (04) - Base Curve Paramet	The significance of the base curve parameter
164	E0164	Transistor Operation and Character... (05) - Operating Point and and Load Lines	Finding the 'operating point' using the graphical device called 'load line'
165	E0165	Transistor Operation and Characteristics (06) - BJT Biasing	The importance of d.c. biasing
166	E0166	Transistor Operation and Characteristics (07) - Fixed Base Bias	An exploration of fixed base bias
167	E0167	Transistor Operation and Characteristics (08) - Collector Feedback	An exploration of collector feedback bias
168	E0168	Transistor Operation and Characteristics (09) - Self Bias	An exploration of self or potential divider bias
169	E0169	Transistor Operation ... (10) - MOSFET Operations & Char	An introduction to the metal oxide semiconductor field-effect transistor
170	E0170	Transistor Operation and Characteristics (11) - FET Transistor Model	Designing a large signal (dc) model for an n-channel enhancement MOSFET
171	E0171	Transistor Operation and Characteristics (12) - MOSFET Biasing	A lesson that shows you how the self bias circuit can provide a stable dc operating point
172	H172	Differentiation : Introducing Differentiation	Explains what is meant by the gradient of a curve and introduces differentiation as a method for finding the gradient at any point.
173	H173		

174	H174		
175	H175		
176	H176		
177	H177		
178	H178		
179	H179		
180	H180		
181	H181		
182	H182		
183	H183		
184	H184		
185	H185		
186	H186		
187	H187		
188__	H188		
189	H189		
190	H190		
191	H191		
192	H192		
193	H193		
194	H194		
195	H195		
196	H196		
197	H197		
198	H198		
199	H199		
200	H200		
201	H201		
202	H202		
203	H203		
204	H204		
205	-		
206	M206	An Introduction to Crystallography	Basic lines of symmetry within

		(1) - Reflection Symmetry	crystals
207	M207	An Introduction to Crystallography (2) - Rotation Symmetry	Describes rotation axis of symmetry and symmetry elements
208	M208	An Introduction to Crystallography (3) - The 10 Plane Point Group	Translational Symmetry and Lattices and Crystals
209	M209	An Introduction to Crystallography (4) - Unit Cells	Unit Cells and 5 plane lattices.
210	M210	An Introduction to Crystallography (5) - Glide Line Symmetry	Glide Line Symmetry, the 17 Plane Group and Plane Group Identification